ACADEMIC CURRICULA

POST GRADUATE DEGREE PROGRAMMES

Master of Technology

(Choice Based Flexible Credit System)

Regulations 2021

Volume – 22
Syllabi for School of Bioengineering Programme

Professional Core and Elective Courses

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

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ACADEMIC CURRICULA

Biomedical Engineering

Professional Core Courses

Regulations 2021

SRM INSTITUTE OF SCIENCE & TECHNOLOGY
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Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

Course Code	21BMC501T	Course Name	HUMAN ANATOMY AND PHYSIOLOGY	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biomedical Engineering*	**Data Book / Codes / Standards**	*NIL*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the contribution of each organ system to the maintenance of homeostasis*
CLR-2:	*elucidate the physiological aspects of normal growth and development*
CLR-3:	*analyze the physiological response and adaptations to the environment*
CLR-4:	*understand physiological principles underlying diseases and abnormalities*
CLR-5:	*gear students in health-oriented, medical and biological programs*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Programme Outcomes (PO)		
		1	**2**	**3**
CO-1:	*describe physiological processes of all body systems in detail*	*1*	*-*	*1*
CO-2:	*explain physiological processes on an appropriate level (knowledge, comprehension, application and analysis)*	*1*	*2*	*1*
CO-3:	*explain how the activities of organs are integrated for maximum efficiency*	*1*	*1*	*-*
CO-4:	*elaborate the role of body systems and mechanisms in maintaining homeostasis*	*1*	*-*	*-*
CO-5:	*distinguish between normal and abnormal anatomical and physiological conditions*	*1*	*2*	*1*

Module-1 - General Physiology and Blood	***9 Hour***
Principles of Homeostasis-Structure of cell membrane-Transport mechanisms- Intercellular communications- Fluid compartments of the body- Functions of plasma proteins- Principle of hematopoiesis-Erythropoiesis- Destruction of red cells- Production, Functions of WBC- Regulation of WBC- Functions of platelets- Hemostasis Blood groups- ABO grouping system - Examples of transfusion- Anemia--lymph organs- other pathologies	
Module-2 - Nerve- Muscle and Respiration System	***9 Hour***
Principles of bioelectricity-Genesis of resting membrane potential-Action potential-Propagation-Properties of nerve fibers-Neuromuscular junction, transmission-Muscle proteins-Excitation – contraction coupling-Contraction kinetics of skeletal muscles-Smooth muscle-Injury and repair of nerves and muscles-Energetic of nerve & muscle-Introduction to respiratory system-Lung volumes and capacities-Mechanics of respiration-O2 carriage, O2–dissociation curve-CO2 carriage, CO2–dissociation curve-Regulation of respiration-disorders like cyanosis	
Module-3 - Cardiovascular and GI Tract	***9 Hour***
Introduction to Cardiovascular system-Action potential and spread of impulse in the heart-vascular system –arteries, arterioles, capillaries, venules -Cardiac cycle-Volume changes-Cardiac cycle-Pressure changes-Functional basis of heart sounds and murmurs-Neural regulation of cardiac activity- Regulation of heart rate, blood pressure- Cardiac output measurement and regulation-Electrocardiogram(ECG)- Analysis and ECG reading-General organization of G.I. tract- Mastication and deglutition- Biliary and pancreatic secretions- Physiology of colon- Defecation- Defecation -Neural control	
Module-4 - Kidneys, Reproductive System and Neurophysiology	***9 Hour***
Renal hemodynamics- network of blood capillaries -Glomerular filtration- Regulation of renal function- regulation of acid-base balance -Micturition- Artificial kidney, dialysis and renal transplantation-General structure and functions of Male and Female reproductive system, Hormone production and physiology of menstruation and fertilization-Introduction to neurophysiology-CSF- Neuroglial cells-Synaptic transmission- Properties of synaptic transmission- Neurotransmitters	
Module-5 – Sensory, Motor Systems and Special Senses	***9 Hour***

Principles of sensation- Coding of sensory information-Functional organization of ascending sensory pathways- Physiology of pain-Characteristics and properties of reflexes-Types of reflexes-Eye: Functions of retina: photoreception- Electroretinography-Central mechanisms of vision- Visual perception- Functional anatomy of ear: impedance matching- Organ of Corti: peripheral auditory mechanism Auditory pathway- Olfactory- Pathway of smell- Physiology of taste- Taste perception- Limbic system- Emotions

Learning Resources	*1. Arthur. C. Gyton, John Edward Hall, "Textbook of Medical Physiology", Saunders, 2000.*	*2. Elaine N. Marieb, Katja Hoehn," Human Anatomy & Physiology, Pearson. 10th edition.2016*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*10%*	*-*	*10%*	*-*
Level 2	*Understand*	*20%*	*-*	*10%*	*-*	*10%*	*-*
Level 3	*Apply*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*10%*	*-*	*10%*	*-*
Level 6	*Create*	*-*	*-*	*10%*	*-*	*10%*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. T. Anbu Selvan, Wipro GE Health care Pvt Ltd	*1. Dr. S. Poonguzhali, Professor, Anna University*	*1. Dr. Varshini Karthik, SRMIST*

Course Code	21BMC502J	Course Name	ADVANCED BIOMEDICAL INSTRUMENTATION	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biomedical Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*describe various Bio signal acquisition and physiological system*
CLR-2:	*demonstrate the working principles of respiratory measurement techniques*
CLR-3:	*explain the various medical laboratory instruments*
CLR-4:	*learn and perform the measurement of bone density and body fat analyzer*
CLR-5:	*analyse the importance of various critical care equipment*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*analyze the real time acquisition of bio signals*	*3*		*2*
CO-2:	*elaborate the working principle of different respiratory system analysis*	*2*	*1*	*2*
CO-3:	*demonstrate the working principles of various medical laboratory instruments*	*3*		*1*
CO-4:	*measure and interpret the results of body fat analyzer and bone density*	*2*	*1*	*2*
CO-5:	*understand the working principle of various critical care equipment*	*3*		*1*

Module-1 - Bio signal Acquisition and Instrumentation	***15 Hour***
Action Potentials and Cellular Depolarization - Design of Biopotential electrodes - Electrical activity in heart - Electrode Design and Einthoven's Triangle - Standard Twelve-Lead Configuration - ECG System Design - Common-Mode Signals and Other Noise Sources, Design of Lead-Off Circuitry - Abnormal ECG Recordings and Clinical Interpretation - Electrical Signals Generated in the Brain - EEG System Design - 10-20 electrode placement system for Electroencephalography(EEG) monitoring - Features of a Normal EEG: Delta, Theta, Alpha and Beta Waves - Applications of BCIs to Communication Devices - EMG ,EOG - Wearable Health Monitors-Technology for Wearable Sensors ***Experiments:*** *Real time acquisition and analysis of ECG Monitoring system* *Real time acquisition and analysis of EEG Monitoring system* *Design of EMG audio amplifier circuit*	
Module-2 - Respiratory System Analysis and Measurements	***15 Hour***
Human respiratory system, Lung volumes and capacities, Gas laws, Spirometer, Methods of respiration rate measurement, Artificial respiratory therapy, Medical gases and safety system, Oxygen therapy, Intermittent positive pressure breathing therapy, Nebulizer, Humidifier, Artificial mechanical ventilation, Anesthesia machine, Faults and maintenance procedures for ventilators, Wearable respiratory monitoring devices. ***Experiments:*** *Pulmonary function analysis using Spirometer* *Design of respiration rate measurement* *Design of Heart rate measurement*	
Module-3 - Medical Laboratory Instrumentation	***15 Hour***
Colorimeter, clinical Flame photometer, Spectrophotometry, Automated Biochemical analysis system, Selective ion electrode-based electrolyte analyser, Blood cell counter, coulter counter, automatic recognition and differential counting of cell, Blood gas analyzer, Electrolyte monitoring, Chromatograph, Auto analyser, NMR blood flowmeter, Ultrasonic blood flow meter, Laser Doppler blood flow meter. ***Experiments:*** *Study of flame photometer, Study of spectrometer, Study of chromatograph*	
Module-4 - Bone Density, Body Fat Analyzing Devices	***15 Hour***

BMD measurements: Single X-ray absorptiometry (SXA), Dual X-ray absorptiometry (DXA), Quantitative ultrasound bone densitometer, Radiation safety in X-ray Densitometry, Diagnosing osteoporosis, Predicting Fracture risk, Body composition analysis, Two component model of body composition Analysis, underwater weighing, Skinfold measurement, Bioelectric impedance analysis ***Experiments:*** *Measurement of BMD and DEXA machine* *Measurement of body fat using BCA machine*
Module-5 – Critical Care Equipment and Robotics ***15 Hour***
Pulse oximeter, Skin reflectance oximeter - Intravascular oximeter – Dialyzer - Haemodialysis machine - Peritonial dialyzer, Portable Kidney machine , Bed side monitoring , Central monitoring console, Defibrillator , Automated External Defibrillator , Pacemaker, Infusion pumps -Mobile and Electronic Health: Mobile Phones and Smartphone Apps- Design Considerations for Wireless Implanted Devices -Cardiovascular Implantable Electronic Devices-Implanted Pressure Sensors for Glaucoma - Nano Robots – Applications in Robotic surgery. ***Experiments:*** *Design of Mobile app for vital parameter monitoring* *Design of pulse oximeter for the measurement of oxygen saturation* *Mini Project*

Learning Resources	1. *Andrew G. Webb, Principles of Biomedical Instrumentation, Cambridge University Press,2018* 2. *Khandpur Handbook of Biomedical Instrumentation, McGraw Hill Education (India) Private Limited,2014* 3. *Sudip Paul, Angana Saikia, Vinayak Majhi, Vinay Kumar Pandey, Introduction to Biomedical Instrumentation and Its Applications, Elsevier Science, 2022*	4. *Leslie Cromwell, Fred J Weibel, Erich A Pfeiffer, "Biomedical Instrumentation and measurements, "Pearson Education, PHI Learning private limited ,India 2nd edition,2007.* 5. *Sydney Lou Bonnik, Lori Ann Lewis,"Bone densitometry and Technologists,Sringer,3rd Edition,2015* 6. *Raymond Tong kai yu tong, "Wearable Technology in Medicine and Health Care", Elsevier,2016.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*-*	*20%*	*20%*	*-*
Level 2	*Understand*	*20%*	*-*	*-*	*-*	*20%*	*-*
Level 3	*Apply*	*30%*	*-*	*-*	*40%*	*20%*	*-*
Level 4	*Analyze*	*30%*	*-*	*-*	*-*	*20%*	*-*
Level 5	*Evaluate*	*-*	*-*	*-*	*40%*	*10%*	*-*
Level 6	*Create*	*-*	*-*	*-*	*-*	*10%*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. T. Anbu Selvan, Wipro GE Health care Pvt Ltd	1. *Dr. S. Poonguzhali, Professor, Anna University*	*1. Dr. P. Lakshmi Prabha, SRMIST*

Course Code	21BMC503J	Course Name	ADVANCED BIOMATERIALS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biomedical Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*attain the knowledge on basic properties of biomaterials*
CLR-2:	*study the phenomena of various materials for orthopedic applications.*
CLR-3:	*acquire new knowledge of biodegradable materials and its applications.*
CLR-4:	*familiarize with nanomaterial in medical implant application*
CLR-5:	*obtain the concept of different types of biomaterials applied in rapid prototype technology.*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*make a student understand the basic principles and properties of biomaterials*	*1*	*-*	*1*
CO-2:	*analyze various types of metals used in implant applications.*	*1*	*-*	*1*
CO-3:	*explain the process of the importance of ceramics and polymers used in biomedical diagnostics*	*1*	*-*	*-*
CO-4:	*encourage the students to perform nanomaterial-based project work*	*1*	*-*	*-*
CO-5:	*create problem-solving ability among students for design and developing strategies to build medical implant solutions*	*1*	*2*	*1*

Module-1 - Basic Biomaterials System ***12 Hour***

Introduction to biomaterial -Biocompatibility host response-cell materials interaction biocompatibility-invitro and in-vivo test- Steps for Characterization of biomaterials -Advanced ceramics materials – Hydroxy apatite Structure and Properties of Hydroxyapatite, HA, and Calcium - Deficient Apatite, CDA -Calcium phosphate biomaterial- yttria and zirconia-based biomaterials and its applications

Experiments: *Bacterial sample staining method.*

Specimen preparation for identification of metals/alloys hand polishing and acid etching

Preparation and measurement of simulated body fluid solution

Module-2 - Material for Orthopedic Application ***12 Hour***

Introduction about orthopedics- Structure and Properties of Hard Tissues- Processing and Properties of Bioceramics and Bioceramic Composites -Polymeric biomaterials and their types- Polymer composite-based materials and their properties. Issues Limiting Performance of Metallic Biomaterials-wear and corrosion-based materials -Titanium and cobalt-based materials- Other Non-Ferrous Metals and Their Alloys-Surface Coating on Metals and their Applications.

Experiments: *Study the corrosion test of coated and uncoated metals*

Determination of hardness of the materials

Physical Characterization of Coated/Uncoated Surfaces Contact Angle measurement polycaprolactone (PCL)

Module-3 - Biodegradable Materials ***12 Hour***

Bioceramics: New Developments, clinical applications, Requirements for Successful Implant Systems, Osseointegration and Bone/Implant Interface, Introduction and Application Areas of Degradable Implants Nanotechnology Biodegradable Polymer and its applications, Basic Properties, Production Technologies Development of Biodegradable Medical Implants Made of Iron-Based Materials, Biodegradable Metal Materials, Economic Impact of Biodegradable Metallic Implants

Experiments: *Preparation and measurement of artificial saliva solution* *Physical Characterization of Coated/Uncoated Surfaces Contact Angle Measurement Poly -hydroxybutyrate – co -hydroxy valerate (PHBV)* *Preparation of new nanocomposite (Polymer and Ceramics)*
Module-4 - Nanomaterials in Medical Implants ***12 Hour***
Injectable hydrogel as biomaterials- Hydrogels Formed by Fast Chemical Reaction/Physical Transitions-Nano materials for improved orthopedic and bone tissue engineering application- Nanostructured metal and polymer, Introduction to processing of Biomaterials for ceramics, Bio composites, and Processing for Scale- Properties and Behavior of Shape Memory- Medical device based on Bio-inspired Si-C Based Ceramics- Functionally graded all ceramics Hip implants- Methods of Nano fibrous Scaffold Synthesis ***Experiments:*** *Spray coating in nanoceramics composite materials* *Study Of the Operation of Electrospinning Machine* *Dip coating method in nanoceramics composite*
Module-5 – Rapid Prototyping in Biological Materials ***12Hour***
Material properties of structural biomaterials, Rapid prototyping, a novel manufacturing approach to structural implants, Rapid prototyping in mimicking structural intricacies of biological materials, Materials for 3D printing in medicine: metals, polymers, ceramics, hydrogels, Computational analyses and 3D printed models: a combined approach for patient-specific studies, 3D printed in vitro disease models. ***Experiments:*** *Study of The Operation Of 3D Printer in medical implant* *Mini project, Model lab*

Learning Resources	1. *Bikramjit Basu, Dhirendra Katti, and Ashok Kumar, "Advanced Biomaterials fundamental processing, and applications" A JOHN WILEY & SONS, INC., PUBLICATION, 2016* 2. *Rosario Pignatello "Advances in Biomaterials Science and Biomedical Applications" Intech 2018.*	3. *Dr. Deepak M. Kalaskar, 3D printing in Medicine, wood head publishing Elsevier 2017.* 4. *Sharma, C. P. (Ed.). (2019). Biointegration of medical implant materials. Woodhead Publishing.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*-*	*20%*	*20%*	*-*
Level 2	*Understand*	*20%*	*-*	*-*	*-*	*20%*	*-*
Level 3	*Apply*	*30%*	*-*	*-*	*40%*	*20%*	*-*
Level 4	*Analyze*	*30%*	*-*	*-*	*-*	*20%*	*-*
Level 5	*Evaluate*	*-*	*-*	*-*	*40%*	*10%*	*-*
Level 6	*Create*	*-*	*-*	*-*	*-*	*10%*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. T. Anbu Selvan, Wipro GE Health care Pvt Ltd	*1. Dr. S. Poonguzhali, Professor, Anna University*	*1. Dr.S.Gnanavel, SRMIST*

Course Code	21BMC504J	Course Name	BIOMEDICAL SIGNAL ANALYSIS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biomedical Engineering*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*explore the fundamentals characteristics of biomedical signals*
CLR-2:	*provide a deep knowledge about the cardiological signal processing and analysis*
CLR-3:	*impart knowledge about the neurological signal processing*
CLR-4:	*illustrate about adaptive filtering techniques for canceling noise and interference in the various bio-signal*
CLR-5:	*apply machine learning and pattern recognition for bio signals for various applications*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*describe the characteristics of biomedical signals*	*1*	*2*	*2*
CO-2:	*analyze the various algorithms in the ECG signal analysis*	*3*	*1*	*1*
CO-3:	*familiarize the signal processing techniques in the analysis of EEG Signals*	*2*	*1*	*3*
CO-4:	*apply the adaptive filtering techniques to remove the noise in the bio signals*	*1*	*1*	*2*
CO-5:	*implement the machine learning algorithms in bio signal classification*	*2*	*1*	*3*

Module-1 - Introduction to Bio signals ***15 Hour***

Fundamentals of signal processing, Bioelectric Signals, Action potential, Electrooculogram, Electroencephalogram, Evoked potential, Electrogastrogram, Electrocardiogram, Phonocardiogram, Electro Myogram, signal characteristics, Speech signals, Analysis and synthesis, Otoacoustic emission (OAE) signals, Vibromyogram, Bioacoustic signal characteristics, Mechanical signals, Objectives of biomedical signal analysis, Difficulties in biomedical signal analysis

Experiments:

- *Basic representation of biomedical signals*
- *Analysis of speech signals*
- *Correlation of Bioelectric signals*

Module-2 - Cardiac Signal Processing ***15 Hour***

ECG data acquisition, Lead system, Removal of Motion artifacts, Power line interference, ECG Parameters and their estimation, Waveform analysis, ECG QRS Complex detection, Template matching method, Differentiation techniques, Simple high speed QRS detection method, Estimation of R-R interval, Estimation of ST segment, ECG analysis based on wavelet detection method, ECG power spectrum, Arrhythmia analysis and its Identification criteria, Heart rate variability, HRV analysis

Experiments:

- *Analysis of ECG signal*
- *Analysis of Arrhythmia*
- *HRV analysis*

Module-3 - Neuro Signal Processing ***15 Hour***

EEG signal and its characteristics, Waveform pattern, Time domain analysis, Frequency domain analysis, Linear prediction theory, first order prediction, Second order prediction, Time series model, Autoregressive (AR)model, Moving average (MA) model, Autoregressive moving average (ARMA) model, Autoregressive moving average exogenous (ARMAX) model, Estimation of AR

parameters, Least square method, Estimation of MA parameters using autocorrelation method and Iterative method, Estimation of ARMA Parameters, Adaptive segmentation, Autocorrelation method, Seizure signal analysis and detection, Evoked potential, Event-Related Potentials (ERPs), deep nerve stimulation (DNS) ***Experiments:*** ● *Analysis of EEG signals* ● *Spectral analysis of EEG signals* ● *Detection of EEG Rhythms*
Module-4 - Adaptive Filters Applications in Bio signals ***15 Hour***
Adaptive filter Principles, Least mean square adaptive algorithm, Derivation ,Block diagram, Adaptive noise canceller with and without noise, Cancellation of 60Hz interference in ECG, Cancelling donor heart interference in Heart transplant ECG, Cancellation of ECG signals from electrical activity of chest muscles, Cancelling of maternal ECG from fetal ECG, Cancellation of high frequency noise in Electro surgery, Enhancement of electro gastric measurements by adaptive noise cancellation, removal of artifact in EEG using adaptive filter ***Experiments:*** ● *Design of adaptive filter* ● *Application of adaptive filter in bio signal analysis* ● *Mini project*
Module-5 – Application of Machine Learning and Pattern Recognition in Bio signal Analysis ***14 Hour***
Pattern classification, Supervised pattern classification, Unsupervised pattern classification, Cluster seeking methods, Classification of Normal Vs Ectopic beat using linear discriminant function, Bayes classifier, Classification of arrhythmia using SVM Algorithm ***Experiments:*** *Mini project using a machine learning algorithm for bio signal analysis application*

Learning Resources	1. *Rangaraj. M.Rangayyan, "Biomedical signal processing", Wiley-IEEE press, 2nd edition, 2015.* 2. *N.Vyas, " Biomedical Signal Processing" ,First edition, University Science Press, New Delhi 2011*	3. *Reddy D.C, "Biomedical signal processing: Principles and Techniques", Tata McGraw-Hill, New Delhi, 2nd edition, 2005*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 practice (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*-*	*20%*	*20%*	*-*
Level 2	*Understand*	*20%*	*-*	*-*	*-*	*20%*	*-*
Level 3	*Apply*	*30%*	*-*	*-*	*40%*	*20%*	*-*
Level 4	*Analyze*	*30%*	*-*	*-*	*-*	*20%*	*-*
Level 5	*Evaluate*	*-*	*-*	*-*	*40%*	*10%*	*-*
Level 6	*Create*	*-*	*-*	*-*	*-*	*10%*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. T. Anbu Selvan, Wipro GE Health care Pvt Ltd	*1. Dr. S. Poonguzhali, Professor, Anna University*	*1. Dr.Amrutha Veluppal, SRMIST*

Course Code	21BMC505J	Course Name	TECHNIQUES IN MEDICAL IMAGE ANALYSIS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biomedical Engineering*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*elaborate the basic image operations and image enhancement techniques.*
CLR-2:	*apply the various types of image segmentation algorithms in medical imaging*
CLR-3:	*illustrate the concepts of feature extraction, selection and classification algorithm*
CLR-4:	*analyze the various image registration algorithms and fusion methods*
CLR-5:	*describe the application of various advanced segmentation algorithm in medical imaging*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*describe the elements of visual perception and various image enhancement techniques*	*1*	*-*	*3*
CO-2:	*implement the image segmentation algorithms for various medical imaging*	*1*	*1*	*2*
CO-3:	*apply the feature extraction and selection techniques in medical images and perform classification*	*1*	*2*	*2*
CO-4:	*elucidate the image registration and fusion algorithms*	*1*	*2*	*2*
CO-5:	*differentiate and analyze the various advanced segmentation techniques applied in medical images*	*1*	*1*	*2*

Module-1 - Image Fundamentals and Enhancement Techniques ***12 Hour***

Components of Image Processing, Visual Perception and its elements, 2D Sampling theory, Reconstruction from its samples, Image Quantization, Neighborhood operations on the images, Geometric Transformations, Gray level transformation process, Histogram techniques, Image smoothening and Sharpening in spatial domain, Frequency domain

Experiments:

- *Fundamental operations on medical images*
- *Gray level transformation process in medical images*
- *Image smoothening using spatial filters and histogram processing*

Module-2 - Image Segmentation Techniques ***12 Hour***

Intensity based Segmentation, types of thresholding, Otsu and Multi level thresholding, Edge based segmentation method, Marr-Hildreth-canny edge detector, Region based segmentation, Basic active contour model, Level set method, Clustering based algorithm, k –means clustering, U-Net- based Segmentation.

Experiments:

- *Adaptive thresholding and edge detection technique*
- *Segmentation by clustering technique*
- *Segmentation by simple active contour model*

Module-3 - Feature extraction, selection and Classification ***12 Hour***

Statistical feature extraction, First order, Second order features, Gray level co-occurrence matrix (GLCM) method Introduction, Local binary pattern, Speeded up robust features (SURF), Scale invariant transform features (SIFT), Feature selection techniques, Image classification, CT and MRI image classification using Random forest classifier, SVM-K-nearest neighbor

Experiments:

- *Statistical feature extraction in X-ray images*

● *Feature selection algorithms* ● *Image classification using neural networks*
Module-4 - Image Registration and Image Fusion ***12 Hour***
Image Registration, Introduction, Dimensionality transformation, Surface based registration algorithm, Head and hat, Iterative closest point algorithm, Non-Rigid registration, B-Splines, Registration of MRI, CT, PET, CT images, Image Fusion, Pixel based Image fusion, Wavelet transform based image fusion ***Experiments***: ● *Medical Image Registration* ● *Fusion of CT and MRI images*
Module-5 – Applications of Medical Image Analysis ***12 Hour***
Medical Image Visualization, Diagnosis of diabetic retinopathy, Segmentation of blood vessels using matched filtering, Detection of micro aneurysms, Diagnosis of spinal deformity, Cervical Cell Image Analysis and Classification, Fat segmentation in MRI images, Deep learning algorithms in medical imaging. ***Experiments:*** ● *Mini Project*

Learning Resources	1. *Rafael C., Gonzalez and Richard E. Woods, "Digital Image Processing", Pearson Education Asia, Third Edition, 2007* 2. *Anil.k.Jain, "Fundamentals of Digital image processing", Prentice Hall of India, 2nd edition 1997.* 3. *Joseph V.Hajnal, Derek L.G.Hill, David J Hawkes, "Medical image registration", Biomedical Engineering series, CRC press,2001.*	4. *https://towardsdatascience.com/overview-of-feature-selection-methods-a2d115c7a8f7* 5. *Geoff Dougherty. Medical Image Processing, Techniques and applications Springer Nature, 2011*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 Practice (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*-*	*20%*	*20%*	*-*
Level 2	*Understand*	*20%*	*-*	*-*	*-*	*20%*	*-*
Level 3	*Apply*	*30%*	*-*	*-*	*40%*	*20%*	*-*
Level 4	*Analyze*	*30%*	*-*	*-*	*-*	*20%*	*-*
Level 5	*Evaluate*	*-*	*-*	*-*	*40%*	*10%*	*-*
Level 6	*Create*	*-*	*-*	*-*	*-*	*10%*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. T. Anbu Selvan, Wipro GE Health care Pvt Ltd*	1. *Dr. S. Poonguzhali, Professor, Anna University*	1. *Dr.U.Snekhalatha, SRMIST*

ACADEMIC CURRICULA

Biomedical Engineering

Professional Elective Courses

Regulations 2021

SRM INSTITUTE OF SCIENCE & TECHNOLOGY
(Deemed to be University u/s 3 of UGC Act, 1956)

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

Course Code	21BME601T	Course Name	ADVANCED MEDICAL IMAGING SYSTEMS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	1	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biomedical Engineering*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*gain knowledge about advances in Ultrasound imaging*
CLR-2:	*understand the working principle of CT and its types*
CLR-3:	*learn the concepts of MRI and its applications*
CLR-4:	*gain knowledge in microwave and infrared imaging*
CLR-5:	*perceive knowledge on ongoing research in Nuclear imaging*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*outline the advances in Ultrasound imaging*	3	3	1
CO-2:	*illustrate the working principle of CT*	2	2	1
CO-3:	*narrate the concepts of MRI*	3	2	1
CO-4:	*describe the functionality of microwave and infrared imaging*	2	2	2
CO-5:	*depict the ongoing research in Nuclear imaging*	1	2	3

Module-1 - Ultrasound Imaging	***9 Hour***
Ultrasound terminologies - Interaction of US with matter - Ultrasound transducer - Mode of display: A, B, M Mode - Doppler scan, Duplex scanner - Elastography: Introduction, basic principles, Instrumentation - Strain elastography, Shear wave elastography, Transient elastography - Applications of elastography - Intravascular imaging - Acoustic radiation force impulse imaging - 3D,4D Ultrasound imaging: techniques and applications	
Module-2 - Computed Tomography (CT)	***9 Hour***
CT System components, scanning system - Reconstruction techniques - 4 Π Interpolation, 180 ̊interpolation - Isotropic imaging, Phase selective imaging, Adaptive array detector - Matrix detector configuration - Mixed matrix detector design - CT artifact - Electron beam CT: Instrumentation - Helical CT: Instrumentation - Multi slice CT - Multi slice helical CT reconstruction - CT angiography, CT fluoroscopy	
Module-3 - Magnetic Resonance Imaging (MRI)	***9 Hour***
MRI: Physics - T1 relaxation, T2 relaxation, T2 relaxation - MRI Instrumentation – MRI sequences: Advanced spin echo (SE) sequences, Advanced gradient echo (GE) sequences, Advanced inversion recovery sequence, Advanced diffusion weighted sequence, Echo planar imaging (EPI), Diffusion tensor imaging (DTI), fMRI - State related fMRI, Event-related fMRI - Perfusion MRI - MR angiography (MRA) sequences - MR spectroscopy*	
Module-4 - Microwave and Infrared Imaging	***9 Hour***
Microwave imaging: Basic concepts, approaches - Transmitter configuration - Receiver configuration - Cell configuration - Microwave imaging apparatus - Microwave imaging applications - Medical Thermography: Introduction, physics - Physical factors which affect thermography - Thermographic equipment - Infrared detectors - Pyroelectric vidicon (PEV) tube - Thermal camera based on IR sensor - Clinical applications of thermography.	
Module-5 – Nuclear imaging and other Advanced Imaging Techniques	***9 Hour***

PET: Working principle – SPECT: Working principle – Gamma ray camera - PET-CT – PET-CT Applications - CT Fractional Flow Reserve - Optical Tomography: introduction, Interferometry principle - OCT setup - Time domain OCT, Fourier domain OCT - Clinical applications of OCT - Polarization based imaging: principle, Instrumentation - Photo acoustic imaging: principle, Instrumentation – Hyper-spectral imaging: principle, Instrumentation – Principle of Tetra hertz imaging

Learning Resources	1. *R.S.Khandpur., 'Handbook of Biomedical instrumentation', Tata McGraw Hill Publishing Co Ltd., 3rd edition, 2014.* 2. *Jerrold T. Bushberg, John M. Boone., "The essential physics of medical imaging", Lippincott Williams & Wilkins, 3rd edition, 2011.* 3. *William hendee R, Russell Ritenour E, "Medical imaging physics", Fourth Edition, 2002.* 4. *Ivan Nenadic, Matthew Urban, James Greenleaf, Jean-Luc Gennisson, Miguel Bernal, Mickael Tanter "Ultrasound Elastography for Biomedical Applications and Medicine", 1st Edition, 2018* 5. *M. A. Flower (Editor)., "Webb's Physics of medical imaging, Second Edition", CRC Press, Taylor & Francis Group, ISBN: 978-0-7503-0573-0, 2nd edition, 2016.*	6. *Nadine Barrie Smith, Andrew Webb, "Introduction to medical imaging: Physics, Engineering and clinical applications", Cambridge University Press, 1st edition, 2010.* 7. *K. Kirk Shung, Michael Smith, Benjamin M.W. Tsui., "Principles of medical imaging", Academic Press, 1st edition, 2012.* 8. *Natalia K. Nikolova, "Introduction to Medical Imaging", Cambridge University Press, 1st edition, 2017.* 9. *Matteo Pastorino, "Microwave Imaging", Wiley, 1st Edition, 2010.* 10. *Paul Suetens, "Fundamentals of Medical Imaging", 2017, 3rd Edition, Cambridge University Press, Cambridge.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*10%*	*-*	*10%*	*-*
Level 2	*Understand*	*20%*	*-*	*10%*	*-*	*10%*	*-*
Level 3	*Apply*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*10%*	*-*	*10%*	*-*
Level 6	*Create*	*-*	*-*	*10%*	*-*	*10%*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. T. Anbu Selvan, Wipro GE Health care Pvt Ltd	*1. Dr. S. Poonguzhali, Professor, Anna University*	1. *Dr.Nijisha Shajil,SRMIST*

Course Code	21BME602T	Course Name	BIOMECHANICS AND FINITE ELEMENT ANALYSIS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biomedical Engineering*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*study about the bone structure and functions of skeletal muscle*
CLR-2:	*comprehend the structure, movements, and loads applied on upper extremity*
CLR-3:	*explore about the lower extremity and biomechanical modeling*
CLR-4:	*understand the fundamentals of finite element methods*
CLR-5:	*implement the fundamental processing of fundamental analysis*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*discriminate between the function of muscle and bone*	2	-	-
CO-2:	*apply linear and angular kinetics and kinematics of human movement*	2	-	2
CO-3:	*understand the purpose, function, implication, and limitation of biomechanical modeling*	2	1	2
CO-4:	*summarize the Finite Element Method (FEM) and exemplify its application*	2	1	-
CO-5:	*identify the appropriate choice of element type for a given analysis.*	2	2	1

Module-1 - Introduction to Terminology in Biomechanics, Human Muscle and Bone Growth	***9 Hour***
Forms of motion – Standard reference terminology – Joint movement: Terminology – Qualitative analysis of human movement–Basic concepts related to kinetics – Mechanical loads on human body – Effects of loading – Tools for measuring kinetic and kinematic quantities – Composition and structure of bone tissue – Bone growth and development – Bone physiology; Material behavior of bone – Osteoporosis - Skeletal muscles in the body, the structure of muscles, hill force-velocity curve, the sliding filament model	
Module-2 - Linear and Angular Kinetics and Kinematics of Human Movement In Upper Extremity	***9 Hour***
Newton's Laws – Mechanical behavior of bodies in contact work – Power, and energy relationships – Resistance to angular acceleration – Linear kinematic quantities –Kinematics of projectile motion – Factors influencing projectile trajectory –Angular kinematic relationships – Relationships between linear and angular motion. Human Upper Extremity (Shoulder, Wrist, and Joints of hand): Structure and movements, loads on the region, and common injuries – modeling lower arm lifting a weight	
Module-3 - Biomechanics of Human Lower Extremity and Spine	***9 Hour***
Human Lower Extremity (Hip, Knee, and Ankle): Structure and movements, loads on the region, and common injuries; Spine: Structure, movements, muscles, and loads on the region – Common injuries of back and neck – Kinematics and musculature - mechanics of standing, walking, running, jumping and other types of motions	
Module-4 - Basics of Finite Element Methods	***9 Hour***
Need of Finite Element Methods (FEM) in solids and structures - basic concept of FEM, Steps in FEM - Concepts of compatibility and completeness - Finite elements of an elastic continuum-displacement approach, Generalization of the finite element concepts -weighted residual and variational approach –Element shapes, nodes, nodal unknowns and coordinate systems–shape functions–strain displacement matrix – Linear elements – quadratic elements–– rectangular elements – analysis of one-dimensional problem –linear triangular elements-isoparametric elements	
Module-5 – Application of Finite Elements Analysis in Biomechanics	***9 Hour***
Introduction to the use of FEM in steady state field problems-heat conduction, fluid flow and non-linear material problems. Computer procedures for Finite element analysis (tutorial), Stress-strain relationship- Discretization – modeling operations – solid modeling – Boolean operators – additional operations – viewing of model – meshing –solution and post processing (using FEA software like ANSYS)– case studies in biomechanics. Method of Establishing Lumbar Spine Model with Finite Element Technique	

Learning Resources	1. *Susan.J. Hall, "Basic biomechanics", Tata McGraw Hill, Sixth edition, 2011.* 2. *J. G Webster, "Medical instrumentation –Application & design", John Wiley and sons Inc. Fourth edition, 2010.* 3. *D. J. Schneck and J. D. Bronzino, "Biomechanics- Principles and Applications", CRC Press, Second Edition, 2000.* 4. *Duane Knudson, "Fundamentals of Biomechanics", Springer, Second Edition, 2007.* 5. *S.S. Bhavikati, "Finite element analysis", New Age International Ltd, First edition, 2005*	6. *Tirupathi R. Chandrupatla, Ashok D. Belegundu, "Introduction to finite elements in Engineering", Pearson education, First edition, 2011* 7. *Saeed moaveni, "Finite element analysis theory and application with ANSYS", Prentice Hall, Third edition, 2007.* 8. *R. D. Cook, D. Malkus, M. E. Plesha, and R. J. Witt, Concepts and Applications of Finite Element Analysis, Wiley India, Fourth Edition, 2003.* 9. *Irving P. Herman, Physics of the Human Body, Springer, New York, NY, November 2006*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*10%*	*-*	*10%*	*-*
Level 2	*Understand*	*20%*	*-*	*10%*	*-*	*10%*	*-*
Level 3	*Apply*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*10%*	*-*	*10%*	*-*
Level 6	*Create*	*-*	*-*	*10%*	*-*	*10%*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. T. Anbu Selvan, Wipro GE Health care Pvt Ltd	1. *Dr. S. Poonguzhali, Professor, Anna University*	1. *Dr.A.Bhargavi Haripriya, SRMIST*

Course Code	21BME603T	Course Name	BIOMEDICAL OPTICS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biomedical Engineering*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the concept of light matter interaction*
CLR-2:	*learn the basics of laser physics*
CLR-3:	*acquire knowledge about light tissue interaction mechanism*
CLR-4:	*know about the therapeutic applications of light*
CLR-5:	*learn the concepts of microscopic and diagnostics imaging techniques*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*explain about different types of light matter interaction*	3	2	1
CO-2:	*describe the physics of laser*	3	2	1
CO-3:	*illustrate about light–tissue interaction mechanisms and applications*	1	1	3
CO-4:	*summarize about the therapeutic applications of light*	3	2	1
CO-5:	*apply the microscopic imaging concepts in disease diagnosis*	2	1	3

Module-1 - Laser Tissue Interaction	***9 Hour***
General behaviour of light in biological tissue, Light and Matter – Reflection and Refraction, Absorption and Scattering, Basic physics of light-matter interaction, Absorption and its biological origins, Scattering and its biological Origins, Polarization and its biological origins, Fluroscence and its biological origins, Multiphoton fluorescence microscopy for deep tissue imaging-overview	
Module-2 - Laser Properties	***9 Hour***
Laser Principles-Materials- Pump sources- Resonators-Laser Variables- Laser Power, Light Delivery Protocol- Power Density Profile of the Beam, Gaussian-Beam Profile, Top-Hat Beam Profile- Irradiation Spot Size, Power Density and Energy Density of a Light Source Local Beam Angle of Incidence with the Tissue, Collimated or Diffuse Irradiation, Light Wavelength, Repetition Rate, Pulse Length, Light Delivery Pulse Modulation, Tissue Variables, Optical Properties of the Tissue, Surface Contour, Tissue Temperature	
Module-3 - Photochemical and Photobiological Applications in Medicine	***9 Hour***
Photochemical Principles, Light-Reactive Biological Chromophores, Photochemical Effects, Photodynamic Therapy, The Photosensitizer Excitation Process, The Role of Oxygen, Delivery, Photosensitizers, Dosimetry, Clinical Applications, Light Sources, Advantages and disadvantages of PDT, Photobiological Biostimulation, Photobiological Effects, Photothermal Medical Applications of the Photothermal Effect Photobiological Nonthermal Interaction	
Module-4 - Laser Applications in Medicine	***9 Hour***
Photophysical, Delivery Considerations, Laser Use in Cardiology, Dentistry and Oral Surgery, Ophthalmology, Oncology, Cardiovascular Surgery, Dermatology, General Surgery, Gastroenterology, Gynecology-Neurosurgery, Otorhinolaryngology, Urology	
Module-5 – Optical Imaging and Diagnostic Techniques	***9 Hour***
Photophysical, Optical Microscopy, Confocal Microscopy, Multiphoton Imaging, Transillumination Imaging, Optical Coherence Tomography, Doppler OCT, Optical Coherence Tomography in Dentistry, overview of 3D Visualization of blood vessels using OCT, Photoacoustic Imaging-Photobiological, Immunostaining, Immunofluorescence, NIR Spectroscopy, Diagnostic Applications of Spectroscopy, Fiberoptic Sensors, Optical Biopsy, Determination of Blood Oxygenation	

Learning Resources	1. *Lihong V. Wang, Hsin-i Wu, "Biomedical Optics Principles and Imaging", Wiley–Interscience, 2007.* 2. *Markolf H.Niemz, "Laser Tissue Interaction Fundamentals and Application" Third Edition, 2007Leon Goldman, M.D., & R.James Rockwell, Jr., Lasers in Medicine, Gordon and Breach Science Publishers Inc., 1975.*	3. *Tuan Vo Dirh, Biomedical Photonics – Handbook, CRC Press, Bocaraton, 2003.* 4. *Paras N, Prasad, "Introduction to Biophotonics", John Wiley & Sons,First Edition, 2003.* 5. *Gerhard K. Ackermann, Jürgen Eichler, "Holography: A Practical Approach", WILEY-VCH Verlag GmbH & Co, first edition, 2008.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*10%*	*-*	*10%*	*-*
Level 2	*Understand*	*20%*	*-*	*10%*	*-*	*10%*	*-*
Level 3	*Apply*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*10%*	*-*	*10%*	*-*
Level 6	*Create*	*-*	*-*	*10%*	*-*	*10%*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. T. Anbu Selvan, Wipro GE Health care Pvt Ltd	*1. Dr. S. Poonguzhali, Professor, Anna University*	*1.Dr.T. Jayanthi, SRMIST*

Course Code	21BME604T	Course Name	TROUBLESHOOTING AND REGULATORY AFFAIRS IN MEDICINE	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biomedical Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*compile the concepts of troubleshooting procedures*
CLR-2:	*summarise the troubleshooting of different passive components*
CLR-3:	*describe the troubleshooting techniques of different semiconductor devices*
CLR-4:	*assess the techniques for troubleshooting different biomedical equipments*
CLR-5:	*recognize the regulatory aspects for different medical devices*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*describe the troubleshooting process of an equipment in detail*	1	-	2
CO-2:	*explain the troubleshooting of different passive components*	1	-	-
CO-3:	*summarize the troubleshooting techniques of different semiconductor devices*	1	-	-
CO-4:	*elaborate the techniques for troubleshooting different biomedical equipment*	1	-	-
CO-5:	*write the regulatory aspects of different medical devices*	1	-	2

Module-1 - Fundamental of Troubleshooting Procedures	***9 Hour***
Construction of electronic equipment – Components – Equipment failure – Causes of equipment failure – Troubleshooting process – Fault finding – Fault finding Aids – Troubleshooting techniques – Grounding systems in electronic equipment - Methods of Grounding – Temperature Sensitive Intermittent Problems – Corrective Measures – Preventive maintenance – Tools & aids for servicing & maintenance – Systematic troubleshooting checks – Situations when repairs should not be attempted	
Module-2 - Troubleshooting of Passive Components	***9 Hour***
Hand tools for troubleshooting and servicing - Soft tools for troubleshooting and servicing – Different types of resistors – Features and applications - Failures in fixed resistors - Troubleshooting of fixed resistors - Tips for troubleshooting – Different types of inductors – Tips for troubleshooting – Different types of capacitors – Failures in capacitors - Tips for troubleshooting – Resonant circuits – Tips for troubleshooting	
Module-3 - Troubleshooting of Semiconductor Devices	***9 Hour***
NPN – BJT – Troubleshooting techniques – PNP – BJT – Troubleshooting techniques – JFET – Troubleshooting techniques – MOSFET – Troubleshooting techniques – Insulated Gate Bipolar Transistor (IGBT) – Troubleshooting techniques - SCR – Troubleshooting techniques – TRIAC – Troubleshooting techniques – TRIAC – Troubleshooting techniques – OPAMP – Troubleshooting techniques - Removing ICS from the Circuit Board - Mounting IC in the Circuit Board	
Module-4 - Troubleshooting of Biomedical Equipment	***9 Hour***
Causes for failure in ECG machine – Troubleshooting techniques – Causes for failure in EEG machine – Troubleshooting techniques - Causes for failure in Ultrasound Machine – Troubleshooting techniques Troubleshooting techniques - Anesthesia machine – Troubleshooting techniques - Autoclaves and sterilizers – Troubleshooting techniques - Endoscopes – Troubleshooting techniques - X-ray machine – Troubleshooting techniques – CT machine – Troubleshooting techniques - MRI machine - Troubleshooting techniques – Safety work with high voltage equipment - Common troubleshooting techniques of high voltage equipment	
Module-5 – Regulatory Bodies for Medical Devices	***9 Hour***

Introduction - Regulatory agencies - Voluntary and mandatory standards – Global regulatory agencies – FDA – Regulatory aspects for medical devices – OSHA – Regulatory aspects for medical devices – Indian regulatory bodies – CDSCO – Indian medical devices registration and approval - Maintenance Management of medical devices - Essentials of a Good Equipment Management Program

Learning Resources	1. *Edition John J. Tobin, Gary Walsh, Medical Product Regulatory Affairs: Pharmaceuticals, Diagnostics, Medical Devices, 2nd Edition, Wiley-Blackwell, 2023* 2. *Jack Wong, Raymond Tong, Medical Regulatory Affairs: An International Handbook for Medical Devices and Healthcare Products, 3rd Edition, Jenny Stanford Publishing, 2022* 3. *Jonathan S. Kahan, Rachel Meyers, "Medical Device Development: Regulation and Law", 2nd Edition, Parexel, 2009* 4. *Theodore R. Kucklick, "The Medical Device R&D Handbook", Second Edition, Taylor & Francis, 2006*	5. *John J. Tobin, Gary Walsh, "Medical Product Regulatory Affairs: Pharmaceuticals, Diagnostics, Medical Devices", Wiley – Blackwell, First edition,20086.* 6. *Carl T. Demarco, "Medical Device Design and Regulation", ASQ Quality Press, First edition ,2011* 7. *World health organization -Geneva ǁ Medical Device Regulations –Global Overview and Guiding Principlesǁ, First edition,2003*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*10%*	-	*10%*	-
Level 2	*Understand*	*20%*	-	*10%*	-	*10%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	*10%*	-
Level 6	*Create*	-	-	*10%*	-	*10%*	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. T. Anbu Selvan, Wipro GE Health care Pvt Ltd*	1. *Dr. S. Poonguzhali, Professor, Anna University*	1. *Dr.P.Muthu, SRMIST*

Course Code	21BME605T	Course Name	BIOMEDICAL SENSORS AND APPLICATIONS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biomedical Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*learn the basic concepts of sensing technologies*
CLR-2:	*study the operating principle of transducers for measurement of physical quantities*
CLR-3:	*understand the fundamentals of biosensors*
CLR-4:	*know the materials used for biosensor fabrication*
CLR-5:	*learn the concepts of smart sensors*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*explain the characteristics of transducers*	2	3	2
CO-2:	*develop measurement systems to quantify physical quantities*	3	2	3
CO-3:	*explain the principles of biosensors*	2	2	2
CO-4:	*identify appropriate materials for biosensor fabrication*	2	2	2
CO-5:	*apply modern sensing technologies*	2	3	3

Module-1 - Transducer Characteristics	***9 Hour***
Transducer: Introduction, Definition, Classification, Characteristics, Selection criteria, Static characteristics, Dynamic characteristics, Standards, Measurement errors: Sources, types and ways of minimizing errors, Calibration- Needs and methodologies, Calibration methods for blood pressure monitors	
Module-2 - Transducers for Measurement of Physical Quantities	***9 Hour***
Strain gauge: Principle of operation, Classification, Gauge factor, Derivation, Strain gauge in respiratory measurements, capacitive transducers for measurement of physical quantities, Load cell: Construction and operation, LVDT: Construction and operation: Piezoelectric sensor: Construction and operation, Piezoelectric and photoelectric sensor for cardiac measurements, Flex Sensors: Construction and operation, Hall effect transducer: Principles, Construction and operation, Applications	
Module-3 - Principles of Biosensors	***9 Hour***
Introduction; General configuration of biosensor; Generations of biosensors; Basic principle and instrumentation of different biosensors: electrochemical, optical, acoustic, piezoelectric, and calorimetric biosensors; Biological recognition systems: enzyme, antibody, nucleic acid, cell, and tissue; Properties of ideal materials for biosensors, Applications of Biosensors in physiological monitoring.	
Module-4 - Materials for Fabrication of Biosensors	***9 Hour***
Classes of materials for biosensors: polymers, material containing metal complex, sol-gel materials, nanomaterials, composite materials, metal oxides, photonic crystals, and zeolite materials	
Module-5 – Advances in Sensing Technologies	***9 Hour***
Smart Sensors: Introduction, Need, Architecture, Salient features, Introduction to micro/nano fluidics, basic components of lab-on-a-chips and its integration, e-Nose, System Description, OFC- Introduction ,Total internal reflection, Concepts of SPR, SPR Sensors, Concept of Evanescence, Evanescence Sensor, Grating, Grating Sensors- Principles, Grating Sensors- Applications, Grating Sensors- Applications	

Learning Resources	1. *Sawhney A.K, "A Course in electrical and electronic measurements and instrumentation", Dhanpat Rai & Co (P) Ltd, Educational and Technical Publishers, 19th Revised edition 2011, Reprint 2014.* 2. *Patranabis D, "Sensors and transducers", PHI, 2nd edition, 2004* 3. *Biosensors and modern bio-specific analytical techniques, L. Gorton (ed) Volume XLIV Elsevier 2005.* 4. *Advances in biosensors, B. D. Malhotra & A. P. F. Turner (eds), Volume 5, Elsevier science 2003.*	5. *Murty DVS, "Transducer and instrumentation", PHI, 2nd edition, 2010.* 6. *U.A. Bakshi, A.V. Bakshi, "Measurements and instrumentation", Technical Publications, 3rd revised edition, 2010.* 7. *Paras N, Prasad, "Introduction to biophotonics", John Wiley & Sons, 1st edition, 2003*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*10%*	*-*	*10%*	*-*
Level 2	*Understand*	*20%*	*-*	*10%*	*-*	*10%*	*-*
Level 3	*Apply*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*10%*	*-*	*10%*	*-*
Level 6	*Create*	*-*	*-*	*10%*	*-*	*10%*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. T. Anbu Selvan, Wipro GE Health care Pvt Ltd	*1. Dr. S. Poonguzhali, Professor, Anna University*	*1. Dr. D. Kathirvelu, SRMIST*

Course Code	21BME606T	Course Name	KINESIOLOGY AND ERGONOMICS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biomedical Engineering*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the concepts of kinesiology and its applications*
CLR-2:	*express the basic analysis of forces in upper and lower extremity*
CLR-3:	*analyze the characteristics of different posture and gait*
CLR-4:	*develop the comfortable working environment through physical ergonomics*
CLR-5:	*understand the behavior of humans as they interact with machines through cognitive ergonomics*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*develop the concepts of the kinesiology in different applications*	1	-	1
CO-2:	*describe the concepts of kinesiology in upper and lower extremity*	2	-	1
CO-3:	*assess the impact of posture and gait*	2	2	2
CO-4:	*improve efficiency and to reduce the risk of discomfort through physical ergonomics*	2	2	2
CO-5:	*explore to implement cognitive ergonomics intervention on working conditions*	2	1	1

Module-1 - Overview of Kinesiology	***9 Hour***
Introduction to kinesiology- Anatomical Position-Principles of Plane and Axis-Various types of movements- Joint flexibility-Technique to increase the flexibilities-Mechanical characteristics of muscle-Muscle actions- Need for biomechanics to understand muscle Actions-Sports medicine and rehabilitation applications.	
Module-2 - Kinesiology of Upper and Lower Extremity	***9 Hour***
Analysis of the forces on the shoulder complex during activity-Forces on the elbow during upper extremity weight bearing-Analysis of the forces on the hip during activity- Analysis of forces under dynamic conditions- Analysis of the forces on the knee during activity-Forces and moments on the structures of the knee joint during activity.	
Module-3 - Posture and GAIT	***9 Hour***
Postural stability and postural adaptation-Behavioural aspects of posture-Posture and job relation-Posture and body supportive devices-Characteristics of Ideal posture and postural abnormalities - Characteristics of Normal Gait-Factors influencing Gait - The Gait cycle- Kinematics of locomotion - Muscle activity during locomotion - Kinetics of locomotion - Factors that influence parameters of gait.	
Module-4 - Physical Ergonomics	***9 Hour***
Introduction to ergonomics- Muscular effort-• Energy expenditure- Introduction to Human centered design- Anthropometric design principles - Description of various dimensions of body- Applied problems on physical ergonomics.	
Module-5 – Cognitive Ergonomics	***9 Hour***
Introduction to cognitive ergonomics -Human information processing model-Perception and attention resources-Memory-Response selection and execution-Design Guidelines for cognitive work-Problems on cognitive and physical environment-Tools and Techniques used for ergonomics analysis.	

Learning Resources	1. *Carol A. Oatis, "Kinesiology the Mechanics and Pathomechanics of Human Movement., Lippincott Williams & Wilkins, a Wolters Kluwer business, 2nd edition, 2009.* 2. *Gavriel Salvendy., "Handbook of Human factors and Ergonomics", john wiley & sons., 4th edition, 2012.* 3. *Joseph Hamill & Kathleen M. Knutzen, "Biomechanical Basis of Human Movement", Lippincott Williams & Wilkins, a Wolters Kluwer business, 3rd edition, 2009.*	4. *Duane Knudson, Fundamentals of Biomechanics, 2nd edition, Springer, 2007.* 5. *Robert Bridger, "Introduction to Ergonomics", CRC press, 3rd edition, 2008.* 6. *Dul, J. and Weerdmeester, B.Ergonomics for beginners, a quick reference guide, Taylor& Francis, 1993.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*10%*	*-*	*10%*	*-*
Level 2	*Understand*	*20%*	*-*	*10%*	*-*	*10%*	*-*
Level 3	*Apply*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*10%*	*-*	*10%*	*-*
Level 6	*Create*	*-*	*-*	*10%*	*-*	*10%*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. T. Anbu Selvan, Wipro GE Health care Pvt Ltd*	1. *Dr. S. Poonguzhali, Professor, Anna University*	*1.Dr.D.Ashokkumar, SRMIST*

Course Code	21BME607T	Course Name	TISSUE ENGINEERING AND REGENERATIVE MEDICINE	Course Category	E	PROFESSIONAL ELECTIVES	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biomedical Engineering*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*learn the fundamentals of tissue engineering principles.*
CLR-2:	*study the different concepts of tissue engineering*
CLR-3:	*acquire advancement of tissue engineering*
CLR-4:	*familiarize with basic biological systems in the human system*
CLR-5:	*gain knowledge about human organ system*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*describe the basic utility and potential of tissue engineering principles.*	1	1	1
CO-2:	*analysis problem-solving ability among students for developing strategies to build tissue engineering solutions.*	1	2	-
CO-3:	*design and fabrications of tissue engineering products*	1	1	-
CO-4:	*explain the human body and organ system*	1	-	-
CO-5:	*explain the human organ and regenerative therapy*	1	-	1

Module-1 - Basics Concepts of Tissue Engineering	***9 Hour***
Introduction to Tissue engineering - Cell source - Types of cell Sources - Three-dimensional interactions - Cells as Therapeutic Agents with examples, Cell numbers and growth rates - Tissue organization - Tissue Components - Tissue types, Functional subunits - Tissue Dynamics, Dynamic states of tissues - Homeostasis in highly prolific tissues and Tissue repair. Angiogenesis - Measurement of cell characteristics - cell morphology - Cell number and viability - Cell-fate processes, cell motility - Cell function - Cell-extracellular matrix interactions - Binding to the ECM, Modifying the ECM - Malfunctions in ECM signaling - Direct Cell-Cell contact - Cell junctions in tissues, malfunctions in direct cell-cell contact Signaling.	
Module-2 - Types and Application of Tissue Engineering	***9 Hour***
Scaffolds for tissue engineering - Classes of potential scaffold materials - The criteria for an ideal scaffold - Polymer scaffolds - Polymer scaffolds applications – Electro spinning method -Bioactive ceramic scaffolds - Bioactive ceramic scaffolds and its applications - Substrate Scaffold Materials - Nano composites - Control of architecture - sterilization of scaffolds - Sterilization methods - Cell culture protocols - Basic techniques for assessment of cell viability.	
Module-3 - Recent Advancement of Tissue Engineering	***9 Hour***
Immunochemical techniques in tissue engineering and biomaterial science - Basic immunological principles - Common immunochemical techniques used in biomaterials - Immunochemical applications in biomaterial science and tissue engineering research - Clinical applications of tissue engineering - Cell source, Stable 3D constructs – Cartilage - Tendons, ligaments and bone - Regeneration in the cardiovascular system - Bioprinting techniques-3D printing techniques in cardiac stent	
Module-4 - Ectoderm-Derived Organs	***9 Hour***
Regeneration of hair and nail; regeneration of corneal epithelium and lens of eye; injury-induced regeneration in cornea and regulation by epithelial-stromal interaction; auditory sensory cells and hair cells regeneration by niche signals; structure of the nervous system; axon regeneration in the central nervous system and injured spinal cord and neural retina; regeneration of the optic nerve.	
Module-5 – Endoderm-Derived Organs	***9 Hour***

Intestinal epithelium, structure; stem cells in regeneration; transit amplifying cells, liver structure and function; primary and secondary regeneration by compensatory hyperplasia and stem cells, respectively, pancreas-structure and function; regeneration of B- cells from patients pancreas, stem cells, and non-B-cells. Lung: cells involved in the regeneration of respiratory epithelium, niche signals.

Learning Resources	1. *Larry L. Hench and Julian R. Jones, Biomaterials, artificial organs and tissue engineering, CRC Press 2010* 2. *Sujata V. Bhat "Biomaterials" Springer 2002* 3. *Clemens van Blitterswijk (2008), Tissue Engineering, Academic Press*	4. *Regenerative Biology and Medicine Edited by Jose A. Andrades, ISBN 978-953-51-1108-5, 866 pages,* 5. *Publisher: InTech, Chapters published May 22, 2013*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*10%*	*-*	*10%*	*-*
Level 2	*Understand*	*20%*	*-*	*10%*	*-*	*10%*	*-*
Level 3	*Apply*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*10%*	*-*	*10%*	*-*
Level 6	*Create*	*-*	*-*	*10%*	*-*	*10%*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. T. Anbu Selvan, Wipro GE Health care Pvt Ltd	*1. Dr. S. Poonguzhali, Professor, Anna University*	*1., Dr S. Gnanavel, SRMIST*

Course Code	21BME608T	Course Name	REHABILITATION ENGINEERING AND ASSISTIVE TECHNOLOGY	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biomedical Engineering*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*define the basic concepts of rehabilitation engineering*
CLR-2:	*learn about the manual and powered wheelchairs*
CLR-3:	*understand the working of orthotics and prosthetics*
CLR-4:	*explore the various tools used in visual and hearing impairments.*
CLR-5:	*describe the different use of augmentative and alternative communication tools*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*utilize the design process of rehabilitation engineering*	2	-	-
CO-2:	*differentiate the types and technologies with wheelchairs*	2	1	1
CO-3:	*design the basic orthotics and prosthetics*	2	2	3
CO-4:	*evaluate the assistive technology tools and its usage in visual and hearing impairments.*	2	1	1
CO-5:	*analyze the usage of augmentative and alternative communication tools*	2	2	2

Module-1 - Fundamentals of Rehabilitation Engineering	***9 Hour***
Introduction-Participatory Action Design-Policy, Human, Activity, Assistance, Technology, and Environment (PHAATE) model-Service Delivery Models-Service Delivery Process-Universal Design-Seven Principles of Universal Design-Benefits of Universal Design-Barriers to Implementing Universal Design-Use of a Design Process-Iterative design and User-Centered Design -Standards Related to Universal Design-Examples of Universally Designed Products.	
Module-2 - Wheelchair and its Components	***9 Hour***
Manual Wheelchairs-Manual Wheelchair User Profiles-Basic Structural Components-Wheelchair Propulsion-Electric Power Wheelchairs-Electric Power Wheelchair User Profiles-Basic Structural Components-Power and Drive Systems-Control System-Power-Assisted Wheelchairs-Multifunctional Wheelchairs-Wheelchair Standards-Fatigue-Strength Tests-Static-Strength Tests- Challenges and realities associated with using a wheeled mobility device-Case studies	
Module-3 - Orthotics and Prosthetics	***9 Hour***
Anatomy of upper & lower extremities-Classification of amputation types-Prosthesis prescription-Hand and arm replacement-Different types of models-externally powered limb prosthesis-Foot orthosis-Pediatric orthosis-Wrist-hand orthosis-feedback in orthotic system- Spinal orthotics- Lower extremity- and upper extremity- orthosis-Components of upper limb prosthesis-Components of lower limb prosthesis- Pre and post-surgery rehabilitation - Functional electrical stimulation-Advanced innovative technologies in orthotics and prosthetics.	
Module-4 - Assistive Technology for Visual and Hearing Impairment	***9 Hour***
Hearing functional assessment-Surgical and non-surgical hearing aids-Devices to improve hearing-Implants-Anatomy of eye-Image formations in eye-Categories of visual impairment-Artificial vision implants-Cortical and retinal implants-Low and High technology to improve mobility-Electronic Travel Aids(ETA) - AT for dual sensory impairments-AT for leisure and recreation-Activities of daily living (ADL)-Daily living aids-AT in Home- Alternative devices for safety-Orientation & navigation Aids-Alert systems- models of assessment for assistive technology- Issues in decision-making: selecting appropriate assistive technology tools-Case studies	
Module-5 – Augmentative and Alternative Communication	***9 Hour***

Augmentative and alternative communication (AAC) and Assistive technology (AT) software- Universal principles in AAC and AT-Evidence based practice in AT-Human factors in evaluation of AT – Environmental and social factors- Psychological factors influencing the use of technology, Sensory and Motor factors-Low and high technology assistive devices- Integrating Augmentative communication in the classroom, home, and community-Issues and considerations for low and high tech tools.

Learning Resources	1. *Rory A Cooper, Hisaichi Ohnabe, Douglas A. Hobson, "An Introduction to Rehabilitation Engineering", 1st edition, CRC Press, 2006* 2. *Horia-Nicolai.L.Teodorescu, Lakhmi C. Jain, "Intelligent Systems and Technologies in Rehabilitation Engineering", 1st edition, CRC press, 2010.* 3. *Rory.A.Cooper, "Rehabilitation Engineering Applied to Mobility and Manipulation", 1st edition, CRC Press, 2010*	4. *Albert M. Cook, Janice M. Polgar, "Assistive Technologies: Principles and Practice", 4th edition, Elsevier, 2015* 5. *Oliver Wendt, Raymond W Quist, Lyle L Lloyd, "Assistive Technology: Principles and Applications for Communication Disorders and Special Education", Emerald group publishing Ltd, 1st Edition, 2011.* 6. *Marion A Hersh, Michael A, Johnson, "Assistive Technology for Visually impaired and blind people", Springer 1stEdition, 2008*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*10%*	*-*	*10%*	*-*
Level 2	*Understand*	*20%*	*-*	*10%*	*-*	*10%*	*-*
Level 3	*Apply*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*10%*	*-*	*10%*	*-*
Level 6	*Create*	*-*	*-*	*10%*	*-*	*10%*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. T. Anbu Selvan, Wipro GE Health care Pvt Ltd	*1. Dr. S. Poonguzhali, Professor, Anna University*	1. *Dr.D.Ashokkumar,,SRMIST*

Course Code	21BME609T	Course Name	ARTIFICIAL NEURAL NETWORKS AND GENETIC ALGORITHMS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biomedical Engineering*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*demonstrate the basic Artificial Neural Network models*
CLR-2:	*apply the radial basis function and support vector machine in biomedical applications*
CLR-3:	*illustrate the concepts of neural network based on competitive networks*
CLR-4:	*analyze and compare the genetic algorithm with other optimization techniques*
CLR-5:	*describe the biomedical applications of genetic algorithms*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*describe the concepts of Artificial neural network models and its architectures*	*1*	*-*	*2*
CO-2:	*elucidate about radial basis function network and support vector machine*	*1*	*1*	*2*
CO-3:	*apply the concepts of neural network based on competition*	*1*	*2*	*1*
CO-4:	*analyze the genetic algorithm and its applications*	*1*	*1*	*2*
CO-5:	*explore the various genetic algorithm operators and its applications.*	*1*	*-*	*1*

Module-1 - Artificial Neural Network Model	***9 Hour***
Models of a Neuron - Network architectures: Single layer, Multilayer- Network architectures: Recurrent, Non-Recurrent- Perceptron: Architecture- Algorithm- Perceptron convergence theorem- Back propagation network- Architecture- Algorithm- Application- Hopfield network: Architecture, Hopfield -travelling salesman problem-Tutorials	
Module-2 - Radial Basis Function Networks and Support Vector Machine	***9 Hour***
Radial Basis function (RBF) -learning in RBF - Applications- K- Means clustering- Recursive least square Estimation of the weight vector- Hybrid learning procedure for RBF networks- Boltzman machine- Learning algorithm- Applications- Support Vector Machine- optimal hyperplane for linearly separable and Non-Separable pattern-Applications-Tutorials	
Module-3 - Neural Network Based on Competition	***9 Hour***
Kohonen Self organizing Map (SOM): Architecture- Algorithm- Learning vector Quantization (LVQ): Architecture- Algorithm- Max net: Architecture- Mexican Hat: Architecture- Training algorithm- Hamming net: Architecture- Application procedure- Adaptive Resonance Theory (ART) Fundamentals- architecture - Learning in ART- Tutorials	
Module-4 - Introduction to Genetic Algorithm	***9 Hour***
Evolution and Genetic Algorithm-Gradient based local optimization method- Random search- Stochastic Hill climbing- Simulated annealing- Simple genetic algorithm- Comparison of Genetic algorithm with other optimization techniques-Genetic algorithm at work simulation by hand- Application of Genetic algorithm	
Module-5 – GA Operators and Biomedical Applications	***9 Hour***
Genetic operators-Reproduction- Crossover- Mutation, Replacement- Fitness form- Scaling-Population- Data structure- Encoding: Binary, Octal- Hexadecimal- ECG signal classification using neural network- Breast cancer detection	

Learning Resources	1. *Laurene Fausett, "Fundamentals of Neural Networks: Architectures, Algorithms, and Applications", Pearson Education India, 3rd edition, 2008* 2. *James A Freeman and David M.Skapra, "Neural Network", Addison – Wesley, India, Third edition, 2008* 3. *Simon Haykin, "Neural network and learning Machines", Pearson, Third edition, 2019.*	4. *David Goldberg, Genetic Algorithms in Search, Optimization and Machine Learning", Pearson Education, Fourth edition, 2009.* 5. *Melanie Mitchell, An Introduction to Genetic Algorithms" Prentice Hall of India, New Delhi, First edition, 1998*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*10%*	*-*	*10%*	*-*
Level 2	*Understand*	*20%*	*-*	*10%*	*-*	*10%*	*-*
Level 3	*Apply*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*10%*	*-*	*10%*	*-*
Level 6	*Create*	*-*	*-*	*10%*	*-*	*10%*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. T. Anbu Selvan, Wipro GE Health care Pvt Ltd	*1. Dr. S. Poonguzhali, Professor, Anna University*	*Dr.U.Snekhalatha, SRMIST*

Course Code	21BME610T	Course Name	NEUROENGINEERING	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biomedical Engineering*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*elucidate the basic function of neurons and the nervous system*
CLR-2:	*describe the process of neurotransmission and various types of neurotransmitters*
CLR-3:	*illustrate the functioning of different neuro-prosthetic devices*
CLR-4:	*elaborate the concepts of different neural imaging techniques*
CLR-5:	*explore the future trends in neural engineering*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*recall the basic functions of neurons and the nervous system*	*3*	*3*	*1*
CO-2:	*summarize the process of neurotransmission and various types of neurotransmitters*	*3*	*2*	*1*
CO-3:	*describe the working of different neuro-prosthetic devices*	*2*	*3*	*1*
CO-4:	*illustrate the concepts of different neural imaging techniques*	*2*	*2*	*2*
CO-5:	*familiarize the future trends in neural engineering*	*2*	*3*	*3*

Module-1 - Introduction to Neurons and Nervous Systems	***9 Hour***
Introduction to Neural Engineering and Design - Structure and function of neurons – Membrane Potential and the Passive Electrical Properties of the Neuron - Action Potential - Synaptic Transmission- Structural connectivity in the brain - Sensory Coding - Visual processing - Auditory processing - Motor cortex - Somatosensory cortex – Limbic system - Learning and Memory - Decision-Making and Consciousness	
Module-2 - Neuro-Transmitters and Neuro-Transmission	***9 Hour***
Neurotransmission - Stages in neurotransmission - Synaptic transmission - Chemical and electrical synaptic transmission - Neurotransmitters and their release - Types of neurotransmitters - Fast and slow neurotransmission –Disorders Associated with defects in Neurotransmission - Brain plasticity and neurorehabilitation	
Module-3 - Neuro-Prosthetics	***9 Hour***
Sensory prosthetics - Visual prosthetics - Retinal prosthetic – Auditory prosthetics - Auditory brain stem implant - Bladder control implant - Myoelectric prosthetics - Brain-computer interface - Fundamentals of neural stimulation - Spinal cord stimulator- Transcranial Magnetic Stimulation - Deep brain stimulation	
Module-4 - Neuro Diagnostics	***9 Hour***
Electroencephalography (EEG) - Electromyography (EMG) and Nerve Conduction Studies (NCS) - Magnetoencephalography (MEG) - Functional Magnetic Resonance Imaging (fMRI) - Functional near-infrared spectroscopy (fNIRS) - Positron emission tomography (PET) – Computerized axial tomography (CAT) scans in brain imaging - Cranial ultrasound - Diffuse optical tomography (DOT) -	
Module-5 – Future Trends in Neural Engineering	***9 Hour***
Neural Modeling – Neural Tissue Engineering - Neurorobotics – Neuro-regeneration – Neuro informatics – Neuromarketing – Applications of machine intelligence in Neuroscience – Neuro ethics	

Learning Resources	1. *Kandel, Eric R., James H. Schwartz, Thomas M. Jessell, Steven Siegelbaum, A. James Hudspeth, and Sarah Mack, eds. Principles of neural science. Vol. 4. New York: McGraw-hill, 2000.* 2. *Bin He "Neural Engineering", First edition, Springer 2005* 3. *Metin Akay "Handbook of Neural Engineering", First edition, Wiley –IEEE press, 2007*	4. *Koch Chrisof Segev,Idan "Methods In Neuronal Modelling: From Ions To Networks", Second Edition, MIT Press, 1999.* 5. *Warren E.Finn, Peter G.Lopresti, "Handbook of Neuroprosthetic methods", CRC press, Baco Raton Florida, 2003.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*10%*	*-*	*10%*	*-*
Level 2	*Understand*	*20%*	*-*	*10%*	*-*	*10%*	*-*
Level 3	*Apply*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*10%*	*-*	*10%*	*-*
Level 6	*Create*	*-*	*-*	*10%*	*-*	*10%*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. T. Anbu Selvan, Wipro GE Health care Pvt Ltd	*1. Dr. S. Poonguzhali, Professor, Anna University*	*Dr. Nijisha Shajil, SRMIST*

Course Code	21BME611T	Course Name	BIOMEMS AND BIO MICROFLUIDICS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biomedical Engineering*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the fundamental principles of BioMEMS and biomicrofluidics*
CLR-2:	*acquire an idea about the materials and various fabrication methods and techniques*
CLR-3:	*describe the concepts of various interfaces in microfluidic systems*
CLR-4:	*get an idea about the fluidic control methods and detection methods*
CLR-5:	*overview on the application of bioMEMS and biomicrofluidics in various biological system*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*comprehend the fundamental principles of BioMEMS and Bio microfluidics*	*1*		*1*
CO-2:	*explain various materials and fabrication methods and techniques*	*1*	*2*	*1*
CO-3:	*analyze the various interfaces with surface and devices*	*2*	*1*	
CO-4:	*recognize the Interfaces in Microfluidic Systems*	*2*		*3*
CO-5:	*outline of the BioMEMS and Bio microfluidics application in biological system*	*1*	*2*	*2*

Module-1 - Basics of BioMEMS and Bio microfluidics	***9 Hour***
Introduction to BioMEMS and Bio microfluidics – Working Principles for Microsensor – Types of microsensors – Working Principle for Micro actuator – Application of Micro Actuations – Definition of a fluid – Equations of Conservation – Navier Stokes Equation – Boundary Condition in Fluid Mechanics – Energy Equation – Species Conservation Equation – Pressure – driven flows – Low Reynolds Number Flows – Electrokinetic and its phenomenon – Debye length – Types of microsensors: Chemical Sensors – Biomedical Sensors & Biosensor – Optical Sensors – Pressure Sensors – Thermal Sensor – Acoustic Wave Sensors	
Module-2 - Material Fabrication Methods and Techniques	***9 Hour***
Substrates and wafers - Packaging materials – Photolithography - Ion implantation – Diffusion - Spin coating – Oxidation - Physical vapor deposition - Chemical vapor deposition - Electrochemical vapor deposition – Epitaxy – Etching - Micromachining Techniques - Bulk Micro Manufacturing - Types of Etching process in bulk micromanufacturing - Surface Micromachining – LIGA - Difference between LIGA, SM, BM - Applications of Bulk Micromachining, Surface Micromachining, LIGA	
Module-3 - Interfaces in Microfluidics	***9 Hour***
Introduction to surfaces - Surface charge - Surface energy - Thermodynamics of surfaces - Formation of surface layers - Surface modification methods - Physical methods - Chemical methods - Surface characterization methods - Indirect methods - Direct methods - Surface tension-driven flows - Thin film dynamics - Device interfaces	
Module-4 - Fluidic Control and Detection Methods	***9 Hour***
Fluid Control: Basic theory - Pressure Driven Flow - Shear driven Flow - Electrokinetically driven flow - Single Molecule Detection Methods - Optical detection methods - Electrochemical method - Measurement of Fluidic Properties - Non Intrusive flow measurement techniques - Streaming potential/current measurement in pressure-driven flows - Current monitoring in electroosmotic flow - Optical flow imaging techniques using a tracer - Properties of flow tracers - Scalar image velocimetry - Nanoparticle image velocimetry - Laser-induced fluorescence photobleaching anemometer with stimulated emission depletion	
Module-5 – Applications to Biological System	***9 Hour***

Microcantilever BioMEMS – Basic Principles of Sensing Biomechanical Interactions – Detection Modes of Biomechanical Interactions – Static Mode and Dynamic mode – Tissue scaffold fabrication using MEMS approaches – Electrophoresis: DNA separation – Shear driven flow: Biomolecular separation – Bioanalysis: Immunoassay – Micro gas chromatography: a case study for a lab on a chip – Micro scale impedance measurements for flow diagnostics at the nanoscale: a case study system – Paper Based Microfluidic Devices – Lens Based Glucose Sensor – Catheter based sensors – Microneedles – Implantable Microelectrodes

Learning Resources	1. *Tai-Ran Hsu, "MEMS & Microsystems- Design, Manufacture and Nanoscale Engineering, John Wiley & Sons, 2nd Edition, 2008* 2. *Nitaigour Premchand Mahalik, "MEMS", Tata McGraw Hill, 2nd Reprint, 2008* 3. *Steven S.Saliterman, "Fundamentals of BioMEMS & Medical Microdevices", International Society for Optical Engineering, 1st Edition, 2006* 4. *Albert Folch, "Introduction to BioMEMS", CRC Press, 1st Edition, 2013* 5. *Simona Badilescu and Muthukumaran Packirisamy, "BioMEMS Science and Engineering Perspectives", CRC Press, 1st Edition, 2011* 6. *Wanjun Wang & Steven A.Soper, "BioMEMS- Technologies and applications", CRC Press, 1st Edition, 2007*	7. *Ellis Meng, "Biomedical Microsystems", CRC Press, 1st Edition, 2011Shaurya Prakash & Junghoon Yeom "Nanofluidics and Microfluidics Systems and Application", Elsevier,First edition 2014* 8. *Shaurya Prakash & Junghoon Yeom "Nanofluidics and Microfluidics Systems and Application", Elsevier, First edition 2014* 9. *Sushanta K. Mitra, Suman Chakraborty "Microfluidics and Nanofluidics Handbook: Fabrication, Implementation, and Applications", CRC Press; 1 edition, 2017* 10. *Patric Tabeling "Introduction to Microfluids" Oxford U. Press, New York 2005.* 11. *Francesco Piraino, Šeila Selimović "Diagnostic Devices with Microfluidics (Devices, Circuits, and Systems)", CRC Press; 1 edition, 2017*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*10%*	*-*	*10%*	*-*
Level 2	*Understand*	*20%*	*-*	*10%*	*-*	*10%*	*-*
Level 3	*Apply*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*10%*	*-*	*10%*	*-*
Level 6	*Create*	*-*	*-*	*10%*	*-*	*10%*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. T. Anbu Selvan, Wipro GE Health care Pvt Ltd	*1. Dr. S. Poonguzhali, Professor, Anna University*	*1. Mrs. Oinam Robita Chanu, SRMIST*
		2. Dr. Sukanta Kumar Tulo, SRMIST

Course Code	21BME612T	Course Name	INTELLIGENT HEALTHCARE USING MACHINE LEARNING AND DEEP LEARNING TECHNIQUES	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biomedical Engineering*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*familiarise the different types of supervised learning algorithms*
CLR-2:	*describe the different types of unsupervised learning algorithms*
CLR-3:	*elaborate the basics of deep learning, activation functions, optimization techniques and evaluation metrics*
CLR-4:	*illustrate the different DNN architectures and healthcare applications*
CLR-5:	*familiarise the different types of supervised learning algorithms*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*discuss various learning models and training the models*	*3*	*1*	
CO-2:	*develop the different types of supervised learning algorithms*	*2*	*1*	
CO-3:	*analyse and apply the different unsupervised learning algorithms*	*3*	*1*	
CO-4:	*explain the basic deep learning model, hyperparameters and optimization techniques*	*3*	*1*	
CO-5:	*apply the different types of deep learning models in healthcare*		*2*	*1*

Module-1 - Introduction to Artificial intelligence and Machine learning	***9 Hour***
Definition of AI and its historical background - Narrow (Weak) AI vs. General (Strong) AI – the state of the art of AI in medicine – agents and environment – problem Solving – searching - types of learning: Supervised, Unsupervised and Reinforcement learning – predictive and descriptive models – training a model – holdout method – K -fold cross validation – learning : lazy vs easy learner – model representation and interpretability - uniform convergence- over and under fitting – bias variance tradeoff	
Module-2 - Supervised Learning	***9 Hour***
Regression Models: linear regression - logistic regression – Support Vector Regression (SVR) – Gaussian Process Regression (GPR) - decision trees – random forest - ensemble methods - classification Models: Support Vector Machine – discriminant analysis - Naïve Bayes model - nearest neighbor	
Module-3 - Unsupervised Learning	***9 Hour***
Dimensionality reduction - principal component analysis - connectivity based clustering – hierarchical - distribution based clustering – Expectation Maximization algorithm (EM) - Gaussian Mixture Model - density based clustering – centroid based clustering - K-Means - grid based clustering - Statistical Information Grid based Clustering (STING) - evaluation metrics – confusion matrix - classification accuracy - logarithmic loss - Receiver Operating Curve (ROC) - F1 score – mean absolute error - mean square error	
Module-4 - Introduction to Deep Learning	***9 Hour***
Shallow neural network vs Deep Neural Network - basic deep feed-forward neural network - activation functions: Sigmoid, Tanh, and ReLU - hyper parameters tuning - weight Initialization for deep networks - optimization techniques - Gradient Descent - Stochastic Gradient Descent (SGD) - Adaptive Gradient (AdaGrad) - AdaDelta - ADAM (Adaptive Moment Estimation) - early stopping – dropout - small dataset class imbalance possible solutions - data augmentation - redesign the loss function	
Module-5 – DNN Architectures and Applications	***9 Hour***
Basic CNN architecture - ImageNet Database - CNN - Alex Net - VGG Net - ResNet architectures and medical applications - basic Recurrent Net – Long Short-Term Memory network (LSTM) - basic recursive network - generative adversarial network - U- Net architecture and applications - deep learning platforms – Torch – Keras – Tensorflow - DL4J	

Learning Resources	1. *S. Russel and P. Norvig, "Artificial Intelligence – A Modern Approach", Second Edition, Pearson Education* 2. *Tony J. Cleophas and Aeilko H. Zwinderman, "Machine Learning in Medicine - a Complete Overview", Springer,2015* 3. *Vinod chandra S.S, Anand hareendran S. "Artificial intelligence and machine learning", PHI Learning; 1st edition, 2014*	4. *Applied Deep Learning: A Case-Based Approach to Understanding Deep Neural Networks, By Umberto Michelucci, Delaware corporation, 2018* 5. *Deep Learning for Medical Image Analysis, edited by S. Kevin Zhou, Hayit Greenspan, Dinggang Shen, Academia Press, 2017* 6. *Deep Learning, An MIT Press book, Ian Goodfellow and Yoshua Bengio and Aaron Courville, Introduction to Deep Learning: From Logical Calculus to Artificial Intelligence, By Sandro Skansi, Springer, 2018*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*10%*	*-*	*10%*	*-*
Level 2	*Understand*	*20%*	*-*	*10%*	*-*	*10%*	*-*
Level 3	*Apply*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*10%*	*-*	*10%*	*-*
Level 6	*Create*	*-*	*-*	*10%*	*-*	*10%*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. T. Anbu Selvan, Wipro GE Health care Pvt Ltd	*1. Dr. S. Poonguzhali, Professor, Anna University*	*1.Dr.S. P.Angeline Kirubha, SRMIST*

Course Code	21BME613T	Course Name	BIOMETRICS AND BIOMIMETICS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biomedical Engineering*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand biometric fundamentals and fingerprint recognition principles*
CLR-2:	*explore advanced face recognition techniques and voice biometrics significance.*
CLR-3:	*introduce gait characteristics and emerging biometric technologies.*
CLR-4:	*delve into biomimetics, muscle design, and cognitive mechanisms.*
CLR-5:	*analyze biosensing, biomimetic actuators, and applications.*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*evaluate biometrics foundations and security measures in fingerprint recognition.*	*1*	*1*	*1*
CO-2:	*apply advanced techniques in face recognition and understand voice biometrics applications.*	*1*	*2*	*1*
CO-3:	*recognize gait characteristics and explore emerging biometric technologies.*	*2*	*1*	*1*
CO-4:	*understand biomimetics, muscle design, and cognitive mechanisms.*	*1*	*2*	*1*
CO-5:	*analyze biosensing, biomimetic actuators, and their applications.*	*2*	*1*	*1*

Module-1 - Fundamentals of Biometrics and Fingerprint Recognition	***9 Hour***
Definition, Evolution, and Operation of Biometric Systems, Block Diagram Description, Performance and Different Errors in Biometric Systems: Performance Evaluation, parameters, applications and Characteristics of Biometrics, Application of Biometrics in Forensics, Government, Commercial sectors, and its Legal Considerations Introduction to different fingerprint sensing technologies, Feature Extraction and Enhancement techniques, Finger Print Matching Techniques: Correlation-Based Methods and Rigid Feature-Based Techniques, Performance Evaluation, Security Measures for Fingerprint Recognition and Standardization	
Module-2 - Face Recognition and Voice Biometrics	***9 Hour***
Overview and Significance of face recognition, Various techniques in face recognition: Eigenfaces, Linear Discriminant Analysis, Independent Component Analysis, and Local Feature Analysis. Major steps, and methodologies for face recognition. Introduction to voice biometrics: available technologies and their significance, Feature Extraction and Tokenization, Speaker Recognition: Text-Dependent vs text-independent Speaker Recognition, Applications of Voice Biometrics: Voice Authentication vs Speaker Detection	
Module-3 - Gait and other emerging Biometric	***9 Hour***
Introduction to human gait, gait characteristics, sensing modules for gait characterization, application of Image proceeding for gait signature estimation. Recognizing a signature, Sensing modules for signature characterization. Brainwave biometrics. Multimodel biometric systems, Applications and future trends in biometrics	
Module-4 - Introduction to Biomimetics and Mechanism of Cognition	***9 Hour***
Biologically Inspired Structure, parts, Defense and attack mechanism, Interfacing Biology and Machines, Muscle Function, Design, and Adaptation Biomimetics of Muscle Design, Mechanism of Cognition and Open-Ended Design Automation: Mechanized Cognition and Training, Visual Cognition and Evolution of Machine Bodies, Evolving Bodies and Brains, Morphology Representations: Tree, Developmental, and Regulatory Network Representations	
Module-5 – Biosensing, Biomimetic Actuators, and Applications	***9 Hour***

Introduction of Biomimetic Tactile Sensing: Neural interfacing for biosensing, Biomimetic vision systems, Novel Biomimetic Materials: Design of Self-Oscillating Polymer Gel, Control of Self-Oscillating Chemo-mechanical Behavior, Biomimetic Soft Actuators, Self-healing biomaterials, Biomimetics of Motion: Biomechanics and Rhythmics, Control Center in Biomechanics of Motion, External and Internal Actuation: Active and passive, Recent advancements in Biomimetics system design and applications

Learning Resources	1. *Anil K jain, Patrick Flynn, Arun A. (Eds.), Handbook of Biometrics, Springer, 2008.* 2. *John D. Woodward, Jr. Nicholas M. Orlans Peter T. Higgins, "Biometrics", dreamtech, 2003.* 3. *J. Wayman, A. Jain, D. Maltoni and D. Maio (Eds.), Biometric Systems: Technology, Design and Performance Evaluation, Springer, 2005*	4. *Yoseph Bar-Cohen, "BIOMIMETICS Biologically Inspired Technologies", CRC Press, 1st Edition, 2006. Trung Dung Ngo, "Biomimetic Technologies: Principles and Applications", Wood head Publishing Ltd, 1st Edition, 2015.* 5. *Sandra Persiani, "Biomimetics of Motion: Nature-Inspired Parameters and Schemes for Kinetic Design", Springer, 1st Edition, 2019* 6. *P Gruber, D Bruckner, C Hellmich,· H B. Schmiedmayer, H. Stachelberger, I C. Gebeshuber, "Biomimetics – Materials,Structuresand ProcessesExamples, Ideas and Case Studies", Springer, 1st Edition, 2011*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*10%*	*-*	*10%*	*-*
Level 2	*Understand*	*20%*	*-*	*10%*	*-*	*10%*	*-*
Level 3	*Apply*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*10%*	*-*	*10%*	*-*
Level 6	*Create*	*-*	*-*	*10%*	*-*	*10%*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. T. Anbu Selvan, Wipro GE Health care Pvt Ltd	*1. Dr. S. Poonguzhali, Professor, Anna University*	1. *Dr.Rohit Gupta, SRMIST*

Course Code	21BME614T	Course Name	HUMAN MACHINE INTERFACE	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biomedical Engineering*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the historical evolution and significance of Human Machine Interface (HMI)*
CLR-2:	*analyze the human factors influencing HMI design, including interaction speeds, ergonomics, and usability*
CLR-3:	*explore various interface technologies and their relevance to HMI in Biomedical Engineering.*
CLR-4:	*comprehend the basics of physiological signal acquisition, processing, and feature extraction for effective HMI.*
CLR-5:	*explore the components and technologies involved in BCI systems and their ethical considerations*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*define and explain the fundamentals of HMI applied to the Biomedical Engineering*	1	-	-
CO-2:	*identify and evaluate the human factors influencing HMI design*	1	-	-
CO-3:	*analyze various interface technologies and the role of AI in the context of HMI for Biomedical Engineering.*	2	1	1
CO-4:	*demonstrate knowledge of physiological signal acquisition, processing techniques, and feature extraction for effective HMI*	2	1	2
CO-5:	*evaluate the components and functioning of BCI systems and their role in the rehabilitation*	1	-	1

Module-1 - Introduction to Human-Machine Interface	***9 Hour***
Fundamentals of HM- Definition, history and Evolution, Importance of HMI in Biomedical Engineering, Interface design: I/O channels, Hardware, Software requirements. Human Factors in HMI Design, Human Interaction Speeds, Ergonomics and Usability, Overview of Interface Technologies- Sensor and recognition based input for interaction-Visual Displays- Haptic Interface	
Module-2 - Physiological Signal Processing for HMI	***9 Hour***
Basics of Physiological Signal Acquisition, Various human physiological signals for an effective HMI. Signal Conditioning and Pre-processing Techniques for various techniques. Feature Extraction Techniques applied for effective HMI. Time-Frequency Analysis in Physiological Signal Processing. Application of AI in Physiological Signal Processing for HMI development.	
Module-3 - Brain-Computer Interface (BCI)	***9 Hour***
Introduction to Human Neuro Anatomy, Introduction to Brain-Computer Interface (BCI), Basic Components of a BCI System, Invasive and Non-invasive BCI, Neural Interfaces/BCI development - Electroencephalography (EEG) - Principle and working of EEG - Computerized axial tomography (CAT) scans in brain imaging - Functional Magnetic Resonance Imaging (fMRI).	
Module-4 - User-centric Design and Multimodal Interaction in Biomedical HMI	***9 Hour***
Introduction to user-centered design, understanding human cognition and physical abilities, prototyping and evaluation techniques, and fundamentals of graphical design. Designing consideration and methodology of human-centric HMI, Overview of Multimodal Interfaces, Various Fusion Techniques in Multimodal HMI, Role of Virtual and Augmented Reality in Interfaces	
Module-5 – Advanced Human Machine Interface Techniques	***9 Hour***
Application uses in robotics -Robotics and wearable technology for measurement--Clinical application of robotics and technology in the restoration of walking- clinical application of robotics and technology in children undergoing neurorehabilitation- biomimetic design of neural prosthesis. Neurofeedback, Neuromodulation, and adaptive HMI. Ethical Considerations in Biomedical HMI.	

Learning Resources	1. *Dix, Alan. Human-computer interaction. Pearson Education, 2003.* 2. *Liang, Hualou, Joseph D. Bronzino, and Donald R. Peterson, eds. Biosignal processing: principles and practices. CRC Press, 2012.* 3. *Grifoni, Patrizia, ed. Multimodal human computer interaction and pervasive services. IGI Global, 2009.*	4. *Nam, Chang S., Anton Nijholt, and Fabien Lotte, eds. Brain–computer interfaces handbook: technological and theoretical advances. CRC Press, 2018.* 5. *Panagiotis Artemiadi, Neuro-Robotics: From Brain Machine Interfaces to Rehabilitation Robotics springer publishing 2014.* 6. *David J. Reinkensmeyer, Volker Diet, Neurorehabilitation Technology, springer publishing 2016.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*10%*	*-*	*10%*	*-*
Level 2	*Understand*	*20%*	*-*	*10%*	*-*	*10%*	*-*
Level 3	*Apply*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*10%*	*-*	*10%*	*-*
Level 6	*Create*	*-*	*-*	*10%*	*-*	*10%*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. T. Anbu Selvan, Wipro GE Health care Pvt Ltd	*1. Dr. S. Poonguzhali, Professor, Anna University*	*Dr. Rohit Gupta,SRMIST*

Course Code	21BME615T	Course Name	MEDICAL ROBOTICS AND AUTOMATION	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biomedical Engineering*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the fundamentals of design and control of robots for medical applications*
CLR-2:	*study about robotic surgery and interventional radiology*
CLR-3:	*comprehend the concepts in kinematics, dynamics, and control relevant to medical robotics*
CLR-4:	*develop analytical and experimental skills in image-guided interventions*
CLR-5:	*explore the various roles that robotics can play in healthcare*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*apply the fundamental knowledge and choose appropriate design*	2	1	1
CO-2:	*analyze the robotic surgery technique and features.*	2	1	1
CO-3:	*learn and understand the dynamics and kinematics of a robotic surgical systems*	2	2	2
CO-4:	*outline the importance of medical robots in minimally invasive and image guided interventions*	2	2	2
CO-5:	*describe the role of surgical robots in healthcare systems*	2	1	1

Module-1 - Robotics Characteristics	***9 Hour***
Potential use of robots in medical procedure, Degree of Freedom, Kinematics and Inverse Kinematics, Mathematical representation of positioning and orientation, Components and design of surgical robotic systems. Manipulator introduction, End effector, Accuracy versus medical robots, Tool configuration Jacobian, relation between joint and end effector velocities. Potential advantages using robots in medical surgery, Kinematic tree, Kinematic loop	
Module-2 - Tracking Technologies for Medical Robotics	***9 Hour***
Introduction to tracking technologies, Requirements of position sensor, medical application, Dynamic referencing, Types of position sensor, Classification based on medical applications, Mechanical linkage, Optical systems, Sound based tracking systems, Impedance based tracking systems, Electromagnetic tracking systems, Coil and needle Integration.	
Module-3 - Robotic Surgical Systems	***9 Hour***
Introduction to robotic ophthalmic surgery, Types of surgery: glaucoma, Refractive surgery, Eye muscle surgery, vitreoretinal surgery. Robotic-assisted intraocular surgery, Deployable structure introduction, Types, Geometrical characteristics of deployable circular structures, Servo motorized intermediate pins, Laparoscopic system with flexible deployable structure, Use of robotics in vascular surgery	
Module-4 - Mobile Robotics Fundamentals	***9 Hour***
Introduction to mobile robot, Vehicles with front wheel steering, Robot attitude, Definition of pitch, yaw and roll, General rotation matrix, Robot navigation, Coordinate systems, Array of Global Positioning Sensor (GPS) Antennas, Inclinometer/compass, Need for obstacle avoidance, Obstacle avoidance technique, Sensors used in obstacle detection, Navigation Architectures, Modularity for code reuse and sharing	
Module-5 – Robotic Surgery and Ethical Challenges	***9 Hour***
Introduction, Types of robotic surgery, the patient experience of robotic surgery, The marketing of robotic surgery, Strategy planning, Comparison of robotic surgery with other surgery, Limitations of other robotic surgery modalities, The need for training to robotic surgery, Training procedure, Cost verses benefits of robotic surgery, Apex Robotic Technology (ART) Ethical issues related to remotely operated surgery, The automated hospital, ethical issues of assistive robotics	

Learning Resources	1. Seth hutchinson, and M. Vidyasagar,-Robot Modeling and Control, Wiley Publishers, 2006. 2. Paula Gomes, "Medical robotics minimally invasive surgery", Woodhead, 2012.	3. Achim Schweikard, Floris Ernst, ―Medical Robotics‖, Springer, 2015. 4. Jocelyne Troccaz, ―Medical Robotics‖, Wiley-ISTE, 2012. 5. Vanja Bonzovic, ‖Medical Robotics‖, I-tech Education publishing, Austria,2008

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	20%	-	10%	-	10%	-
Level 2	Understand	20%	-	10%	-	10%	-
Level 3	Apply	30%	-	30%	-	30%	-
Level 4	Analyze	30%	-	30%	-	30%	-
Level 5	Evaluate	-	-	10%	-	10%	-
Level 6	Create	-	-	10%	-	10%	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. T. Anbu Selvan, Wipro GE Health care Pvt Ltd	1. Dr. S. Poonguzhali, Professor, Anna University	1. Dr.G.Anitha, SRMIST

Course Code	21BME616T	Course Name	HOSPITAL MANAGEMENT SYSTEM	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biomedical Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*compile the concepts of quality management strategies in hospital management*
CLR-2:	*summarize the performance management methods and tools in hospital management*
CLR-3:	*describe the project evaluation for performance improvement*
CLR-4:	*assess the techniques to apply health data analytics in performance measurement*
CLR-5:	*recognize the ethics and quality assurance compliance in hospital management*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*compile the concepts of quality management strategies in hospital management*	1	-	1
CO-2:	*summarize the performance management methods and tools in hospital management*	1	-	-
CO-3:	*describe the project evaluation for performance improvement*	1	-	-
CO-4:	*assess the techniques to apply health data analytics in performance measurement*	1	-	-
CO-5:	*recognize the ethics and quality assurance compliance in hospital management*	1	-	2

Module-1 - Quality and Quality Management Strategies	***9 Hour***
Quality - Quality management formula – Quality principles – Improvement cycle – Quality management approaches - Roles and focus in performance improvement - Types of Quality and Performance Improvement – Performance based planning – Health care strategy – Problem identification - Guideline for performance management	
Module-2 - Performance Management Methods and Tools	***9 Hour***
Structural Measures - Process Measures - Outcome Measures - Plan–Do–Check–Act - Six Sigma - DMAIC - Managing Defects - Process Capability Index - Six Sigma Benefits – Lean - Lean versus Six Sigma - Theory of Constraints - Process Modeling - Other Tools and Techniques - Root cause analysis - Cause-and-effect analysis - Failure modes and effects analysis	
Module-3 - Performance Improvement and Strategic Alignment	***9 Hour***
Building a new Quality or performance improvement (PI) Department - Approach to developing quality teams - Process improvement methodology - Project plan - Project organization chart - Risk issues log. ERP, enterprise resource planning - Project Comparison with Risk Analyses - Evaluating a Project's Strategic Alignment - Strategic Alignment Factors - Project Evaluation Summary - Evaluation of project alignment	
Module-4 - Health Data Analytics in Performance Improvement	***9 Hour***
Examples of Clinical and Administrative Data - General relationships among provider information applications - General relationships among health plan applications - Examples of Medical Claim Data Elements - Illustration of normalized database- Examples of Facility Revenue Codes - Statistical Analysis in Health Analytics - Applying Analytics in Performance Improvement - Cost per discharge by physician	
Module-5 – Ethics in Quality Assurance Compliance	***9 Hour***
Ethical and Legal Aspects -Medical / Professional acts – Law of Torts – Consumer protection act - Consent for Medical Examination, Treatment and Autopsy - The Medical Service - Refusal of Treatment - Defective Equipment - Negligent Monitoring – Professional negligence - Quality Assurance - Establishing Criteria for Diagnosis, Investigations and Treatment through Record Review and audit - Purpose of Quality Assurance - Standards and Criteria - Quality Assurance Committee - Quality assurance framework	

Learning Resources	1. *S.D. Gupta, Anoop Khanna, Healthcare system management, Springer, 2022* 2. *James R. Langbeer II "Performance Improvement in Hospitals and Health Systems Managing Analytics and Quality in Healthcare 2nd Edition", Taylor francs, 2018* 3. *Kathryn J. Hannah Marion J. Ball Series Editors, "Health Informatics", Springer Science Business Media, LLC 2nd edition, 2009*	4. *Pradip Kumar Ray, Jhareswar Maiti, "Healthcare Systems Management: Methodologies and Applications: 21st Century Perspectives of Asia", Springer, 2018* 5. *Gerald L. Glandon, Donna Jean Slovensky, Detlev Herb Smaltz," Information Systems for Healthcare Management", Health Administration Press, 2014*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*10%*	-	*10%*	-
Level 2	*Understand*	*20%*	-	*10%*	-	*10%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	*10%*	-
Level 6	*Create*	-	-	*10%*	-	*10%*	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Mr. T. Anbu Selvan, Wipro GE Health care Pvt Ltd*	1. *Dr. S. Poonguzhali, Professor, Anna University*	1. *Dr.P.Muthu, SRMIST*

ACADEMIC CURRICULA

Biotechnology

Professional Core Courses

Regulations 2021

SRM INSTITUTE OF SCIENCE & TECHNOLOGY
(Deemed to be University u/s 3 of UGC Act, 1956)

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

Course Code	21BTC501J	Course Name	BIOMOLECULES	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biotechnology*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*explain about biomolecules at structural and functional level.*
CLR-2:	*describe about bioenergetics and metabolism*
CLR-3:	*analyze about the carbohydrate and protein metabolic pathways and their effects.*
CLR-4:	*analyze about the lipid and nucleic acid metabolic pathways and their effects.*
CLR-5:	*discuss about various metabolic disorders*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*analyze about the structure and function of biomolecules*	*3*	*2*	*2*
CO-2:	*describe about bioenergetics and metabolism*	*2*	*2*	*2*
CO-3:	*analyze about the carbohydrate and protein metabolism*	*2*	*2*	*2*
CO-4:	*analyze about the lipid and nucleic acid metabolism*	*3*	*3*	*3*
CO-5:	*describe about. various metabolic disorders*	*3*	*3*	*3*

Module-1 - Structure and Function of Biomolecules ***15 Hour***

Introduction to Biomolecules. Classification, structure – stereoisomerism, characteristics and functions of carbohydrates - Monosaccharides and Oligosaccharides, Polysaccharides and Complex carbohydrate. Lipids – types of membrane lipids, phospholipids and glycolipids - Lipid/Membrane Rafts – Composition, properties, types, functions. Protein structure and functions – primary, secondary, tertiary and quaternary structures – Domains, motifs, and folds in protein structure - Protein folding, Amino acids structure, classification and properties, Biological important peptides. Nucleic acids – structure and functions.

Practice:

1.Estimation of proteins by Bradford's method

2.Salting in, salting out and dialysis of proteins

Module-2 - Bioenergetics and Metabolism ***15 Hour***

Energetics-ATP as energy currency, Mechanism of ATP synthesis, biologic oxidation and standard reduction potentials structural organization and electron flow of respiratory chain, chemiosmotic theory of oxidative phosphorylation. Mitochondrial membrane transporters- shuttle systems

Practice:

3.Estimation of Cholesterol by Zak's Method

4.Assay of Alkaline Phosphatase Activity

Module-3 - Metabolism of Carbohydrates and Proteins ***15 Hour***

Carbohydrate metabolism - Glycolysis, Cori cycle and Glucogenesis, Citric acid cycle and Glycogen metabolism and its regulation, Protein metabolism - Urea cycle, degradation of amino acids.

Practice:

5.Estimation of Protease activity in commercially available detergent

6.Immunoelectrophoresis
Module-4 - Fatty Acid and Nucleic Acid Metabolism ***15 Hour***
Overview of Fatty Acid Metabolism - synthesis and degradation of fatty acids, cholesterol biosynthesis, lipoprotein. Nucleotides - De novo and salvage pathways.
Practice:
7.Dot ELISA
8.Western Blotting
Module-5 - Biomolecules and Disease ***15 Hour***
Metabolic disorders, Disease and control measures for Glycogen storage disease – Pathophysiology of Diabetes mellitus, Diagnosis and treatment for Diabetes mellitus, hypoglycemia. Amino acids – phenylketonuria and Cystinuria. Albinism, Alkaptonuria, Lipids – sphingolipids storage disease - Atherosclerosis and Fatty liver. Nucleic acids – gout disease, Types of gout and clinical manifestations, Diagnosis and Treatment of gout.
Practice:
9.Chromatography/Column separation
10.Detection of apoptotic proteins using Florescence Microscope / FACS

Learning Resources	1. *.Donald Voet, Judith G. Voet and Charlotte W. Pratt, "Fundamentals of Biochemistry – Life at the molecular level". John Wiley and Sons, Inc., Asia, 2018.* 2. *Robert K. Murray, Daryl K. Granner and Victor W. Rodwell, "Harper's Illustrated Biochemistry". McGraw Hill Education (Asia), 2019.*	3. *Jeremy M. Berg, John L. Tymozko and Lubert Stryer, "Biochemistry", Fifth edition, W.H. Freeman and Company, New York, 2019.* 4. *David L. Nelson and Michael M. Cox, "Lehninger Principles of Biochemistry" Fourth Edition, W H Freeman and Company, New York, 2019.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 Practice (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	-	*15%*	*15%*	-
Level 2	*Understand*	*25%*	-	-	*20%*	*25%*	-
Level 3	*Apply*	*30%*	-	-	*25%*	*30%*	-
Level 4	*Analyze*	*30%*	-	-	*25%*	*30%*	-
Level 5	*Evaluate*	-	-	-	*10%*	-	-
Level 6	*Create*	-	-	-	*5%*	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Dr. C. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com*	1. *Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in*	1. *Dr.R.A.Nazeer, SRMIST*
2. *Dr. Karthik Periyasamy, Aurobindo Pharma Limited, Hyderabad,karthikmpk@gmail.com*	2. *Prof. R. B. Narayanan, Anna University, Chennai, arbeen09@gmail.com*	2. *Dr.S.Subhashini (Sr), SRMIST*

Course Code	21BTC502J	Course Name	BIOPROCESS TECHNOLOGY	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biotechnology*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*apply the various methods of enzyme immobilization and evaluating their kinetic efficiency*
CLR-2:	*assess the metabolic stoichiometry and energetics of the biochemical process*
CLR-3:	*analyze the design and operation of various industrially important bioreactors*
CLR-4:	*analyze the operation of solid/liquid separation of fermented extracts*
CLR-5:	*illustrate the various methods of polishing and formulation of bioproducts*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*describe the various enzyme kinetic mechanisms and methods of enzyme immobilization*	3	-	3
CO-2:	*interpret the stoichiometry and energetics of product formation mediated by cell growth*	3	-	3
CO-3:	*discuss on the design and operation of bioreactors for the cultivation of microbial, plant and animal cell cultures.*	3	3	3
CO-4:	*explain the methods of purification of intracellular and extracellular products*	3	-	3
CO-5:	*explain the methods of polishing and formulation of products*	3	2	3

Module-1 - Enzyme Technology	***15 Hour***
Industrial Enzymes and their actions, Classification of enzymes, Factors affecting enzyme activity, Michaelis-Menten Kinetics and its variation, Enzyme Inhibitors, Types of enzyme inhibition, Enzyme immobilization strategies for the design of robust and efficient biocatalysts, Mass transfer effects and diffusional limitations, Stabilization of immobilized enzymes in non-aqueous environment, Industrial use of immobilized enzymes, Case studies for industrial biotransformation using oxidoreductase, hydrolase and isomerase ***Practice:*** *1. Effect of pH and temperature on enzyme activity* *2. Preparation of immobilized enzymes* *3. Enzyme kinetics of free and immobilized enzymes*	
Module-2 - Microbial Technology	***15 Hour***
Types of microbial fermentations, Process flow sheets of primary and secondary metabolite production, Medium formulation, Microbial growth curve and kinetics, Stoichiometric of cell growth and product formation, Elemental balance, degree of reduction, Determination of yield and stoichiometric coefficients, Kinetics of thermal death of microorganism, Types of sterilization – batch and continuous, Power requirements for mixing, Gas liquid mass transfer in cellular systems, Determination of oxygen transfer rates, Case studies for industrial production of primary and secondary metabolite ***Practice:*** *4. Batch sterilization kinetics* *5. Microbial growth kinetics in SSF and SMF* *6. Medium optimization by PBD and RSM*	
Module-3 - Bioreactor - Instrumentation and Control Systems	***15 Hour***
Types of bioreactor, Modes of operation of bioreactor, Strategies for choosing a bioreactor, Bioreactor instrumentation and control, Monitoring of biochemical parameters, Instrumentation for measurements of fermentation (pH, temperature, and DO), Bioreactor configurations for production of metabolites from microbial sources, immobilized cells, plant and animal sources, Application of computer control and sensing	

technologies for bioreactor systems, Case studies for Bioprocessing in the context of biofuels and biopharmaceuticals. ***Practice:*** *7. Determination of KLa* *8. Deactivation kinetics of enzymatic reaction* *9. Deactivation kinetics of microbial growth*
Module-4 - Downstream Processing - I ***15 Hour***
Importance of bio separation in biotechnological processes, Problems and requirements of bioproduct purification, Engineering analysis in Bio separation, Cell disruption methods for intracellular products, Solid – Liquid Separation, Batch filtration, Continuous rotary filters, Cross flow filtration, Membrane-based bio separation – Classification of membrane processes, Ultrafiltration, Microfiltration, Dialysis. ***Practice:*** *10. Cell disruption by Sonication,* *11.Cell disruption by High Pressure Homogenization,* *12.Chemical and Enzymatic method of cell disruption*
Module-5 - Downstream Processing - II ***15 Hour***
Batch extraction, Precipitation by salt and solvents, Large scale precipitation, Chromatography – principles, instruments and practice, Ion exchange, Gel permeation, and Bio affinity chromatography, Analysis of purity, Product formulation, Crystallization- Basic concepts, Batch crystallizers, Crystallization Principles, Batch Crystallizers, Drying Principles, Dryer Description and Operation, Case studies. ***Practice:*** *13. Protein concentration by Precipitation methods* *14.Protein concentration by Aqueous two-phase extraction* *15. Protein purification by ion exchange chromatography*

Learning Resources	1. *Harrison. R.G., Todd. P.W., Rudge S.R, Petrides. D.P, "Bio separation Science and Engineering", 2nd edition, Oxford University press, 2015.* 2. *Kargi. F., Shuler. M.L., "Bioprocess Engineering: Basic Concepts", 3rd Edition. Prentice Hall, 2021.*	3. *Doran P.M., "Bioprocess Engineering Principles", 2nd Edition, Academic Press, 2013.* 4. *Hilterhaus L., Liese A., Kettling U., Antranikian G "Applied Biocatalysis: From Fundamental Science to Industrial Applications. WILEY-VCH Verlag GmbH & Co. Publishers, 2016.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	-	*15%*	*15%*	-
Level 2	*Understand*	*25%*	-	-	*20%*	*25%*	-
Level 3	*Apply*	*30%*	-	-	*25%*	*30%*	-
Level 4	*Analyze*	*30%*	-	-	*25%*	*30%*	-
Level 5	*Evaluate*	-	-	-	*10%*	-	-
Level 6	*Create*	-	-	-	*5%*	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. G. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	*1. Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in*	*1. Dr. V. Vinoth Kumar, SRMIST*
2. Dr. Karthik Periyasamy, Scientist, Biocon, karthik.periyasamy@biocon.com	*2. Prof. R. B. Narayanan, Anna University, Chennai, arbeen09@gmail.com*	*2. Dr. P. Radha, SRMIST*

Course Code	21BTC503T	Course Name	IMMUNOLOGY AND IMMUNOPATHOLOGY	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biotechnology*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*explain the principles of immune responses*
CLR-2:	*analyze the different types of immune response*
CLR-3:	*discuss different immunoglobulins and their functions*
CLR-4:	*discuss different mucosal responses to pathogens*
CLR-5:	*illustrate various immunodeficiency diseases and treatments*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*describe the basic concepts of molecular immunology*	*3*	*-*	*3*
CO-2:	*describe recent advances in immunoassays*	*3*	*-*	*3*
CO-3:	*analyze recent developments in molecular immunology*	*3*	*-*	*3*
CO-4:	*illustrate practical techniques including ELISA, western blot flow cytometry and immunofluorescence*	*3*	*-*	*3*
CO-5:	*apply current immunological technologies and Discuss cutting—edge techniques used in vaccine therapies*	*3*	*2*	*3*

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Module-1 - Introduction to the Immune System	***9 Hour***
Organs and types of immune response (Innate & Adaptive), Antigen, antigenicity and immunogenicity, Band T cell epitopes, Structure and functions of antibody, Antibody diversity and interaction with antigens, Mechanism of Innate immunity, MHC complex, Immunoglobulins- clonal selection theory, Inflammatory responses, and mechanism, Pathogen recognition and LPS, Toll-like receptors- Signaling pathway and Complement system and activation mechanisms, Hypersensitivity reactions.	
Module-2 - Basis of self and non-self, Antibody	***9 Hour***
Structure, function and immune response, Antibody classes, Monoclonal Antibodies, Cell-mediated immunity – components and mechanism, Antigen processing and presentation, MHC functions and restrictions, Lymphocytes mechanism in adaptive immunity, B and T cell receptors, B and T cell maturation, diversity and Activation, Immunoglobulins mechanism and gene arrangement, Biology of cytokines, Importance of co-stimulatory molecules in B and T cell activation.	
Module-3 - Introduction to the mucosal system and organization	***9 Hour***
Microfold cells and T-cell binding, IgA mechanism of action, Mucosal regulation and response to infection, Protective immunity and oral tolerance, Effector mechanism against pathogens, Immune responses to – viruses & bacteria, Transmission and Pathogenesis of TB, Malaria and Protozoan diseases, Preventive mechanisms, Vaccines – DNA, Recombinant and subunit vaccines, Reverse vaccinology, peptide, and conjugate vaccines	
Module-4 - Immunodeficiency	***9 Hour***
Types, diseases and treatments, HIV, Hypersensitivity reactions, - Types and Immune tolerance, Autoimmunity – mechanisms, immune response to transplantation and graft rejection mechanisms, Host response reactions, Immune suppression therapy, Tumours – immune recognition, escape, vaccines and cytokine therapy.	

Module-5 - Immunoassays	***9 Hour***
Principles and Applications - Immunoprecipitation, Immunoelectrophoresis, Immunocytochemistry, Immunofluorescence, Flow cytometry, Magnetic Sorting, Label-free immune assays, Surface plasmon resonance, Radio immune assays Immunoelectron microscopy, Gene knockout animal models, Stem cell transplant technology, Development of effective immuno drug targets for infectious diseases, engineered antibodies; catalytic antibodies; idiotypic antibodies; (scFv) antibodies and molecular evolution of scFv for enhanced sensitivity and specificity, dendritic cells based immunotherapy, combinatorial libraries for antibody isolation, CAR T-cell therapy, Immune check point inhibitors.	

Learning Resources	1. *Emily P. Wen, Ronald Ellis and Narahari S. Pujar, "Vaccine Development and Manufacturing" Wiley, 1st Edition, 2014.* 2. *Judith A. Owen, Jenni Punt and Sharon Stranford, "Kuby Immunology", W.H. Freeman and Company, 7th Edition, 2018.* 3. *Sudha Gangal and Shubhangi Sontakke, "Textbook of basic and clinical immunology," Universities Press, 2013.*	4. *Robert R. Rich, Thomas A Fleisher, William T. Shearer, Harry Schroeder, Anthony J. Frew and Cornelia M. Weyand, "Clinical Immunology-Principles and Practice" Elsevier, 5th Edition, 2018.* 5. *Antibodies: A Laboratory Manual, Edward A. Greenfield, Cold Spring Harbor Laboratory Press, 2nd Edition, 2014*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Dr. G. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com*	1. *Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in*	1. *Dr. S Sahabudeen, SRM IST*
2. *Dr. Karthik Periyasamy, Scientist, Biocon, karthik.periyasamy@biocon.com*	2. *Prof. R. B. Narayanan, Anna University, Chennai, arbeen09@gmail.com*	2. *Dr. S. Nageswaran, SRM IST*

Course Code	21BTC504J	Course Name	GENE MANIPULATIONS AND GENOME ANALYSIS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biotechnology*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*comprehend the underlying principles of gene structure, function, and regulation.*
CLR-2:	*acquire knowledge on gene cloning strategies and use of modern tools and techniques for manipulation*
CLR-3:	*develop proficiency in using software and databases for genome analysis and interpretation.*
CLR-4:	*understand the methodologies and applications of gene editing technologies in research*
CLR-5:	*understand epigenetics regulation in Eukaryotic organism*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*comprehend the fundamental concepts of genome structure*	*2*	*2*	*-*
CO-2:	*design and execute experiments for gene manipulation*	*2*	*2*	*-*
CO-3:	*design research projects that contribute to the expanding field of genomics.*	*3*	*--*	*2*
CO-4:	*analyze recent developments in genetics*	*3*	*3*	*-*
CO-5:	*apply current epigenetic technologies to study gene function.*	*3*	*-*	*3*

Module-1 – Genome Organization	***15 Hour***
Prokaryotic genome, Complicity of eukaryotic genome, Karyotyping, Cot value – Nucleosome structure, Repetitive gene sequence- organization of repetitive sequence, satellite, Minisatellite, Microsatellite, CpG islands, SNPs, Gene families, Pseudogenes, Ribonucleic acids, Non coding RNA- snRNA, miRNA, LNC RNA, SiRNA, Circ RNA , piRNA ***Practice:*** *1.DNA isolation from E coli* *2.DNA isolation from Animal cell* *3.RNA isolation from E coli* *4.RNA isolation from Animal Cell*	
Module-2 – Recombinant DNA Technology	***15 Hour***
Gene cloning strategy- Type of cloning vectors for prokaryotic and eukaryotic system- pUC18, pET28 A, pPIC, pPIC -alpha , pCDNA3, pCAMBIA, Expression vector, Polymerase chain amplification reaction- Nested PCR, RACE PCR, LAMP PCR *Practice:* *5.Primer Designing (Gene Specific)* *6.Gene specific Amplification* *7.Transformation of E coli cell*	

8.Transfection of Animal cell
Module-3 – Genome Sequencing and Analysis ***15 Hour***
Sanger sequencing, Next sequencing platforms - Illumina, Nanaopore, Roche 45, PacBIO, Sequencing QC, Assembly and Annotation tools, Comparative genomics, Transcriptome , Transcriptome analysis, Microarray ***Practice:*** *9.Bacterial genome QC analysis* *10.Assembly and annotation* *11.Transcriptome analysis- Differential gene expression*
Module-4 – Genome Editing ***15 Hour***
Genome editing technologies, Conventional genome editing technique, Homologous recombination, Homing endonuclease system, Zinc finger nuclease, Transcription activator-like effector nuclease , Clustered regularly interspaced short palindromic repeats/Cas proteins. Knockout animal and application ***Practice:*** *12.Designing of Guide RNA* *13.CRISPR deletion in Bacteria*
Module-5 – Epigenetics Analysis ***15 Hour***
Epigenetic regulation, Reprogramming, DNA methylation, Histone Modification, -methylation, Acetylation, Phosphorylation, Ubiquitination, Transgenerational inheritance, Imprinting- maternal effect, Patterns effect, DNA methylation analysis, DNA – Protein interaction analysis. Chromatin Immuno precipitation analysis. ***Practice:*** *14.Chip seq data analysis*

Learning Resources	*1. Sandy B. Primrose, Richard Twyman; Principles of Gene Manipulation and Genomics 7th Edition, Wiley-Blackwell 2013*	*2. T A Brown ; Genome 5, CRC Press 2023*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	-	*15%*	*15%*	-
Level 2	*Understand*	*25%*	-	-	*20%*	*25%*	-
Level 3	*Apply*	*30%*	-	-	*25%*	*30%*	-
Level 4	*Analyze*	*30%*	-	-	*25%*	*30%*	-
Level 5	*Evaluate*	-	-	-	*10%*	-	-
Level 6	*Create*	-	-	-	*5%*	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Dr. G. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	*1. Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in*	*1. Dr. Lilly M Saleena, SRM IST*
2. Dr. Karthik Periyasamy, Scientist, Biocon, karthik.periyasamy@biocon.com	*2. Prof. R. B. Narayanan, Anna University, Chennai, arbeen09@gmail.com*	*2. Dr. S. Barathi, SRM IST*

Course Code	21BTC505J	Course Name	MODELING AND SIMULATION IN BIOPROCESS ENGINEERING	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biotechnology*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*learn the fundamentals of modelling and simulation*
CLR-2:	*know the models of fundamental laws*
CLR-3:	*learn the mathematical methods of models in reactor and bioreactors*
CLR-4:	*learn the prominence of numerical methods*
CLR-5:	*familiarize with MATLAB programming and simulation*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*understand the stages in model formation*	*1*	*1*	*2*
CO-2:	*form models for continuity equation and energy equation*	*2*	*2*	*2*
CO-3:	*derive models for reactors*	*2*	*2*	*2*
CO-4:	*gain knowledge on numerical integration*	*2*	*2*	*2*
CO-5:	*acquire knowledge in using MATLAB and Simulink*	*3*	*3*	*3*

Module-1 - Introduction to Modelling and Simulation	***15 Hour***
Uses of Mathematical Models- Scope of Coverage - Principles of Formulation-An Overview of Modelling and Simulation- Types of models- Types of Equations in a Model and Solution Strategy- Sources of Equations- Types of Simulation Applications of Simulation-Fundamental Laws- Continuity Equations-Energy Equations- Equations of Motion-Transport Equations- Equations of State- Equilibrium ***Practice:*** *1.2D and 3D plot using MATLAB* *2. Curve Fitting and parameter estimation for the data using MATLAB* *3.Microbial growth curve and Parameter estimations of Monod Kinetics*	
Module-2 - Bioreactor Models	***15 Hour***
Models for the Ideal Stirred Tank Bioreactor-Reactor - Ideal Continuous stirred tank Bioreactor-Ideal fed Batch Bioreactor -Bubble Column (BC) and Airlift Tower Loop Reactors- Flow Models ***Practice:*** *4.Enzymatic reaction and Parameter estimation in Michalis Menten Kinetics* *5.Dynamic simulation of chemical kinetics reactor* *6.Dynamic simulation of Binary distillation column*	
Module-3 - Bioprocess Models and Metabolic Flux Analysis	***15 Hour***
Unstructured Models-Structured Models-Segregated Models-Flux quantification methods- Metabolite Balancing-Isotopic Tracer Techniques- Application of Metabolic Flux Analysis in the Elucidation of Metabolic Networks ***Practice:*** *7.Dynamic simulation in Fluidized bed Reactor* *8.Dynamic simulation of batch reactor* *9.Dynamic simulation of Fed batch reactor*	
Module-4 – Modeling of Bioprocess Control	***15 Hour***
Accuracy and Reliability of Measured Data-Bioprocess Control-Adaptive linearizing control of Bioprocess	

Practice: *10.Dynamic Simulation of continuous stirred tank reactor* *11.Dynamic simulation of acetone- butanol- Ethanol Production.* *12.SIMULINK in Fed Batch Reactor*
Module-5 - Numerical Methods- MATLAB and Simulink Programming in Bioprocess ***15 Hour***
Curve fitting linear and Nonlinear models -Parameter Estimations- Numerical Methods in bioprocessing- MATLAB fundamentals- MATLAB programming in Bioprocess-SIMULINK fundamentals-Simulink in Bioprocess and Biocontrol system ***Practice:*** *13.SIMULINK in Batch reactor* *14.SIMULINK in CSTR* *15.SIMULINK in Control system*

Learning Resources	1. *Luben. W.L., "Process Modelling Simulation and Control for Chemical Engineers", McGrawHill, 1990.* 2. *Ashok Kumar Verma," Process Modelling and Simulation in Chemical, Biochemical and Environmental Engineering"CRC Press, 2015.* 3. *Schiigerl . K,K.-H. Bellgardt (Eds.), "Bioreaction Engineering Modeling and Control" Springer-Verlag Berlin Heidelberg 2000.* 4. *Burstein L., "Matlab in Bioscience and Biotechnology, Woodhead Publishing, 2011.*	5. *Biquette. W.B., "Process Dynamics- Modeling analysis with simulation", Prentice Hall; 1 edition, 1998.* 6. *Beers. K.J., "Numerical Methods for Chemical Engineering Applications in MATLAB", Massachusetts Institute of Technology, Cambridge University press. 2007. www.intelligen.com/ SuperPro Designer user guide.* 7. *Shijie Liu, "Bioprocess Engineering Kinetics, Sustainability, and Reactor Design" Elsevier,2020.* 8. *Joseph DiStefano," Dynamic Systems Biology Modeling and Simulation", Academic Press, 2013*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	-	*15%*	*15%*	-
Level 2	*Understand*	*25%*	-	-	*20%*	*25%*	-
Level 3	*Apply*	*30%*	-	-	*25%*	*30%*	-
Level 4	*Analyze*	*30%*	-	-	*25%*	*30%*	-
Level 5	*Evaluate*	-	-	-	*10%*	-	-
Level 6	*Create*	-	-	-	*5%*	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Dr. P. Bala Kumaran, Proklean Technologies (P) Limited, Chennai, genbalu86@gmail.com*	1. *Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in*	1. *Dr. M.Venkatesh Prabhu, SRMIST*
2. *.Dr. Karthik Periyasamy, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com*	2. *Prof. R. B. Narayanan, Anna University, Chennai, arbeen09@gmail.com*	2. *Dr. P. Radha, SRMIST*

ACADEMIC CURRICULA

Biotechnology

Professional Elective Courses

Regulations 2021

SRM INSTITUTE OF SCIENCE & TECHNOLOGY
(Deemed to be University u/s 3 of UGC Act, 1956)

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

Course Code	21BTE501T	Course Name	TISSUE ENGINEERING	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biotechnology*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*introduce basic knowledge on tissue engineering from the perspective of engineers*
CLR-2:	*provide knowledge on tissue organization and cell communication*
CLR-3:	*summarize methods for culturing cells along with biomaterials and bioactive molecules*
CLR-4:	*provide knowledge about evaluation of scaffolds for tissue engineering*
CLR-5:	*demonstrate stem cells isolation, characterization, applications, and signaling pathways*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*understand the properties of tissue engineering components*	*2*	*2*	*2*
CO-2:	*illustrate various scaffolds with their properties in tissue engineering*	*2*	*2*	*2*
CO-3:	*understand the cells along with their matrix for cell communications*	*2*	*2*	*2*
CO-4:	*understand various sources of stem cells and their utilization as induced pluripotent stem cells*	*2*	*2*	*2*
CO-5:	*explain preimplantation genetic diseases and their identification*	*2*	*3*	*2*

Module-1 - Introduction to Tissue Engineering	***9 Hour***
Basic definition; History of tissue engineering; Components in tissue engineering – biomaterials, cells, and bioactive molecules; Biomaterials – polymers and ceramics, properties of biomaterials, Cells – primary cells, cell lines; Bioactive molecules-nucleic acids, growth factors, hormones, phytocompounds	
Module-2 - Basic Concepts in Tissue Engineering	***9 Hour***
Tissue organization, morphogenesis, and remodeling; Tissue types and components; Cell sources; Cell culture; Cell lineages; Tissue repair and wound healing; Cell matrix and cell interaction; Cell proliferation and differentiation; Cell migration; Angiogenesis; Extracellular signaling and the regulation of cell fate	
Module-3 - Biomaterials and Bioactive Molecules in Tissue Engineering	***9 Hour***
Biomaterials in scaffold preparation; Bio composite scaffolds; Fabrications of scaffolds; Scaffolds in drug delivery and tissue engineering; Gene and protein delivery strategies in tissue engineering; Plants derived molecules in tissue engineering; Evaluation of biomaterials and biological responses - cytotoxicity; cell viability	
Module-4 - Stem Cells in Tissue Engineering	***9 Hour***
Types of stem cells; Isolation and characterization; Mesenchymal stem cells and hematopoietic stem cells; Amniotic fluid; in vitro fertilization; Preimplantation genetic diseases; Stem cell niche; Induced pluripotent stem cells; Therapeutic and reproductive cloning; Stem cell signaling – Wnt signaling, Notch signaling	
Module-5 - Tissue Engineering in Clinical Applications Medicine	***9 Hour***
Stem cells and gene therapy; Bone tissue engineering; Cardiac tissue engineering; Neuro regenerative tissue engineering; Skin tissue engineering; Emerging Technologies - organoids, organ-on-chip platforms; Legal, regulatory, and ethical issues in tissue engineering	

Learning Resources	1. *Clemens Van Blitterswijk, Jan De Boer, "Tissue Engineering", 2nd Edition - Academic Press, 2014.* 2. *Lijie Grace Zhang, John Fisher, Kam Leong, "3D Bioprinting and Nanotechnology in Tissue Engineering and Regenerative Medicine", 1st Edition - Academic Press, 2015.*	3. *Tissue engineering – Principles, protocols, and practical exercises, 2020, https://doi.org/10.1007/978-3-030-39698-5* 4. *Tissue engineering, Third edition, 2023, https://doi.org/10.1016/C2020-0-01481-7*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Mr. Nirmal Kumar, Jeevan Stem Cell Foundation, Chennai, stemcell@jeevan.org*	***1.*** *Prof R. Jayakumar, Amrita Vishwa Vidyapeetham. Coimbatore, rjayakumar@aims.amrita.edu*	***1.*** *Dr. N. Selvamururgan, SRMIST*
2. *Dr. B. R. Desikachari, Medical Director, Westminster Health Care, Chennai, brdesikachari@hotmail.com*	2. *Prof. Sudha Warrier, Sri Ramachandra Institute of Higher Education and Research, Chennai. sudha.warrier@sriramachandra.edu.in*	2. *Dr. K. Venkatesan, SRMIST*

Course Code	21BTE502T	Course Name	STEM CELL TECHNOLOGY AND THERAPEUTIC APPLICATIONS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biotechnology*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*introduce the sources of stem cells and a detailed study of various types of stem cells.*
CLR-2:	*introduce embryonic stem cell differentiation and their ethical issues.*
CLR-3:	*summarize methods for identification of adult stem cells, steps involved in lineage reprogramming*
CLR-4:	*provide knowledge about pattern of division between cancer stem cells and normal cells*
CLR-5:	*summarize signaling pathways responsible for stem cell proliferation*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*understand the properties and potency of stem cells*	*2*	*3*	*2*
CO-2:	*discuss the methods for isolation, purification and characterization of embryonic stem cells*	*2*	*3*	*2*
CO-3:	*understand the culture methods and plasticity of adult stem cells*	*2*	*2*	*2*
CO-4:	*understand cancer stem cells isolation, culture and identification*	*2*	*2*	*2*
CO-5:	*explain origin of stem cells from bone marrow and stem cell therapy*	*2*	*3*	*2*

Module-1 - Introduction to Stem Cells	***9 Hour***
Stem cell sources, Unique properties of stem cells, Classification of stem cells, Embryonic stem cell development, Adult stem cells, Amniotic fluids, Potency of stem cells, Similarities between embryonic and adult stem cells, Advantages and disadvantages of embryonic and adult stem cells, Determination of pluripotent nature of embryonic stem cells, Cellular models for pluripotent nature of embryonic stem cells, Stem cell niche	
Module-2 - Properties of Stem Cells and Their Use in Gene Expression	***9 Hour***
Embryonic stem cell culture, Potential of embryonic stem cells, In vitro fertilization, Preimplantation genetic diagnosis, Isolation of embryonic stem cells, Culturing of embryonic stem cells, Cryopreservation, Pluripotent properties of vitrified embryonic stem cells, Identification of human embryonic stem cells, Characterization of human embryonic stem cells, Establishment of embryonic stem cell cultures, Molecular basis of pluripotent nature of embryonic stem cells, Stem cell signaling and mediators, Interleukin signaling and glycoprotein 130, Factors influencing embryonic stem cells, Oct4, Nanog, Altering gene expression using embryonic stem cells, Overexpression-pronuclei method and cell culture method using embryonic stem cells, Embryonic stem cells – Gene knock-unconditional and conditional methods, Embryonic stem cells – Gene knock-in, Genome editing-CRISPR/Cas9	
Module-3 - Plasticity of Stem Cells and Reprogramming of Somatic Cells	***9 Hour***
Somatic stem cells, Sources for somatic stem cells, Isolation and culture of adult stem cells, Bone marrow and cord blood stem cells-advantages and disadvantages, Stem cells – Transdifferentiation, Stem cells – Plasticity, Metaplasia and transdifferentiation, Pancreas to liver, Barrett's metaplasia, Molecular mechanism of Barrett's metaplasia, Transdifferentiation of pigment epithelium, Reprogramming of nucleus, Somatic cell nuclear transfer in stem cell research, Somatic cell nuclear transfer in therapeutic cloning, Somatic cell nuclear transfer in reproductive cloning, Advantages of somatic cell nuclear transfer, Limitations of somatic cell nuclear transfer, Stem cell research-Its applications, Transplantation research-basic research applications-therapeutic delivery system, Ethics and safeguards for clinical applications of human stem cells	
Module-4 - Stem Cell Therapy and Tissue Engineering	***9 Hour***
Hematopoietic stem cells, Classification of hematopoietic stem cells, Lymphoid-hematopoietic system, Nature of hematopoietic stem cells, Source of hematopoietic stem cells, Sketch of bone marrow and its cells, Gene therapy, Germ line gene therapy , Somatic cell gene therapy, Non-viral methods for gene delivery, Liposomes- lipoplexes, Tissue engineering using biomaterials, Embryonic endothelial cells bone graft, Bone	

tissue engineering, Autograft, Allograft and Xenograft, Natural, synthetic biomaterials and stem cells, Cardiac tissue engineering, Biomaterials-methods-cell source for cardiac tissue engineering, Engineered heart tissues challenges, Parkinson's disease – genetics and environmental factors, Stem cell therapy, Stem cell sources for Parkinson's disease
Module-5 - Cancer Stem Cells ***9 Hour***
Introduction to cancer cells and cancer stem cells, Hierarchy of stem cells, Cancer cell progression, Breast cancer progression-sequences of events, Breast cancer bone metastasis, Genetic basis of cancer, Oncogenes, Tumor suppressor genes, Cancer cell behavior, Origin of cancer stem cells, Cancer stem cell hypothesis, Cancer cells therapy, Cancer stem cells resistant , Identification of cancer stem cells, Elimination of cancer stem cells, Identification of new and future therapy, Cancer stem cell pathways, Notch signaling pathway, Notch signaling components-oncogenes, Wnt and stem cells, Wnt signaling pathway, Wnt canonical and non-canonical signaling pathways, Activation/detection of Wnt signaling components-tumor suppressor-oncogenes

Learning Resources	1. *Robert Lanza, Edited by:Robert Lanza and Anthony Atala , "Essentials of Stem Cell Biology"3rd Edition, Academic Press,Copyright © 2014 Elsevier Inc.* 2. *Huang G, Ye S, Zhou X, Liu D, Ying QL. Molecular basis of embryonic stem cell self-renewal: from signaling pathways to pluripotency network. Cell Mol Life Sci. 2015, May;72(9):1741-57.*	3. *Essential current concepts in stem cell biology, 2020, https://doi.org/10.1007/978-3-030-33923-4* 4. *Recent advances in iPSC-derived cell types, Volume 4 in Advances in stem cell biology, 2021, https://doi.org/10.1016/C2019-0-04457-3*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Mr. Nirmal Kumar, Jeevan Stem Cell Foundation, Chennai, stemcell@jeevan.org*	1. *Prof R. Jayakumar, Amrita Vishwa Vidyapeetham. Coimbatore, rjayakumar@aims.amrita.edu*	1. *Dr. N. Selvamururgan, SRMIST*
2. *Dr. B. R. Desikachari, Westminster Health Care, Chennai, brdesikachari@hotmail.com*	2. *Prof. Sudha Warrier, Sri Ramachandra Institute of Higher Education and Research, Chennai. sudha.warrier@sriramachandra.edu.in*	2. *Dr. K. Venkatesan, SRMIST*

Course Code	21BTE503T	Course Name	ANIMAL CELL AS BIOREACTORS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biotechnology*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*educate the students about the basics of animal cells as bioreactors*
CLR-2:	*update the process of engineering cells for maximum expression*
CLR-3:	*provide the concept of generation of biomass*
CLR-4:	*update techniques for adjusting cellular metabolism for optimum product yield.*
CLR-5:	*explain the methods in downstream processing*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*describe about the fundamentals of animal cells as bioreactors*	*1*	*1*	*1*
CO-2:	*design the process of engineering cells for maximum expression.*	*2*	*2*	*2*
CO-3:	*analyze the concept of generation of biomass*	*2*	*2*	*2*
CO-4:	*explain techniques for adjusting cellular metabolism for optimum product yield.*	*3*	*3*	*3*
CO-5:	*analyze the methods in downstream processing.*	*3*	*3*	*3*

Module-1 - Introduction	***9 Hour***
Introducing animal cells as bioreactors-genetically engineered microbial system –limitations-Animal cell technology for Industrial products-The effective control of culture parameters, Generation of the necessary high levels of biomass, Animal cell technology for production of proteins in industries.	
Module-2 - Engineering of cells	***9 Hour***
Engineering cells for maximum expression- transient expression system stable expression system-dominant control regions- Factors governing heterologous gene expression- Baculovirus-Insect Cell Expression production of heterologous protein using lymphoid cell based expression system- improving translational efficiency, Dihydrofolate reductase - Methotrexate (MTX) Selection, Vectors designed for amplifiable expression Adenosine deaminase, Glutamine synthetase, Tandem amplification.	
Module-3 - Generation of Biomass	***9 Hour***
Generation of Biomass-media for animal cell culture- serum free media medium design- Engineering a new medium-Fermenter design for animal cell culture-suspension cell culture-Immobilised cells, Regulation of Proliferation and Differentiation, Growth factors.	
Module-4 - Cellular Metabolism and Optimum Yield	***9 Hour***
Cellular metabolism for optimum yields, Intracellular competition for high-energy intermediates and metabolic precursors -Effect of culture condition on protein glycosylation, Incorrect glycosylation -culture parameters that affect yield Protease release by cells – osmotic shock – Butyrate addition.	
Module-5 - Downstream Processing	***9 Hour***
Downstream processing- production of effective and safe biopharmaceuticals-challenges in purification-Characterization of recombinant protein production-regulatory aspects of using cells as bioreactors-viral contamination of animal cell derived pharmaceuticals and prevention Ligand leaching – causes – improvements	

Learning Resources	1. R. Ian Freshney Culture of Animal Cells. 2021. Wiley-Blackwell. 2. Glyn Stacey, John Davis, Medicines from Animal Cell Culture. 2016. John Wiley & Sons, Ltd.	3. Terence Cartwright ,Animal cells as bioreactors. 2009. Cambridge University Press. 4. Basant Kumar Sinha and Rinesh Kumar , Principles of Animal cell culture. 2008. International book distributing Co.Ltd.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	15%	-	15%	-	15%	-
Level 2	Understand	25%	-	20%	-	25%	-
Level 3	Apply	30%	-	25%	-	30%	-
Level 4	Analyze	30%	-	25%	-	30%	-
Level 5	Evaluate	-	-	10%	-	-	-
Level 6	Create	-	-	5%	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. C. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	1. Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in	1. Dr.R.A.Nazeer, SRMIST
2. Dr. Karthik Periyasamy, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com	2. Prof. R. B. Narayanan, Anna University, Chennai, arbeen09@gmail.com	2. Dr.S.Subhashini (Sr), SRMIST

Course Code	21BTE504T	Course Name	CLINICAL ENDOCRINOLOGY	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biotechnology*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*state the fundamental principles of clinical endocrinology.*
CLR-2:	*illustrate the relevant features of growth hormones and glands.*
CLR-3:	*associate the action of thyroid and parathyroid hormones with iodine intake and calcium homeostasis.*
CLR-4:	*uncover the physiology of adrenal gland, homeostatic control, and the glucocorticoid receptor.*
CLR-5:	*acquire a broad overview of reproductive endocrinology.*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*gain the skills and knowledge required for the understanding of clinical endocrinology.*	*2*	*-*	*1*
CO-2:	*discuss the physiology of gonadotrophs, growth hormone and the hypothalamo-pituitary-adrenal axis*	*2*	*-*	*2*
CO-3:	*correlate the disorders of bone and mineral metabolism with their respective hormones*	*3*	*-*	*2*
CO-4:	*integrate the disorders of stress hormones with the pathology of diabetes mellitus*	*3*	*-*	*3*
CO-5:	*connect the role of endocrine hormone disruption with gonadal dysfunction.*	*3*	*-*	*3*

Module-1 - Endocrine Glands and Hormones	***9 Hour***
Function and classification of hormones- Peptide and steroid hormones, Hormone receptors, neuroendocrine interactions, feedback loops.	
Module-2 - Hypothalamus and Pituitary	***9 Hour***
Hypothalamo-pituitary axis, Action of growth hormones, Anterior pituitary control over gonadal function and development, Posterior pituitary, and social behavior	
Module-3 - Thyroid and Parathyroid Glands	***9 Hour***
Iodine Intake, Action of Thyroid hormones, parathyroid gland: metabolism and transport of vitamin D, Calcium and phosphate balance, Bone and mineral metabolism	
Module-4 - Adrenal Glands, Pancreas and Glucocorticoid Receptors	***9 Hour***
glucocorticoids, structure and function, Stress hormones, Glucose turnover, Insulin and glucagon, Disorders of Carbohydrate metabolism – Diabetes Mellitus Type 1 and 2	
Module-5 - Reproductive Endocrinology	***9 Hour***
Sexual differentiation, gonadotrophins-LH and FSH, Androgens, gonadal Differentiation, Estrogens and the endocrinology of Pregnancy, Endocrine disorders in childhood and adolescence, Endocrine disrupting compounds	

Learning Resources		
	1. *Nussey S, Whitehead S. Endocrinology: An Integrated Approach. Oxford: BIOS Scientific Publishers, 2001* 2. *Shlomo M, Ronald K, Clifford J. R, Richard J. A, and Allison B. G, Williams Textbook of Endocrinology,14th edition, Elsevier, 2019*	3. *Illie, I.R. Introduction to Endocrinology. Springer, 2020*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Dr. C. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com*	1. *Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in*	1. *Dr. S Barathi, SRMIST*
2. *Dr. Karthik Periyasamy, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com*	2. *Prof. R. B. Narayanan, Anna University, Chennai, arbeen09@gmail.com*	2. *Dr. R. Vasantherekha SRM IST*

Course Code	21BTE505T	Course Name	BIOMOLECULAR AND BIOANALYTICAL TECHNIQUES	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biotechnology*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	**The purpose of learning this course is to:**
CLR-1:	*learn the skills to understand the theory and application of Genomics in the field of Biotechnology.*
CLR-2:	*develop the skills to understand the theory and application of Proteomics Techniques in the field of Biotechnology.*
CLR-3:	*learn the skills to understand the theory and application of Enzyme Techniques in the field of Biotechnology.*
CLR-4:	*develop the skills to understand the theory and application of Metabolomic Techniques in the field of Biotechnology.*
CLR-5:	*learn the skills to understand the theory and application of Separation and Advanced Microscopic Techniques in the field of Biotechnology.*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*gain the knowledge and skill to apply various genomics techniques in the field of biotechnology.*	*1*	*2*	*2*
CO-2:	*acquire the knowledge and skill to apply proteomics techniques in the field of biotechnology.*	*2*	*3*	*3*
CO-3:	*hands on experience in the field of enzyme techniques*	*3*	*3*	*3*
CO-4:	*acquire the knowledge and skill to apply metabolites techniques in the field of biotechnology.*	*1*	*3*	*2*
CO-5:	*hands on experience in the field of advanced microscopic techniques*	*2*	*3*	*3*

Module-1 - Introduction to Genomic Based Analytical Techniques	***9 Hour***
Electrophoresis Techniques; hybridization-based techniques; Perform virtual gel electrophoresis and PCR simulations; Molecular fingerprinting techniques – Principles and Applications; Gene silencing techniques - Principles and Applications; IoT and AI based DNA Fingerprinting Prediction tools and Algorithms; Microarray Technology and Data Analysis; Next Generation Technologies and Tools	
Module-2 - Introduction to Proteomics Based Analytical Techniques	***9 Hour***
Mass spectrometry: ionization sources, mass analyzers, different types of mass spectrometers; MALDI – Principle and sample preparation and spectral analysis ; Q-TOF MS - Principle and sample preparation and spectral analysis; Tandem affinity purification-mass spectroscopy (TAP-MS)- Principle and sample preparation and analysis; ESI MS - Principle and sample preparation and spectral analysis; Protein Identification from MS data – Online Tutorial Access Mascot - protein identification, characterization and quantitation using mass spectrometry data- Online Tutorial; Protein-protein interactions (PPI) methods; Modificomics: understanding post-translational modifications	
Module-3- Introduction to Enzyme based Techniques	***9 Hour***
Enzyme Kinetics, Reactions and Assays; Mechanism of enzyme action; IoT based kcat prediction enables improved enzyme-constrained model reconstruction – Online Tutorial; Enzyme Assays; Perform virtual Enzyme Assays & Enzyme Kinetic Modelling; Chemical modification of active site groups; Kinetic Modelling of Enzyme Catalyzed Biotransformation of drug; IOT based Enzyme Engineering and Design	
Module-4 - Introduction to Metabolomics Techniques	***9 Hour***
Metabolite Identifications -Nontargeted Approaches and Targeted Approaches; Metabolite Separation Techniques; Perform virtual Metabolite Quantifications simulations; Metabolite Detection Techniques; Metabolomic Pathway Analysis – In vivo Studies, Invitro Studies; Computational Metabolite Data Analysis - Software's and Statistical Tools ; Pharmacometabolomic	
Module-5 - Special Topics: Advanced Microscopy Techniques	***9 Hour***
Fluorescence Microscopy Techniques – FRET, BiFC, FLIM, FLIP, FRAP, FLAP - Analysis and Applications (Demo); Electron Microscope: TEM & SEM - Analysis and Applications (Demo); Chemical Biology- Drug-like Molecules; New Chemicals	

Learning Resources	1. *Primrose and Twyman (2006), Principles of Gene Manipulation and Genomics. Blackwell, ISBN 1 405 13544 1* 2. *Brown (2000), Essential Molecular Biology VII. AP, ISBN-10: 0199636443* 3. *Ali Masoudi-Nejad, Zahra Narimani , Nazanin Hosseinkhan (2013) , Next Generation Sequencing and Sequence Assembly: Methodologies and Algorithms (Springer Briefs in Systems Biology), [Paperback] ISBN-10: 1461477255*	4. *Lambert and Mazzola (2013), Nuclear Magnetic Resonance Spectroscopy: An Introduction to Principles, Applications and Experimental Methods, ISBN 0- 13-089066-9 (Prentice Hall)* 5. *Edmond de Hoffmann, Vincent Stroobant (2015), Mass spectrometry: principles and applications, 2nd ed, J. Wiley, IBSN 0471485659.* 6. *Alessandra Sussulini (2017), Metabolomics: From Fundamentals to Clinical Applications, Springer Cham ISBN978-3-319-47655-1*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Dr. C. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com*	1. *Prof. B.S. Lakshmi, Director, CBT, Anna University, Chennai*	1. *Dr. W. Richard Thilagaraj, SRMIST*
2. *Dr. Karthik Periyasamy, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com*	2. *Dr. Subramshu Shekar Bhattacharya, IIT, Chennai*	2. *Dr. S. Barathi, SRMIST*

Course Code	21BTE506T	Course Name	PROTEOMICS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biotechnology*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*provide basic concepts and advantage of proteomics over conventional tools of protein analysis*
CLR-2:	*discuss detailed knowledge about gel-based proteomics, instrumentation, methodology and protein identification tools*
CLR-3:	*elaborate extensive literature on MS based quantitative proteomics, tools for PTM detection and quantification*
CLR-4:	*explain concepts and applications of protein microarray and advanced proteomic techniques.*
CLR-5:	*provide knowledge, case studies on applications of proteomics in various fields of biotechnology and assess students' ability to apply the knowledge of proteomics.*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*illustrate the concepts of proteomics and advantages over conventional protein separation techniques*	*2*	*2*	*2*
CO-2:	*gain comprehensive knowledge about principles, generalized protocols and applications of gel-based proteomics and mass spectrometry*	*2*	*2*	*2*
CO-3:	*acquire comprehensive understanding about non-gel based proteomics methods and applications*	*3*	*2*	*2*
CO-4:	*illustrate the concepts and applications of array based proteomics methods*	*3*	*2*	*2*
CO-5:	*explore the applications of proteomics methods in disease models, pharmaceuticals and drug discovery.*	*2*	*2*	*2*

Module-1 –Principles of Proteomics	***9 Hour***
Concepts of proteomics, Advantages of proteomics over genomics, Protein dynamic range (serum/plasma, cells), structure, function and post translational modifications. Analytical tools for protein separation, detection and quantification of protein expression. Conventional Methods of PTM identification. Conventional protein separation techniques: Basic principle of chromatography, instrumentation, ion-exchange, size-exclusion and affinity chromatography techniques.	
Module-1 - Gel-based Proteomics	***9 Hour***
2D –PAGE, Sample preparation (Serum/plasma/biological fluids, cells/bacteria, tissues – homogenization, LN2 Pulverization and Pressure cycling homogenizer), protein quantification. Isoelectric focusing using pH gradient strips and capillary gels. SDS-PAGE separation. Mass spectrometry compatible – various gel staining methods (commassie, silver, SYPRO RUBY/orange fluorescent staining. Staining techniques to visualized Post translational modifications. Image analysis of 2D gels. In-solution/In-gel/On membrane digestion of proteins, MALDI-TOF MS/MS analysis, peptide mass fingerprint (PMF), de novo peptide sequencing, protein sequence database, bioinformatics tools for protein identification. 2D-DIGE analysis: Principle and methodology. Cy3, Cy2 and Cy5 dyes. Differential protein labeling using cyanine dyes (minimal and saturation labeling), 2D-DIGE gel separation and differential spot detection and protein identification. Data analysis. Application of 2DE and 2D-DIGE analysis in biotechnology. Limitations of 2DE analysis.	
Module-3 - Non-gel based Proteomics	***9 Hour***
Introduction to Mass spectrometry based proteomics. Principles and instrumentation. MALDI-TOF MS/MS, On-slide FFPE tissue digestion and MALDI-Imaging Mass spectrometry, SWATH MS and matrisome analysis, SELDI-TOF, LC-ESI MS/MS, Fourier transform MS, Linear ion trap/quadrupole MS, top down/bottom up proteomics, Mass spectrometry based label free quantitative proteomics. Shotgun proteomic techniques. RPLC, Multi dimensional protein identification technology (MudPIT). Label based quantitative methods; ICAT/MCAT, SILAC, Tandem Mass Tags and ITRAQ. PTMs; phosphorylation(IMAC, MOAC & PolyMAC), glycosylation(Lectin and FASP based methods) and acetylation(antibody based method)	
Module-4 - Protein Arrays and Bead Based Arrays	***9 Hour***
Antibody/antigen array, cytokine array, protein pathway array/reverse phase protein arrays, Next generation tissue microarrays, Multiplexed bead based assays, Aptamer-based assay, single cell proteomics,	

single molecular proteomics. Proximity extension assay. Functional and Structural proteomics. Bioinformatic analysis.
Module-5 - Applications of Proteomics and Case Studies ***9 Hour***
Clinical proteomics, biomarker discovery, Medical proteomics-disease diagnosis, Pharmaceutical proteomics, proteomics and plant biotechnology. Applications in cancer biology, cell biology, immunology, diseases and drug discovery. Applications in industrial biotechnology.

Learning Resources	1.*Clinical proteomics by Fernando J.Corrales, Alberto Paradela, Miguel Marcilla, Edition 2022.* 2.*Principles of Proteomics by R.M Twyman, 2nd edition, 2013* 3.*Proteins and Proteomics, A laboratory Manual by Richard J.Simpson, 2002* 4.*Proteomics Introduction to Methods and Applications by Kraj & Silberring 1st edition, 2008*	5.*Industrial Proteomics: Applications for Biotechnology and Pharmaceuticals, 1st Edition , 2005,* 6.*Latest Review articles on proteomics will be provided as resource materials (example; Mass spectrometry-based proteomics as an emerging tool in clinical laboratories, Clinical proteomics, 2023; High-throughput proteomics: a methodological mini-review, Laboratory investigation, 2022 etc.)*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	*-*	*15%*	*-*	*15%*	*-*
Level 2	*Understand*	*25%*	*-*	*20%*	*-*	*25%*	*-*
Level 3	*Apply*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*10%*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*5%*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. C. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com*	1. *Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in*	1. *Dr. D Mohan Kumar, SRMIST*
2. *Dr. Karthik Periyasamy, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com*	2. *Prof. R. B. Narayanan, Anna University, Chennai, arbeen09@gmail.com*	2. *Dr. DVL Sarada, SRMIST*

Course Code	21BTE507T	Course Name	BIOREMEDIATION AND BIODETERIORATION TECHNOLOGIES	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biotechnology*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*explain the fundamental principles of bioremediation and biodeterioration mechanisms and types*
CLR-2:	*discuss on mechanisms of biodegradation of xenobiotics and recalcitrant*
CLR-3:	*describe the bioconversion of specific environmental pollutants*
CLR-4:	*discuss on the applications of biomolecules on the bioremediation and biodeterioration of industrial wastes*
CLR-5:	*illustrate the use of novel materials and biosensors in the environmental pollution abatement and different bioremediation strategies*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*analyze various bioremediation technologies and their mechanisms and biodeterioration methods*	*2*	*2*	*3*
CO-2:	*interpret on the biological pathways for the biodegradation of xenobiotic and recalcitrant from industrial wastes*	*2*	*3*	*3*
CO-3:	*apply the advanced biotransformation processes for the conversion of various environmental pollutants*	*2*	*3*	*3*
CO-4:	*demonstrate the nature of biomolecules and their environmental applications*	*1*	*2*	*3*
CO-5:	*apply novel materials, nanomaterials and biosensors for the environmental bioremediation and monitoring and design effective bioremediation techniques for treatment of industrial pollutants*	*2*	*3*	*3*

Module-1 - Principles of Bioremediation	***9 Hour***
- Introduction to bioremediation of environmental pollutants; Types of bioremediation; Bioremediation Mechanisms; Metabolic process involved in bioremediation; Factors affecting bioremediation; Biological and non-biological factors; Microbes for Bioremediation; Microbes in different habitats; Extremophiles and its tolerance in extreme environment; Bioavailability of contaminants; Bioavailability constraints; Strategies to increase bioavailability; Strategies for improvement of bioremediation techniques; Mycoremediation technologies; Macro and Microfungi on bioremediation; Phytoremediation technologies; Algal Bioremediation.	
Module-2 - Biodegradation of xenobiotics	***9 Hour***
*Bioremediation techniques-In situ and ex situ remediation technologies; Characterization of essential factors for bioremediation; Site specific factors; Molecular techniques in the analysis of contaminated sites; Application of the techniques; Mechanism of biodegradation of xenobiotics: Aliphatic, cycloalkanes, aromatics; Aliphatic hydrocarbon degradation**;** Alkanes and Alkenes**;** Cycloalkanes; Aromatic hydrocarbon degradation; BTEX bioremediation; Degradation of Phenols; Poly chlorinated biphenyls (PCBs)**;** Degradation of Polycyclic aromatic hydrocarbon degradation; Crude oil bioremediation-Case study; Oil spills and oil recovery- Case study; Application of biosurfactants in oil spill bioremediation.*	
Module-3 - Bioconversion of specific pollutants	***9 Hour***
Heavy metal Remediation: Heavy metal pollution and sources; Microbial interactions with heavy metals; Heavy metal removal mechanisms; Genetics of resistance and tolerance; Microbial transformation; Accumulation and concentration of metals in biomass; Biosurfactants in heavy metal remediation; Role of Metallothionein; Bioremediation of metal contaminated sites-Case studies; Biomining-Treatment of wastewater from mines-Case studies; Textile industry effluent treatment- Classification of dyes, mechanisms of dye degradation, Decolourisation and degradation of textile dye-Case studies.	
Module-4 - Biocatalysts and Genetically Engineered Microorganisms on The Bioremediation of Industrial Wastes	***9 Hour***
Structural properties of Laccases; Mechanism of action of laccase on degradation of recalcitrant compounds; Role of laccases in bioremediation of industrial wastes; Treatment of different types of industrial effluents by laccase; Enzymatic pretreatment of lignocellulosic wastes; Role of manganese peroxidase (MnP) in lignin degradation; Role of Lignin peroxidase (LiP); Biofuels production from lignocellulose; Lipases and their role in the conversion of fat containing industrial wastes; Mechanism of action of lipases; Genetically engineered microbes in bioremediation, Role of plasmids in bioremediation; Enhancement of novel microbial degradative abilities; Metagenomics in bioremediation; Molecular biological techniques in bioremediation.	

Module-5 - Solid waste Management	***9 Hour***
Plastics and Microplastics-Effects, Bioremediation, Reuse and Recycling, Bioplastics, Radioactive waste-Sources of radioactive waste, Classification of radioactive wastes, Effects and Dangers of radioactive waste, Radioactive waste disposal and management-Methods, Bioremediation, Challenges, Microbial adaptation for radioactivity, Actinoid Bioremediation, Direct enzymatic reduction of radionuclides, Direct enzymatic reduction of radionuclides, Biosorption and bioaccumulation, Bio stimulation, Biomineralization of radionuclides, Case studies; E-waste Management; Nanomaterials in environmental bioremediation; Biosensors in the Environmental Bioremediation and Biodeterioration.	

Learning Resources	1. *Ram Chandra, Advances in Biodegradation and bioremediation of industrial waste, Taylor and Francis, 2017* 2. *P.Rajendran and P.Gunasekaran, Microbial Bioremediation, MJP Publishers, 2006* 3. *Bruce E. Rittmann, Perry L. McCarty, "Environmental Biotechnology: Principles and Applications" McGraw-Hill, 2001.*	4. *Bimal C. Bhattacharya and Rintu Banerjee, Environmental Biotechnology, Oxford University press, 2007* 5. *Agarwal S. K., "Environmental Biotechnology", APH Publishing, 2000.* 6. *Martin Alexander, "Biodegradation & Bioremediation", Academic press, 1999*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	*-*	*15%*	*-*	*15%*	*-*
Level 2	*Understand*	*25%*	*-*	*20%*	*-*	*25%*	*-*
Level 3	*Apply*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*10%*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*5%*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Dr. S. Sam Gunasekar, Orchid Pharma Ltd., Chennai*	1. *Dr.S.V.Srinivasan, CSIR-Central Leather Research Institute, Chennai*	*1. Dr. K.Ramani, SRMIST*
2. *Dr. R. Chandra Mohan, General Manger, Environment & safety Chennai Petroleum Corporation Ltd. Chennai*	2. *Dr.N.Manickan, CSIR-Indian Institute of Toxicology Research, Lucknow*	*2. Dr. S.Barathi, SRMIST*

Course Code	21BTE508T	Course Name	BIOTREATMENT TECHNOLOGIES AND REGULATION FOR INDUSTRIAL WASTE	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biotechnology*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*gain specialized knowledge in the area of wastewater treatment processes*
CLR-2:	*understand fundamental principles of aerobic biological treatment technologies and reactor designs*
CLR-3:	*gain knowledge on principles of anaerobic biological treatment technologies and reactor designs*
CLR-4:	*analyze the importance of nutrients removal and biotechnological advancements*
CLR-5:	*understand the environmental regulation, laws and auditing pertaining to clean and green eco-system*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*understand with the common physical, chemical and biological unit operations encountered in treatment processes*	*2*	*2*	*3*
CO-2:	*apply an appropriate design of aerobic biological treatment system for the treatment of wastewater*	*2*	*3*	*3*
CO-3:	*evaluate an anaerobic biological treatment system for a given wastewater to achieve a specified end use*	*3*	*3*	*3*
CO-4:	*analyze and discuss emerging biotechnological solutions for advanced wastewater treatment and water recycling*	*2*	*3*	*3*
CO-5:	*understand the laws and regulatory concerns into research on novel technologies for wastewater treatment*	*3*	*3*	*3*

Module-1 - Environmental Pollutants and Physico-Chemical Technologies	***9 Hour***
Environmental Pollutants-Sources, Classification-Municipal and Industrial wastes, Waste management-4R principle, Waste management pyramid, Characteristics of wastewater- proximate, ultimate, Characteristics of wastewater- biochemical, Waste water Treatment-Unit Operations, Physico-chemical methods of wastewater treatment, Removal of Colloids and suspended particles, Filtration-Depth Filtration, Surface Filtration, Membrane Filtration, Adsorption – Ion Exchange, Activated Carbon, VOC removal-Air and Steam Stripping.	
Module-2 - Recent trends in Biological Wastewater Treatment	***9 Hour***
Aerobic Biological Treatment-Conventional Activated Sludge Process (CASP), Cyclic Activated Sludge System (CASS), Characteristics of aerobic activated sludge, Membrane Bioreactor (MBR), , Process analysis and mass balance in an aerobic treatment process; Aerobic attached growth Technologies – Biofilm development process, Biological towers and Trickling filter, Submerged Aerobic Fixed Film Reactor- Granular – Media Filters, Integrated Fixed Film Activated Sludge (IFAS) System and Rotatory biological contactor, Fluidized Bed & Packed Bed- Biofilm reactors, Two stage, Aerobic UNI Tank System, Root Zone Treatment, Algal based technologies, Advanced oxidation process, Electrolysis and Microbial fuel cells.	
Module-3 - Anaerobic Treatment Technologies	***9 Hour***
Anaerobic digestion process: Anaerobic digestion-Process Flow, Anaerobic Biological treatment technologies, Microbiology of Anaerobic digesters-Fermentative, acetogenic-methanogenic, Factors influencing the anaerobic digestion process, Reactor configurations for anaerobic treatment - Upflow anaerobic sludge blanket reactor, Expanded Granular Sludge Bed (EGSB) Reactor, Anaerobic Sequencing Batch Reactor, Anaerobic packed bed Filter, Anaerobic Baffled Reactor, Fluidized anaerobic Bed Reactor, Hybrid (UASB+Packed Bed) Reactor, Anaerobic Membrane Bioreactor, Two Phase AD Process.	
Module-4 - Nutrient Removal and Biovalorization of Industrial Wastes for the Production of Value-Added Products	***9 Hour***
Eutrophication, Recent advances in Nitrogen removal- Nitrification &Denitrification Processes, Biochemistry and Physiology of Nitrifying Bacteria, One – sludge versus two sludge nitrification, Physiology of Denitrifying Bacteria; Tertiary Denitrification, One- sludge denitrification, Key design parameters of biological N removal- Anammox process; Biological Phosphorous Removal: Aerobic process-Normal Phosphorus Uptake into Biomass, Integrated process-EBPR process-mechanisms. Contributions of Biotechnology for the environmental managements and industrial applications, Microbial enzymes for environmental applications, Advantages of immobile cells or enzymes over free cells and free enzymes, Role of Biocatalysts in pollutant removal, Application of Immobilized cells in pollutants removal, Application of Immobilized enzymes in pollutants removal.	

Module-5 - Environmental Regulations and Technology	***9 Hour***
Regulatory Concerns: Laws, regulations and permits (National and International), Air, Water, Solid Waste, Environmental Impact Assessment (EIA), Environmental Auditing-ISO14001, National Environmental Policy act, Occupational Safety and Health Administration (OSHA), Storm Water Regulations; Case studies on treatment and recycling of industrial wastewater- textile, paper, leather, pharmaceutical industries.	

Learning Resources	*1. Wastewater Engineering: Treatment Disposal Reuse by Metcalf & Eddy.* *2. Environmental Biotechnology: Principles and Applications by Bruce E. Rittmann.* *3. Wastewater Engineering Treatment and Reuse: McGraw Hill, G Tchobanoglous,FI Biston, 2002.*	*4. Industrial Wastewater Management Treatment and Disposal by Wastewater. McGraw Hill III Edition 2008.* *5. Biological Wastewater Treatment", Second Edition, Marcel Dekker, Inc., New.York* *6. Vogel. H.C., Todaro. C.L., "Fermentation and Biochemical Engineering Handbook - Principles, Process design, and Equipment", Noyes. Publications, 1997*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. S. Sam Gunasekar,Orchid Pharma Ltd., Chennai*	*1. Dr.G.Sekaran, CSIR-Central Leather Research Institute, Chennai*	*1. Dr. K.Ramani, SRMIST.*
2. Dr.R.Chandra Mohan, Chennai Petroleum Corporation Ltd. Chennai	2 *Dr. Susmita Dutta, National Institute of Technology, Durgapur*	*2. Dr.B.Samuel Jacob, SRMIST.*

Course Code	21BTE601T	Course Name	COMPUTATIONAL AND ARTIFICIAL INTELLIGENCE IN BIOPROCESS ENGINEERING	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biotechnology*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*solve problems in fundamentals of thermodynamics, mass and energy balance.*
CLR-2:	*study the kinetics, mass transfer and scaleup*
CLR-3:	*learn the problems in downstream techniques*
CLR-4:	*learn the fundamentals of ai in process engineering*
CLR-5:	*familiarize the ml and python programming in biosystem*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*understand the fundamentals in biosystem*	*3*	*2*	*3*
CO-2:	*study the kinetics, mass transfer and scaleup in bioreactor*	*3*	*2*	*3*
CO-3:	*gain knowledge in downstream techniques*	*3*	*2*	*3*
CO-4:	*apply AI in bioprocess*	*2*	*2*	*3*
CO-5:	*implement ML and python in bioprocess*	*3*	*2*	*3*

Module-1 - Thermodynamics of Biosystem- Stoichiometric	***9 Hour***
Enthalpy-Entropy-Gibbs Free Energy-Bioenergetics-Heat of Reaction- Heat of Formations-Mass Balance-Yield calculation-Elemental Balance-Electron Balance-ATP synthesis	
Module-2 - Kinetics	***9 Hour***
Growth-Product formation Kinetics-Death- Contaminants-Bioreactors System-Mass transfers -Scaleups	
Module-3 - Bio separations	***9 Hour***
Recovery-Isolations-Concentration- Purifications- Polishing- Case studies	
Module-4 - Artificial Intelligence in Bioprocess	***9 Hour***
AI fundamentals-AI in Bioprocess Systems-Introduction of Expert System-Search Strategies in Artificial Intelligence-Knowledge Representation in Prolog	
Module-5 - Machine Learning and Python Programming in Bioprocess	***9 Hour***
Machine Learning in Bioprocess-Fundamentals of python- solving initial -value problems- Boundary-value problems through ODE- Numerical Integrations through python-Python programming in Biosystems	

Learning Resources		
	1.Michael L. Shuler, Fikret Kargi, Matthew De Lisa "Bioprocess Engineering: Basic Concepts", 3rd Edition, Prentice-Hall, 2017. *2.Tarun K. Ghose, "Bioprocess Computations in Biotechnology" Ellis Horwood Series in Biochemistry and Biotechnology,1990.* *3.Thomas E.Quantrille, "Artificial Intelligence in Chemical Engineering"Academic Press,1st edition.1,1991.*	*4. Nayef Ghasem, "Numerical Methods in Chemical Engineering Using Python® and Simulink",CRC press, 1st Edition 2024.* *5. Qingkai Kong, "Python Programming and Numerical Methods A Guide for Engineers and Scientists",Academic Press, 2021.*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. P. Bala Kumaran, Proklean Technologies (P) Limited, Chennai, genbalu86@gmail.com*	1. *Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in*	1. *Dr. M.Venkatesh Prabhu, SRMIST*
2. *Dr. Karthik Periyasamy, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com*	2. *Prof. R. B. Narayanan, Anna University, Chennai, arbeen09@gmail.com*	2. *Dr. P Radha, SRM IST*

Course Code	21BTE602T	Course Name	MEMBRANE TECHNOLOGY	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biotechnology*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*acquire knowledge on membrane and its application in process industries*
CLR-2:	*understand the engineering in membrane*
CLR-3:	*produce and characterize the membrane*
CLR-4:	*understand concentration polarization and membranes of RO-UF and MF*
CLR-5:	*discuss the membranes as reactor, distillation of alcohol and fouling studies*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*implement membranes for bioprocess industries*	*2*	*2*	*2*
CO-2:	*learn methods separation process and its transport mechanism*	*2*	*2*	*3*
CO-3:	*cast membranes of different types for the separation process*	*3*	*3*	*3*
CO-4:	*apply membrane for dialysis*	*3*	*3*	*3*
CO-5:	*demonstrate membrane for distillation and production*	*2*	*3*	*3*

Module-1 - Membranes overview and its Industrial Application	***9 Hour***
Overview of Separation Processes-Developmental History of membranes-Advantages and Disadvantages of membranes-various industrial applications	
Module-2 - Transport Mechanisms and Membrane Separation Process	***9 Hour***
Transport Mechanisms-Membrane separation process-Modules-Operations	
Module-3 - Membrane casting, and Characterization	***9 Hour***
Membrane precursors-polymeric membrane preparation-polymeric tubular membrane-mixed matrix membrane-ceramic membrane-zeolite membrane-Glass membrane-dense membrane-membrane cost-Characterization Techniques	
Module-4 - Concentration polarization -RO-UF-MF	***9 Hour***
Boundary Layer film model-Determination of Peclet Number-Concentration polarization in liquid separation process-Gas separation processes- cross flow- co-flow-counter flow-Reverse osmosis-Ultrafiltration-Microfiltration	
Module-5 - Membrane distillation, Membrane bioreactors -Fouling - Current trends in Membrane science	***9 Hour***
Membrane distillations-Membrane Bioreactors-Fouling Mechanism and its remedies- Artificial organs-conductive membranes- membranes in warfare-membranes in Health science- Future perspective.	

Learning Resources	
	1. *Kaushik Nath," Membrane Separation Processes", PHI, publication, India, 2012.* 2. *William.K..Wang," Membrane Separations in Biotechnology", Marcel Dekker. INC, New York, 2001* 3. *Scott .K, "Hand Book of Industrial Membranes "Elsevier Publication, 1995.* 4. *Mihir Kumar Purkait, "Membrane Technology in Separation Science"CRC Press,2018* 5. *Richard W .Baker, "Membrane Technology and Applications", John Wiley & Sons, Ltd,Ist Ed.,2004*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. P. Bala Kumaran, Proklean Technologies (P) Limited, Chennai, genbalu86@gmail.com*	1. *Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in*	1. *Dr. M.Venkatesh Prabhu, SRMIST*
2. Dr. Karthik Periyasamy, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com	2. *Prof. R. B. Narayanan, Anna University, Chennai, arbeen09@gmail.com*	2. *Dr. P Radha, SRMIST*

Course Code	21BTE603T	Course Name	PLANT FOOD AND HUMAN HEALTH	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biotechnology*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the plant's food and their nutritional composition*
CLR-2:	*discuss the dietary impact on human health*
CLR-3:	*explain the metabolic diseases caused by diet*
CLR-4:	*comprehend the genetic improvement of plants for nutrition enrichment*
CLR-5:	*describe the biofortification to overcome nutritional deficiencies*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*compare and contrast the different types of nutrients found in food and review the pros and cons of different types of nutritional studies*	*2*	*2*	*-*
CO-2:	*categorize human health issues intensely associated with diet*	*2*	*2*	*-*
CO-3:	*summarize risk factors associated with the development of type 2 diabetes and cardiovascular disease*	*3*	*-*	*2*
CO-4:	*accelerate and enhance plant breeding, and summarize the strengths and weaknesses of each approach*	*3*	*3*	*-*
CO-5:	*summarize the roles of plant science in improving human nutrition*	*3*	*-*	*3*

Module-1 – Introduction to Human Foods from Plants	***9 Hour***
What we get from plant food – Macronutrients (Carbohydrates, proteins, lipids), Micronutrients (Vitamins, Minerals, Phytonutrients), Intestinal bacteria. How nutrition research conducted	
Module-2 - How Diet Affects the Human Health	***9 Hour***
Dietary deficiencies - Dietary deficiencies lead to disability and death - Women, children and the poor are disproportionally affected - Food enrichment	
Module-3 - Diet as a Factor in Chronic Diseases	***9 Hour***
Metabolic syndrome – Type – 2 diabetes, Cardiovascular disease and Cancer. Role of media and marketing in food.	
Module-4 - History and Future of Genetic Improvements in Agriculture	***9 Hour***
Increasing population, degrading soils, disappearing water reserves, escalating energy prices and climate change - Use of GM - Second green revolution..	
Module-5 - Promote Nutrition Education	***9 Hour***
Discussions about the role of government in supporting healthy eating. - Lowering the costs of fruits and vegetables by increasing their yields and shelf-lives - Biofortification efforts can improve the nutritional content of foods, especially staple crops for those whose dietary diversity is limited.	

Learning Resources	1. *American Phytopathological Society (2011). ASPnet (www.aspnet.org) includes a vast collection of online educational articles and materials, including an illustrated glossary.* 2. *Plant Pathology, 5th Edition - December 27, 2004, Author: George N. Agrios, ISBN: 9780120445653, eBook ISBN: 9780080473789* 3. *Ahmed, F. (2010). Health: Edible advice. Nature 468: S10–S12.doi:10.1038/468S10a.* 4. *Quick, J.A., and Murphy, E.W. (1982). The Fortification of Foods: A Review. Agriculture Handbook No. 598. (Washington, DC: U.S. Department of Agriculture, Food Safety and Inspection Service). http:// naldc.nal.usda.gov/download/CAT87209052/PDF* 5. *Thurow, R., and Kilman, S. (2009). Enough: Why the World's Poorest Starve in an Age of Plenty. (New York: Perseus Books).*	6. *Food and Agriculture Organization of the United Nations (2010). Fats and fatty acids in human nutrition: Report of an expert consultation. http://www.who.int/nutrition/publications/nutrientrequirements/fatsandfattyacids_humannutrition/en/index.html.* 7. *Lusser, M., Parisi, C., Plan, D., and Rodrı´guez-Cerezo, E. (2012).Deployment of new biotechnologies in plant breeding. Nat. Biotechnol. 30: 231–239. doi:10.1038/nbt.2142.* 8. *Voytas, D.F. (2013). Plant genome engineering with sequence-specific nucleases. Annu. Rev. Plant Biol. 64: 327–350. doi:10.1146/annurevarplant-042811-105552..* 9. *Qaim, M., and Kouser, S. (2013). Genetically modified crops and food security. PLoS ONE 8: e64879. doi10.1371/journal.pone.0064879.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. P. Bala Kumaran, Proklean Technologies (P) Limited, Chennai, genbalu86@gmail.com*	*1.Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in*	*1. Dr. R Pachaiappan, SRMIST*
2. *Dr. Karthik Periyasamy, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com*	*2. Prof. R. B. Narayanan, Anna University, Chennai, arbeen09@gmail.com*	*2. Dr. DVL Sarada, SRMIST*

Course Code	21BTE604T	Course Name	MEDICINAL PLANTS AND PLANT–MICROBE INTERACTION	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biotechnology*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*explain the process and obtaining drugs from plants*
CLR-2:	*describe the plant secondary metabolites as potential molecules as a drug candidate and metabolic engineering use*
CLR-3:	*understand the various biotic interactions/relationships of the plants for both symbiotic and harmful effects*
CLR-4:	*know the plant and pathogen interactions*
CLR-5:	*discuss the various ways to recognize and respond to pathogens by plants*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*summarize the different approaches used to identify plant candidates for drug-screening programs*	-	*2*	*3*
CO-2:	*compare the three classes of phytochemicals and outline a currently used metabolic engineering approach for drug synthesis*	*3*	-	*2*
CO-3:	*identify plant biotic interactions such as mutualistic, defensive, competition, and threats from humans*	*3*	*3*	-
CO-4:	*compare and contrast the interactions and lifestyles of biotrophs and necrotroph pathogens in plants*	*2*	-	*3*
CO-5:	*summarize the ways that plants defend themselves against pathogens by producing metabolites*	*2*	-	*3*

Module-1 – Introduction to Drugs from Plants	***9 Hour***
historical uses of plants as medicines - Case study, Past to the present: Quest for active compounds – Case studies, the best of both: plant-based medicines, present and future, drugs and therapies from traditional medicines – Case studies, Finding sources for new drugs.	
Module-2 - Classes of Phytochemicals with Medicinal Properties	***9 Hour***
Alkaloids are biosynthetically diverse, Terpenoids are diverse compounds derived from isoprene units, Phenolics: flavonoids, anthocyanins and related compounds mostly products of phenylpropanoid metabolism. Recognizing the value of and protecting biodiversity, Health care for all. Omics, systems, semi-synthetic methods and metabolic engineering, Metabolic engineering can increase yields and make novel compounds.	
Module-3 - Plants and Pest	***9 Hour***
Mutualistic interactions, Pathogens, and pests, Plants and plants – Competition or cooperation, Plants and people. Root nodule symbiosis - Biological nitrogen fixation, Plants and mycorrhizal fungi.	
Module-4 - Plant Pathology	***9 Hour***
Brief history of plant pathology, disease triangle – pathogen, host, environment, strategies of pathogenicity – Biotrophs and necrotroph pathogens and interactions with plants.	
Module-5 - Plant Immune System	***9 Hour***
Plant immune responses - Pathogen-triggered immunity, Effector-triggered immunity, Resistance to necrotrophs, viruses, and cross-talk between stresses. Strategies to manage and prevent diseases.	

Learning Resources		
	1. *American Phytopathological Society (2011). ASPnet (www.aspnet.org) includes a vast collection of online educational articles and materials, including an illustrated glossary.* 2. *Plant Pathology, 5th Edition - December 27, 2004, Author: George N. Agrios, ISBN: 9780120445653, eBook ISBN: 9780080473789*	3. *Gilbert, N. (2011). Regulations: Herbal medicine rule book. Nature 480:S98–S99. doi:10.1038/480S98a.* 4. *Barto, E.K., Weidenhamer, J.D., Cipollini, D., and Rillig, M.C. (2012). Fungal superhighways: Do common mycorrhizal networks enhance below ground communication? Trends Plant Sci. 17: 633–637.doi:10.1016/j.tplants.2012.06.007.*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. P. Bala Kumaran, Proklean Technologies (P) Limited, Chennai, genbalu86@gmail.com*	1. *Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in*	1. *Dr. R Pachaiappan, SRMIST*
2. *Dr. Karthik Periyasamy, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com*	2. *Prof. R. B. Narayanan, Anna University, Chennai, arbeen09@gmail.com*	2. *Dr. DVL Sarada, SRMIST*

Course Code	20BTE605T	Course Name	BIOFUELS AND BIOREFINERIES	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biotechnology*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*analyze the basic principles of generations of biofuels and lignocellulose biorefinery engineering for green energy*
CLR-2:	*elucidates effective methods for the fractionation and conversion of the lignocellulose feedstock*
CLR-3:	*decipher an understanding on the production of various products from lignocellulose biorefinery engineering*
CLR-4:	*comprehend the importance and production of various platform chemicals with commercial significance*
CLR-5:	*apprehend the algal process engineering for the production of energy and chemicals with industrial importance and co_2 sequestration*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*accomplish knowledge on the various biofuels and their classifications and engineering basics of lignocellulose biorefinery*	*1*	*2*	*2*
CO-2:	*explain the various lignocellulose feedstock deconstruction technologies to establish the sugar and lignin platform*	*2*	*3*	*3*
CO-3:	*describe the industrial scale bioconversion technologies for energy and chemicals production*	*3*	*3*	*3*
CO-4:	*understand the platform chemicals production process with commercial importance*	*1*	*3*	*2*
CO-5:	*assess the extent of algal biorefinery for the production of energy and chemicals and the importance of co2 sequestration*	*2*	*3*	*3*

Module-1 - Energy Resources	***9 Hour***
Renewable and Non-Renewable Energy resources; Resource crisis; Resource recycling - Circular economy; Carbon Foot prints; Carbon "Neutral" Fuels; Resource crisis; Resource recycling - Circular economy; Biofuels and Environment; Classification of Biofuels-Generations of Biofuels; Biorefinery: A Reemerging Concept; Biomass recycling; Lignocellulosic resources; Lignocellulose biorefinery engineering; Biorefinery for Chemical and Energy Security; Modes of integrated industrial lignocellulose biorefinery chains; Lignocellulose recalcitrance; Structural analysis of lignocellulose recalcitrance; The role of lignocellulose in society and the economy; Mass transfer resistance of lignocellulose: seepage recalcitrance; Lignocellulose functional components; Pretreatment technologies; Enzymatic pretreatment technologies-Delignification process; 2G ethanol from lignocellulosic biomass; Analytical methods for the biorefinery process and products.	
Module-2 - Lignocellulose Feedstock Engineering	***9 Hour***
Technologies of components fractionation; Molecular level technology; Cell-level technology; Tissue-level technology; Technologies of selective structure deconstruction; Overall conversion of functionality; Current situation for selective structure deconstruction technologies; Development trends of selective structure deconstruction technologies; Steam explosion treatment technology; Principles of Steam explosion; Steam explosion equipment; Continuous steam explosion equipment; Steam explosion technology types; Low pressure and nonpolluting steam explosion technology; Two-phase steam explosion technology; Technical evaluation of steam explosion technology; Establishment of the sugar platform; Hemicellulose platform; Cellulose platform; Establishment of the lignin platform; Comparison of different pretreatments; Product development of the lignocellulose platform.	
Module-3 - Lignocellulose Biorefinery Conversion Engineering	***9 Hour***

Applicability of lignocellulose used in bioconversion; Classifications of bioconversion technologies; Equipment for bioconversion; Mechanisms of lignocellulose physical conversion technologies; Products of lignocellulose physical conversion technologies; Thermochemical conversion technologies; Pyrolysis technology of lignocellulose; Gasification technology of lignocellulose; Liquefaction technology of lignocellulose; Lignocellulose biorefinery product engineering; Bioenergy Concepts; Bioethanol and Biobutanol; Biomethane and Biohydrogen; Biomass briquettes; Bio-oil; Food and animal feed; Bio-based chemicals and materials; Integrated industrial lignocellulose biorefinery chains; Agricultural straw biorefining; Hemp biorefining; Biorefinery modes for lignocellulose rich in active ingredients.
Module-4 - Platform Chemical Biorefinery ***9 Hour***
Production of C3 Platform Chemicals; Propylene Glycol ; 3-Hydroxy-propionic Acid; Butyric Acid; Production of C4 Platform Chemicals; Malic Acid; Fumaric Acid; Succinic Acid; Production of C5 Platform Chemicals; Xylitol; Levulinic acid; Itaconic acid; Furfural; Production of C6 Platform Chemicals; Glucaric Acid; 2,5-Furandicarboxylic Acid; Gluconic Acid; Sorbitol; Platform chemicals and pharmaceutical industries; Animal fat based platform chemical biorefinery; Vegetable oil-based platform chemical biorefinery; Integrated biorefinery for bioenergy and platform chemicals; Case studies on the industrial production of renewable platform chemicals.
Module-5 - Algal Biorefinery ***9 Hour***
Classification of algae and their uses; Growth characteristics of different algal species; Improving the algal chassis for biofuel production; Genetic and metabolic engineering of algae to obtain high yield; Photobioreactors; Types of Photobioreactors; Photobioreactor design parameters; Design of closed photobioreactors for algal cultivation; Factors involved in scale-up problems for the large scale production of algae; Scale-up problems in heterotrophic, autotrophic and mixotrophic Cultures; Harvesting technology for algal biomass production; Potential products of algal biorefinery; Industrially chemicals; Algae as a nutritional supplement; Algae as a source of industrial pigments; Algae process engineering for energy; Gaseous fuel production from algal biomass; Liquid fuel production from algal biomass; Integrated microalgal biorefinery; Cultivations methods; Role of microalgae in microbial fuel cell; Configurations of photosynthetic MFC; Technologies for production of microalgal biofertilizer; CO_2 sequestration technologies.

Learning Resources	*1.* Debabrata *Das*., "*Algal Biorefinery: A Integrated approach*", *1st edition, Springer, 2015.* *2. Satinder Kaur Brar, Saurabh Jyoti Sarma, Kannan Pakshirajan, "Platform Chemical Biorefinery - Future Green Chemistry", Elsevier Inc Publishers, 2016.*	*3. Hongzhang Chen.," Lignocellulose Biorefinery Engineering - Principles and Applications", Elsevier Inc Publishers, 2015.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Dr. C. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	*1. Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in*	*1. Dr. K. Ramani, SRMIST*
2. Dr. Karthik Periyasamy, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com	*2. Prof. R. B. Narayanan, Anna University, Chennai, arbeen09@gmail.com*	*2. Dr. V. Vinoth Kumar, SRMIST*

Course Code	21BTE606T	Course Name	CIRCULAR BIOECONOMY FOR INDUSTRIAL SUSTAINABILITY	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biotechnology*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	**The purpose of learning this course is to:**
CLR-1:	*provide theoretical tools to understand an environmental and sustainable society*
CLR-2:	*learn methods to govern sustainability and circular bioeconomy from a strategic and managerial perspective*
CLR-3:	*develop extensive skills to set up a sustainability-oriented strategy employed in industries*
CLR-4:	*represent crucial opportunities and challenges regarding the circular economy's ability to create a more sustainable industrial operation*
CLR-5:	*propose methods and practice to increase the circular and energy transition journey*

Course Outcomes (CO):	**At the end of this course, learners will be able to:**	Programme Outcomes (PO)		
		1	**2**	**3**
CO-1:	*understand the definition of circular economy and bioeconomy in different industrial sectors*	*2*	*2*	*2*
CO-2:	*learn the principles of biotechnology development and the detailed strategies to transform industries toward bioeconomy*	*3*	*3*	*3*
CO-3:	*provide learners with widely-used calculation strategies for circularity assessment.*	*3*	*2*	*3*
CO-4:	*analysis of implementation strategies to the climate and environmental crisis of industries*	*2*	*3*	*2*
CO-5:	*demonstrate analytical thinking to synthesize and appraise key issues for creating a more circular economy.*	*1*	*3*	*3*

Module-1 - Circular Economy and Bioeconomy in Different Industrial Sectors	***9 Hour***
Concepts of linear economy, circular economy, and bio-economy; Need for circular bioeconomy; Understanding of Major industries that depend on bioresources for production (Paper and Pulp, Textile, Tannery, Biofuel, Industrial Solvents and Green chemicals, Food industry, Distillery, Agro-forestry and Aquaculture industries); Components of industrial operation 'Cradle to Grave'	
Module-2 - Sustainable waste management practices adopted in industries	***9 Hour***
4 R principle, Waste Management Pyramid, Biogasification, biohydrogen from industrial wastes, Waste valorization, Biopolymers from industrial wastes, Bioenzymes from wastes, Waste to Energy conversion strategies (thermal and thermochemical)	
Module-3 - Strategies for circularity assessment	***9 Hour***
Techno-Economic Feasibility Assessments; Life Cycle Assessments; Tools employed for TEA and LCA; Recent advances in green technologies and Industry 4.0(IoT enabled Energy and Environmental Management)	
Module-4 - Implementation strategies to the climate and environmental crisis of industries	***9 Hour***
Carbon Foot Print, Carbon Credit, Net Zero Emission Practices, Zero Liquid Discharge strategies, Environmental Management System, Environmental Impact Assessment	
Module-5 - Policies and future R&D for circular economy	***9 Hour***
Case studies of industrial innovation for circular bioeconomy; Current and Emerging Challenges to circular bioeconomy; Urban and rural integration system for sustainable waste utilization; Role of State and Central Pollution Control Boards and Environmental protection Agency in pollution control; Indian Government schemes for the environmental cleanup- Swachh Bharat Abhiyan	

Learning Resources	*1. Piergiuseppe Morone, Dalia D'Amato, Nicolas Befort and Gülşah Yilan. "The Circular Bioeconomy - Theories and Tools for Economists and Sustainability Scientists", Cambridge University Press, 2023.* *2. Ashok Pandey, Rajeshwar Dayal Tyagi and Sunita Varjani, "Biomass, Biofuels, Biochemical: Circular Bioeconomy: Current Developments and Future Outlook" , Elsevier, 2021.*	***Web resources*** *3. NPTEL: Biomass Conversion Biorefinery by Kaustubha Mohanty, IIT Guwahati, https://archive.nptel.ac.in/courses/103/103/103103207/*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	*-*	*15%*	*-*	*15%*	*-*
Level 2	*Understand*	*25%*	*-*	*20%*	*-*	*25%*	*-*
Level 3	*Apply*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*10%*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*5%*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Dr. R. Dineshkumar, CSIR-CSMCRI,Gujarat	*1. Dr. Rajesh Banu,Central University of Tamil Nadu, Thiruvarur*	*1. Dr. B. Samuel Jacob, SRM IST*
2. Mr. Arul Murugan, Chloroplast Foods Pvt., Ltd., Chennai	*2. Dr. Vinod Kumar, Cranfield University, United Kingdom*	*2. Dr. K. Ramani. SRM IST*

ACADEMIC CURRICULA

Chemical Engineering

Professional Core Courses

Regulations 2021

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

Course Code	21CHC501J	Course Name	COMPUTATIONAL TRANSPORT PHENOMENA	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Chemical Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*introduce fundamental concepts of transport phenomena and CFD, laying the foundation for advanced study*
CLR-2:	*explore velocity distributions in laminar flow systems under isothermal conditions.*
CLR-3:	*investigate turbulent flow phenomena and introduce turbulence modelling techniques.*
CLR-4:	*examine energy transport mechanisms and equations governing non-isothermal systems, focusing on heat transfer principles.*
CLR-5:	*explore mass transport phenomena and principles, including diffusion and mass transfer analogies*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*understand the basic principles of transport phenomena and CFD, including coordinate systems, substantial derivative, and momentum balance.*	*1*	*3*	*2*
CO-2:	*gain proficiency in analyzing and solving laminar flow problems, applying equations of change to various geometries.*	*1*	*3*	*2*
CO-3:	*develop an understanding of turbulent flow characteristics*	*1*	*3*	*2*
CO-4:	*acquire skills in analyzing and solving non-isothermal energy transport problems, including heat conduction and cooling processes.*	*1*	*3*	*2*
CO-5:	*develop proficiency in analyzing and solving mass transport problems, understanding diffusion mechanisms, and applying mass transfer analogies.*	*1*	*3*	*2*

Module-1 - Introduction to Transport Phenomena	**9 Hour**
Viscosity and the Mechanisms of Momentum Transport - Momentum flux and Kinetic energy, Pressure and shear stress, kinetic energy - Coordinate systems, Vector and tensor analysis, Newton law of viscosity - Substantial derivative and Theory of Continuity - Shell momentum balance and Navier stokes equation - Introduction to CFD and its applications - CFD solution strategies - Types of models in CFD - CFD solution procedure	
Module-2 - Velocity Distributions in Laminar Flow - Isothermal Systems	**9 Hour**
Equations of Change – flow over an inclined plane slab as thin film, flow through pipe, flow through annular pipe and flow through two immiscible liquids, flow through narrow slit	
Module-3 - Velocity Distribution in Turbulent Flow - Isothermal Systems	**9 Hour**
Comparisons of laminar and turbulent flows - Time-smoothed equations of change for incompressible fluids - The time-smoothed velocity profile near a wall - Empirical expressions for the turbulent momentum flux - Introduction to Turbulence Modelling in CFD - Turbulence models - Flow over an object: friction factors, Friction factors for flow in tubes	
Module-4 - Mechanisms of Energy Transport and Equations of Change for Non-Isothermal Systems	**9 Hour**
Shell Energy Balances and special forms of energy equation - Heat Conduction with an Electrical Heat Source, Chemical heat source and viscous heat source - Cooling of a Sphere in Contact with a Well-Stirred Fluid - Lumped heat capacitance	
Module-5 - Mechanisms of Mass Transport	**9 Hour**
Theory of Diffusion, diffusivity and mass transfer coefficient - Shell mass balance equation - Diffusion through a Stagnant Gas Film - Diffusion with a Homogeneous Chemical Reaction - Diffusion into a Falling Liquid Film - Lumped mass transfer - Analogy Momentum, energy and Mass transfer: Reynolds Analogy, Chilton Colburn analogy, Prandtl analogy	

Practice	**15 Hour**
1.Introduction to CFD Software Environment	*7.Forced Convection over a Flat Plate*
2.Flow in a Pipe	*8.Cooling of a Heated Block*
3.Flow around a Cylinder	*9.Diffusion in a Binary System*
4.Turbulence Modelling	*10.Boundary Conditions Practice*
5.Conduction in a Rectangular Plate	*11.Meshing Techniques*
6.Natural Convection in a Square Enclosure	*12.Grid Independence Study*

Learning Resources	*1.Byron R. Bird., Warren E. Stewart and Edwin N. Lightfoot, "Transport Phenomena", John Wiley & Sons, New York, 2nd edition 2007.* *2.Christie John Geankoplis "Transport Processes and Separation Process Principles", "Pearson Education", Prentice Hall, 4thEdition 2003.* *3.James R. Welty., Charles E. Wicks., Robert E. Wilson. and Gregory L. Rorrer "Fundamentals of Momentum, Heat, and Mass Transfer", "John Wiley &Sons", New York, 5th edition, 2007*	*4.H. K. Versteeg and W. Malalasekera, "An introduction to computational fluid dynamics – The finite volume method", Longman Group Ltd 1995.* *5.J.H. Ferziger and M. Peric, "Computational Methods for Fluid Dynamics", "Springer", 2002.* *6.Tu, Jiyuan, Guan-Heng Yeoh, and Chaoqun Liu, "Computational fluid dynamics: a practical approach". "Butterworth-Heinemann", 2018.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life Long Learning CLA-2- Practice (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	*-*	*-*	*10%*	*15%*	*-*
Level 2	*Understand*	*25%*	*-*	*-*	*30%*	*25%*	*-*
Level 3	*Apply*	*30%*	*-*	*-*	*30%*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*-*	*30%*	*30%*	*-*
Level 5	*Evaluate*		*-*	*-*			*-*
Level 6	*Create*		*-*	*-*			*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd, Chennai	*1.Dr. Lima Rose Miranda, Anna University, Chennai*	*1. Dr. K. Suresh, SRMIST*
***2.** Mr. S. Stalin, Course Director, Chem Skill Development Centre, Chennai*	***2.** Dr. N. Anantharaman, Former Professor, NIT Trichy*	*2. Dr. S. Sam David, SRMIST*

Course Code	21CHC502J	Course Name	COMPUTER-AIDED PROCESS PLANT SIMULATION	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Chemical Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*recap the inventory rate equation for mass and energy*
CLR-2:	*apply the inventory rate equation to unit operation/processes with recycling and bypassing*
CLR-3:	*estimate the rate constant and order of heterogeneous chemical reactions*
CLR-4:	*prepare block diagram, process flow diagram, piping, and instrumentation diagram*
CLR-5:	*formulate the process flow diagram with control*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*propose the process modeling for any chemical engineering system*	*2*		*1*
CO-2:	*simulate the process flow sheet with recycling and bypassing*	*1*		*2*
CO-3:	*estimate the rate of reaction using experimental data of heterogeneous system*	*2*		*2*
CO-4:	*synthesis of process flow sheet, P&ID diagram, and line sizing*	*1*		*2*
CO-5:	*perform Aspen dynamic simulation with control system*	*2*		*1*

Module-1 - Material and Energy Balance	**9 Hour**
Material balances involve with and without Chemical Reactions, Electrochemical Reactions, Recycling, Parallel, and Bypassing Unit Operation and Process. Energy balances, heat capacity of gaseous and liquid mixtures, and enthalpy changes accompanying chemical reactions.	
Module-2 - Stoichiometry, Unit Operations and Processes	**9 Hour**
Stoichiometry and Unit Operations Distillation, Absorption and Stripping, Extraction and Leaching, Crystallization, Psychrometry, Drying, Evaporation and Less Conventional Operations, Air requirement and Flue Gases and Combustion Calculations.	
Module-3 - Utilization of CO_2 into Methanol	**9 Hour**
Kinetic parameters for elementary reactions – single and multiple reactants, Methanol Reaction Kinetic model, Refitting of kinetic parameters, Choice of reactor and operation conditions, Preliminary Flowsheet layout study, One-stage synthesis flowsheet, Two-stage synthesis.	
Module-4 - Flow sheets and P & I Diagrams	**9 Hour**
Executing a Process Plant – Feasibility study, Basic Engineering, Execution of the project, Pre-commissioning and Commissioning, and Plant Acceptance and Handover. Flow sheets, Equipment lists, and line lists – Block flow diagram, process flow diagram, Piping and Instrumentation Diagram, Utility P & ID, material selection diagram, line list, and equipment list.	
Module-5 - Process Dynamic Modeling	**9 Hour**
Material balances of Unsteady-state operations and processes with Examples, Control of CSTR systems – Nonlinear Dynamic model, Nonlinear Dynamic Simulation, Effect of Jacket Volume, Demonstration of Aspen Dynamics simulation of CSTRs.	

Practice	**15 Hour**
1.Perform the unit operations simulation	5.Power required for a pump in the process flow sheet
2.Analyze the unit process simulation and optimization	6.Demonstration of Nylon 6,6 resin reactor simulation, Simulation of azeotropic distillation of water-ethanol mixture
3.Simulate the flowsheet using the process data and identify the optimum condition	
4.Utilization of CO_2 into methanol - Kinetic model for reaction, LHHW kinetic model, Methanol Reaction Kinetic model, Refitting of kinetic parameters, and One-Stage synthesis flowsheet	7.Prepare piping and instrumentation diagram
	8.Demonstration of Aspen Dynamics simulation of CSTR

Learning Resources	1. BI Bhatt and SB Thakore, "Stoichiometry", Mc Graw Hill Education, Fifth Edition, 2015. 2.J.F. Portha, "Kinetics of Methanol Synthesis from Carbon Dioxide Hydrogenation over Copper-Zinc Oxide Catalysts", Ind Eng Chem Res, Vol 56, pp. 13133 - 13145 3.Achyuta K, "Techno-Economic Analysis of Utilization of CO_2 into Methanol",2023	4.Siddhartha Mukherjee, "Process Engineering and Plant Design: The Complete Industrial Picture", "Taylor & Francis Group", LLC., CRC Press First edition Publication 2022. 5.William L. Luyben, "Chemical Reactor Design and Control", "A John Wiley and Sons, Inc., Publication", 2007

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (45%)		Life Long Learning CLA-2- Practice (15%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	20%	-	-	20%	20%	-
Level 2	Understand	20%	-	-	20%	20%	-
Level 3	Apply	30%	-	-	30%	30%	-
Level 4	Analyze	30%	-	-	30%	30%	-
Level 5	Evaluate		-	-			-
Level 6	Create		-	-			-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd, Chennai	1. Dr. Lima Rose Miranda, Anna University, Chennai	1. Dr. K. Suresh, SRMIST
2. Mr. S. Stalin, Course Director, Chem Skill Development Centre, Chennai	2. Dr. N. Anantharaman, Former Professor, NIT Trichy	2. Dr. P. Muthamilselvi, SRMIST

Course Code	21CHC503J	Course Name	ADVANCED CHEMICAL REACTION ENGINEERING	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Chemical Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the catalytic reaction mechanism and kinetics*
CLR-2:	*familiarize the design aspects of reactors with solid catalysts*
CLR-3:	*develop the rate equation for gas – liquid reactions on solid catalysts*
CLR-4:	*understand the development of fluid – fluid reaction rate equations*
CLR-5:	*familiarize the fluid – fluid reactors design calculations*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*predict the rate limiting mechanism in catalytic reactions*	*3*	*1*	
CO-2:	*design various types of fluidized bed reactors*	*2*		*1*
CO-3:	*analyze the performance of multiphase reactors*	*2*		*1*
CO-4:	*develop rate equation for non-catalytic fluid – fluid reactions*	*2*		*1*
CO-5:	*interpret the design aspects of fluid – fluid reactors*	*2*		*1*

Module-1 - *Catalysis and Catalytic Reactors*	**9 Hour**
Properties and types of catalyst, Reasons for catalyst deactivation, Sequence of steps in a catalytic reaction, Information required for catalytic reactor design, Molecular adsorption model and dissociative adsorption model for adsorption isotherm, Surface reaction kinetics and types of models, Desorption rate law, Electrical analog to heterogeneous reactions, Developing rate law equation for adsorption as rate limiting step, Developing rate law equation for surface reaction as rate limiting step, Developing rate law equation for desorption as rate limiting step, Types and mechanism of catalyst deactivation	
Module-2 - *Reactors with Suspended Solid Catalyst*	**9 Hour**
G/S contacting regimes, from low to very high gas velocity in suspended solid reactors, Geldart classification of solids in Bubbling Fluidized Bed (BFB), Concept of Minimum Fluidizing Velocity and Terminal Velocity, Conditions for Bubbling Fluidized Bed, Models for Bubbling Fluidized Bed, K – L model for Bubbling Fluidized Bed, Material Balance for Gas and for Solids in K – L model for Bubbling Fluidized Bed, Applications of K – L model, Circulating fluidized bed (CFB), Turbulent bed (TB) and solid distribution, Behavior and model of Fast Fluidized Bed (FF), Model for Pneumatic Conveying (PC) reactor and Downflow CFB	
Module-3 - *G/L Reactions on Solid Catalysts*	**9 Hour**
General rate equation, Various ways of running G/L reactions catalyzed by solids, resistances involved in the G/L reaction on a catalyst surface, Performance equations for an excess of liquid reactant (B), Performance equations for an excess of gas reactant (A), Selection criteria for G/L contactor and applications, Slurry reactor – uses, reaction steps and rate equation, Rate limiting steps in slurry reactor, Trickle bed reactor – rate and transport equations, Optimization in chemical reactors	
Module-4 - *Fluid – Fluid Reaction Kinetics*	**9 Hour**
Factors affecting the kinetics, General rate equation form, General stoichiometry and nomenclature for fluid – fluid reactions, Rate Equation for Straight Mass Transfer (Absorption) of gas reactant, Rate	

Equation for Mass Transfer and Reaction, Rate equation for various cases of infinitely fast to very slow reaction, Role of the Hatta Number, Importance of two film theory, Clues to the Kinetic Regime from Solubility Data
Module-5 - *Fluid – Fluid Reactors: Design* **9 Hour**
Factors to consider in selecting a contactor, Typical characteristics of G/L contactors, Contacting patterns for G/L contactors, Rate equation for straight mass transfer in countercurrent tower, Mass Transfer with reaction in a countercurrent tower, Mass Transfer with reaction in a co-current tower, Mass transfer with reaction in an agitated tank contactor, Mass transfer with reaction in bubble tank contactors, Absorption with reaction in a batch agitated tank contactor, Procedure to find the time needed for a given operation
Practice **15 Hour**

1. Performance in a fixed bed reactor	*5. Performance in a slurry reactor - Effect of particle size of the catalyst*
2. Performance in a fluidized bed reactor	*6. Performance in a trickle bed reactor*
3. Performance in a fluidized bed reactor - Effect of fluid velocity	*7. Study of reaction kinetics for a photochemical reaction*
4. Performance in a slurry reactor - Effect of bubble size	*8. Performance in a photocatalytic reactor*

Learning Resources	*1. Octave Levenspiel, "Chemical Reaction Engineering", "John Wiley & Sons", 3rd edition 1999.* *2. H. Scott Fogler, "Elements of Chemical Reaction Engineering" "PHI India Pvt., Ltd"., 3rd edition 2004.* *3. J. M. Smith, "Chemical Engineering Kinetics", "McGraw- Hill", 3rd edition 1981.*	*4. S. Suresh, Sundaramoorthy, "Green Chemical Engineering An Introduction to Catalysis, Kinetics, and Chemical Processes", "Routledge Taylor & Francis group", "CRC Press", 2015* *5. Missen, Ronald William, Charles W. Mims, and Bradley A. Saville. "Introduction to chemical reaction engineering and kinetics.", ''John Wiley & Sons",1999*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life Long Learning CLA-2- Practice (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*-*	*-*	*20%*	*-*
Level 2	*Understand*	*20%*	*-*	*-*	*20%*	*20%*	*-*
Level 3	*Apply*	*30%*	*-*	*-*	*30%*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*-*	*20%*	*30%*	*-*
Level 5	*Evaluate*		*-*	*-*	*30%*		*-*
Level 6	*Create*		*-*	*-*			*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd, Chennai	*1. Dr. Lima Rose Miranda, Anna University, Chennai*	*1. Dr. K. Deepa, SRMIST*
2. Mr. S. Stalin, Course Director, Chem Skill Development Centre, Chennai	*2. Dr. N. Anantharaman, Former Professor, NIT Trichy*	*2. Dr. M. Magesh Kumar, SRMIST*

Course Code	21CHC504J	Course Name	PROCESS AUTOMATION AND CONTROL	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Chemical Engineering*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand process control's main terms and parameters*
CLR-2:	*find whether the system bound to steady state and unsteady state condition*
CLR-3:	*differentiate between discrete, multistep, and continuous controllers*
CLR-4:	*get an exposure on the important parameters to be monitored and analyzed in industry*
CLR-5:	*learn the essentials of process control and instrumentation for a successful career in process industries*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*introduce the dynamics of various processes and modelling of physical processes*	*2*		*1*
CO-2:	*educate the effect of various control actions*	*2*		*3*
CO-3:	*learn the methods of tuning the controller*	*3*		*2*
CO-4:	*get adequate knowledge about basic and advanced control schemes and related issues*	*2*		*1*
CO-5:	*introduce the concept of Multi input Multi output process and its control schemes*	*3*		*1*

Module-1 - Time Domain Dynamics and Control	**9 Hour**
Motivation for Studying Process Control - Uses of Mathematical Models - Examples of Mathematical Models of Chemical Engineering Systems - Two Heated Tanks - Ideal Binary Distillation Column – First order system – Second order system - Linearization - First-Order Linear Ordinary Differential Equation - Second-Order Linear ODES with Constant Coefficients - Nth-Order Linear ODES With Constant Coefficients – Steady state Techniques.	
Module-2 - Frequency-Domain Dynamics and Control	**9 Hour**
Frequency-Domain Solution Techniques - Bode Plots - Nyquist Plots - Nyquist Stability Criterion – Closed loop Specifications in the Frequency Domain - Phase Margin - Gain Margin - Maximum Closed loop Log Modulus - Frequency Response of Feedback Controllers - Proportional Controller- Proportional-Integral Controller - Proportional-Integral-Derivative Controller.	
Module-3 - Conventional Control Systems and Hardware	**9 Hour**
Control Instrumentation – Sensors – Transmitters - Control Valves - Analog and Digital Controllers - Computing and Logic Devices - Performance of Feedback Controllers - Specifications for Closed loop Response - Load Performance - Controller Tuning - Rules of Thumb - On-Line Trial and Error - Ziegler-Nichols Method – Control of multivariable Processes.	
Module-4 - Control Scheme	**9 Hour**
Cascade, Feed-forward, Feed-forward plus Feedback, Ratio control, Inferential control, Dead time and Inverse response compensation, Nonlinear and Adaptive Control, Model reference adaptive control, Computed Variable Control, Dynamic Matrix Control - DMC Algorithm. Digital Control- Sampling and reconstruction, Discrete systems analysis, Stability and controller design using Z transform and difference equations, Smoothing filter realization using difference equations	

Module-5 - Automated Process	**9 Hour**
Building Blocks of Automation System - Distributed Control System - Evolution and advantages of computer control, Configuration of Supervisory, Direct digital control (DDC) and DCS. Artificial Intelligence in Process Control: Expert systems, Neural networks, Fuzzy logic, Neuro Fuzzy, Genetic algorithm, Virtual instrumentation. Programmable Logic Controllers: Comparison with hard wired relay and semiconductor logic, Hardware, Ladder diagram programming, Case studies. Modeling and Simulation for Plant Automation	
Practice	**15 Hour**
1. To study interacting and non-interacting system for the first order system in series *2. To study the control valve characteristic* *3. To study the Valve Positioner* *4. To study the tuning parameter by using various controllers* *5. To study the performance of controllers such PI, PID*	*6. To study the advanced control schemes with examples* *7. To study the Programmable Logic Controllers* *8. To study the Distributed Control System* *9. To study the automated distillation Process* *10. Introduction to Piping software*

Learning Resources	*1 .William L. Luyben "Process Modelling, Simulation and Control for Chemical Engineers" "McGraw-Hill Education", 1990* *2. Carlos A. Smith, Armando B. Corripio, "Principles and Practice of Automatic Process Control" "John Wiley & Sons", 2nd edition, 1997*	*3. Ronald P. Hunter, "Automated Process Control Systems: Concepts and Hardware" "Prentice-Hall", 1987.* *4. Uttam Ray Chaudhuri, Utpal Ray Chaudhuri, "Fundamentals of Automatic Process Control", "CRC Press" ,2019.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life Long Learning CLA-2- Practice (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*-*	*10%*	*20%*	*-*
Level 2	*Understand*	*20%*	*-*	*-*	*10%*	*20%*	*-*
Level 3	*Apply*	*30%*	*-*	*-*	*20%*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*-*	*30%*	*30%*	*-*
Level 5	*Evaluate*				*30%*		
Level 6	*Create*						
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd,Chennai	*1. Dr. Lima Rose Miranda, Anna University, Chennai*	*1. Dr. P. Muthamilselvi, SRMIST*
2. Mr. S. Stalin, Course Director, Chem Skill Development Centre, Chennai	*2. Dr. N. Anantharaman, Former Professor, NIT Trichy*	*2. Dr. K. Sofiya, SRMIST*

Course Code	21CHC505T	Course Name	PROCESS INTEGRATION AND INTENSIFICATION	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Chemical Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*outline the meaning, concept and advantages of process integration and process intensification in chemical process industries*
CLR-2:	*expose the learners to process intensification in heat transfer and know about various compact heat exchangers*
CLR-3:	*import the knowledge of hybrid separation techniques*
CLR-4:	*understand the various membrane processes used for process intensification*
CLR-5:	*provide an overview of miniaturization and microfabrication*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*explain the concept of process integration and process intensification, and the benefits of process intensification in chemical process industries*	*2*	*3*	*3*
CO-2:	*design compact heat exchangers*	*3*	*2*	*3*
CO-3:	*apply intensified reactors and/or separators in process industries*	*2*	*3*	*3*
CO-4:	*solve process challenges using intensified technologies*	*3*	*2*	*3*
CO-5:	*analyze scale up/down issues in the process industries and its advantages*	*2*	*3*	*3*

Module-1 - Introduction	**9 Hour**
Chemical process design and integration: Definition, hierarchy, approaches. Process Integration: Industrial applications, current status, classification, techniques and energy management through process integration. Process Intensification: Meaning and concept, history, benefits, toolbox, equipment, methods, techniques, application. Process integration vs process intensification.	
Module-2 - Heat Exchanger Intensification	**9 Hour**
Compact Multifunctional Heat Exchangers: A Pathway to Process Intensification: Compact heat exchangers: Classifications, plate heat exchangers, spiral heat exchangers, flat tube-and fin heat exchangers, micro channel heat exchangers, matrix heat exchangers. Selection of heat exchanger technology. Single phase flow, flow pattern, heat transfer and pressure drop, fouling, phase-change heat transfer, heat and mass transfer. Applications: Feed and effluent heat exchangers, integrated heat exchangers in separation processes, reactor heat exchangers. Pinch technology.	
Module-3 - Reactive and Hybrid Separations and Their Applications	**9 Hour**
Overview of reactive separations, need for integration of reactions and separations, reactive absorption/stripping, reactive distillation, reactive extraction, reactive adsorption, reactive crystallization/precipitation. Case study: Absorption of NOx, Synthesis of methyl tertiary butyl ether. Hybrid separations: Extractive distillation, adsorptive distillation and other hybrid separations.	
Module-4 - Membrane Engineering in Process Intensification	**9 Hour**
Application areas of membrane engineering for the realization of process intensification strategy, Desalination: RO pre-treatment, RO post-treatment. Membrane-based reactive separations: membrane bioreactor. Membrane-based hybrid separations: Membrane distillation, integrated distillation-pervaporation/vapor permeation systems, membrane absorption/stripping, membrane chromatography (adsorptive membranes), membrane extraction, membrane crystallization	
Module-5 - Miniaturization and Microfabrication	**9 Hour**

Process intensification through micro-reaction technology: Effect of miniaturization on unit operations and reactions, implementation of micro-reaction technology; microfabrication of reaction and unit operation devices - wet and dry etching Processes.

Learning Resources	*1. Stankiewicz, A. and Moulijn, "Reengineering the Chemical Process Plants, Process Intensification", "Marcel Dekker", 2003.* *2. Reay D., Ramshaw C., Harvey A., "Process Intensification", "Butterworth Heinemann", 2008* *3. Kamelia Boodhoo. Adam Harvey, "Process Intensification Technologies for Green Chemistry: Engineering Solutions for Sustainable Chemical Processing", "Wiley", 2013* *4. Segovia-Hernández, Juan Gabriel, Bonilla-Petriciolet, Adrián, "Process Intensification in Chemical Engineering Design Optimization and Control", "Springer", 2016*	*5. Reay, Ramshaw, Harvey, "Process Intensification, Engineering for Efficiency, Sustainability and Flexibility", "Butterworth-Heinemann", 2013* *6. Enrico Drioli, Andrzej I. Stankiewicz, Francesca Macedonio, "Membrane engineering in process intensification—An overview", Journal of Membrane Science. 380 (2011) 1– 8.* *7. Robin Smith, "Chemical Process Design and Integration","John Wiley & Sons,Ltd", 2005* *8. https://youtu.be/-uY66EVQksk?si=LIKMjwXQ1ZqVDE9k.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	*-*	*10%*	*-*	*15%*	*-*
Level 2	*Understand*	*25%*	*-*	*30%*	*-*	*25%*	*-*
Level 3	*Apply*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 5	*Evaluate*				*-*		
Level 6	*Create*				*-*		
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd, Chennai	*1. Dr. Lima Rose Miranda, Anna University, Chennai*	*1. Dr. E. Poonguzhali, SRMIST*
2. Mr. S. Stalin, Course Director, Chem Skill Development Centre, Chennai	*2. Dr. N. Anantharaman, Former Professor, NIT Trichy*	*2. Dr. S. Prabhakar, SRMIST*

ACADEMIC CURRICULA

Chemical Engineering

Professional Elective Courses

Regulations 2021

SRM INSTITUTE OF SCIENCE & TECHNOLOGY
(Deemed to be University u/s 3 of UGC Act, 1956)

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

Course Code	21CHE551T	Course Name	GREEN TECHNOLOGY	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Chemical Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand chemical, physical, and biochemical methods for waste minimization and recycling, with a focus on sustainability and safety.*
CLR-2:	*learn and integrate the principles of green engineering and green chemistry into chemical processes to enhance sustainability and environmental protection.*
CLR-3:	*explore advanced green process technologies such as sono chemistry, microwave-assisted processes, and carbon capture, emphasizing their role in sustainable engineering.*
CLR-4:	*apply the green engineering principles of process intensification through miniaturization in chemical engineering operations.*
CLR-5:	*learn the environmental impact assessment principles and methodologies of sustainable product design to minimize environmental impacts.*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*Implement effective waste minimization techniques and recycling technologies to manage chemical, physical, and biochemical wastes in an environmentally friendly and safe manner.*	*2*	*3*	*3*
CO-2:	*Apply green engineering and green chemistry principles to design and optimize chemical processes that minimize environmental impact and promote sustainability.*	*3*	*2*	*3*
CO-3:	*Utilize advanced green process technologies such as sono chemistry and carbon capture to develop sustainable chemical engineering solutions.*	*2*	*3*	*3*
CO-4:	*Design and operate miniaturized unit operations and apply reactive separation techniques to enhance process efficiency and sustainability.*	*3*	*2*	*3*
CO-5:	*Conduct Environmental Impact Assessments and integrate sustainable product design principles to develop eco-friendly and sustainable products.*	*2*	*3*	*3*

Module-1 - Waste - Resource, Recovery and Management	**8 Hour**
Sources and types of waste - chemical, physical and biochemical methods of waste minimization and recycling - Recycling technologies for plastics, metals, and e-waste. Hazard identification, assessment and safety aspects at process development and design stage. Need for environmental mitigation and energy efficient processes	
Module-2 - Introduction to Green Technology	**9 Hour**
Definition and scope of green technology, Importance of sustainability and environmental protection, Principles of green engineering, Life cycle analysis (LCA), Material selection and eco-design, Regulatory framework and standards for green technology, Principles of green chemistry - an overview of green synthesis and catalysis.	
Module-3 - Green Process Engineering	**10 Hour**
Sono chemistry, Microwave assisted processes, photochemistry, Carbon capture and sequestration technologies, carbon trading, Industrial symbiosis and eco-industrial parks, Solvent selection: Supercritical fluids, ionic liquids, water as a green solvent	
Module-4 - Process Intensification and Miniaturization	**9 Hour**
Principles of intensification by miniaturization, Miniaturization for unit operation – Micromixers, Fluid contactor, heat exchanger reactor, challenges in miniaturization. Reactive separation concept- Heat exchanger reactor design, reactive distillation and its application	
Module-5 - Environmental Impact Assessment and Case Studies	**9 Hour**
Environmental impact assessment (EIA) methodologies, Tools and techniques for impact mitigation, The role of legislation, Barries and drivers, Case studies – Green manufacturing of acetic acid, vitamin	

C, leather tanning, dyes, pesticides, polymers

Learning Resources	*1. M. Lancaster, "Green Chemistry – An introduction text" "RCS" 2002* *2. Martine Poux, Patrick Cognet, Christophe Gourdon, "Green Process Engineering: From Concepts to Industrial Applications", "CRC Press", 2015* *3.John Pitchel, "Waste Management Practices Municipal, Hazardous, and Industrial" Second Edition, "Taylor and Francis group", 2014*	*4.David T. Allen, David R. Shonnard, "Green Engineering: Environmentally Conscious Design of Chemical Processes", "Pearson Education", 2001* *5. David Reay, Colin Ramshaw, Adam Harvey, "Process Intensification: Engineering for Efficiency, Sustainability and Flexibility", Butterworth-Heinemann, second edition, 2013.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	*-*	*10%*	*-*	*15%*	*-*
Level 2	*Understand*	*25%*	*-*	*30%*	*-*	*25%*	*-*
Level 3	*Apply*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 5	*Evaluate*						
Level 6	*Create*						
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd, Chennai	*1. Dr. Lima Rose Miranda, Anna University, Chennai*	*1. Dr. S. Kiruthika, SRMIST*
2. Mr. S. Stalin, Course Director, Chem Skill Development Centre, Chennai	*2. Dr. N. Anantharaman, Former Professor, NIT Trichy*	*2. Dr. K. Selvam, SRMIST*

Course Code	21CHE552T	Course Name	DATA SCIENCE IN CHEMICAL ENGINEERING	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co- requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Chemical Engineering	Data Book / Codes / Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1:	understand the basic statistics for data science
CLR-2:	know the different advanced data structures for data processing
CLR-3:	working with various data formats
CLR-4:	describe ensemble techniques – supervised and unsupervised machine learning
CLR-5:	utilize data analytics options available in python for real-time application development

Course Outcomes (CO):	At the end of this course, learners will be able to:	Programme Outcomes (PO)		
		1	2	3
CO-1:	learn measure of central tendency and dispersion	2		1
CO-2:	create and explore different operations on advanced data structures,	1		2
CO-3:	handle different data formats from different sources of data	1		2
CO-4:	apply the basic level supervised learning Techniques with working knowledge	2		1
CO-5:	identify opportunities for the application of data visualization in various domains		2	1

Module-1 - Understanding Statistics for Data Science	9 Hour
Role of statistics in Data science - Different types of data - Measure of Central Tendency - Measure of Dispersion - Distribution of Data - Analysis of Variance - Statistical analysis of Linear and non-linear Regression models - Error analysis -MSE, RMSE, MAE, MAPE. Introduction to Probability - Sampling Techniques – Simple random, Stratified, Systematic and Cluster sampling -Hypothesis Testing – Categorical vs Continuous –- More than 2 samples-examples - Determine the order and rate constant for elementary and non-elementary reactions. Propose the heat and mass transfer coefficient correlations	
Module-2 - Introduction to Python	**9 Hour**
Introduction to Python programming language - Overview of python Techniques- advantages/ disadvantages - Python IDE installation-windows/Linux And Python IDE overview - Programming basics Variables declaration, operators and indentation - Working with Lists – indexing , slicing, manipulations, operations - Working with Tuples - indexing , slicing, manipulations, operations - Working with Sets - Working with Dictionaries - indexing , slicing, manipulations, operations - Conditional statements-If, If-else, nested if else statements – Loops for and while – when and how to use - User defined functions: Creating functions and calling them - Custom functions: lambda and recursive functions - Introduction to strings - String manipulations - String slicing - Datetime class in python - Manipulation of date time functions - Different class/methods associated with datetime	
Module-3 - Dataframe and Series in Python	**9 Hour**
Introduction to Pandas - Data structure in pandas – Dataframe and Series - Accessing and slicing of series and dataframes - Arithmetic and logical operations on dataframe - Sorting and filtering of series and dataframes - Joining and merging of Dataframes - Groupby operations on Dataframe - Pivot tables to understand the relationship between variables in the data with different - Crosstab to understand the relationship between variables in the data aggregation - File handling: Reading a file, file functions - Data structure in pandas – Dataframe and Series - Accessing and slicing of series and dataframes - Arithmetic and logical operations on dataframe - Sorting and filtering of series and dataframes - Joining and merging of Dataframes - Groupby operations on Dataframe - Pivot tables to understand the	

relationship between variables in the data with different aggregation - Crosstab to understand the relationship between variables in the data.
Module-4 - Machine Learning **9 Hour**
Machine learning what and why? supervised and unsupervised learning. supervised Learning - Maximum likelihood estimation – least squares, robust linear expression, ridge regression. supervise Learning Classification models – Applications and examples -Logistic Regression - Construction of Decision Tree - Classification model performance metric - Confusion matrix – TP, TN, FP and FN - Accuracy, Recall, Precision, F1 score. Unsupervised Learning – Concept and applications in Date measures - Clustering Models: K Means Clustering Mathematics behind KMeans - Cluster Visualization. Antoine equation for vapor pressure, Data collection through online acquisition.
Module-5 - Data Exploration and Visualization **9 Hour**
Introduction to Explorative Data analysis – Structure vs unstructure, dependent and independent, Numerical vs Categorical. Univariate Analysis of Data - Visualization of univariate analysis - Bivariate Analysis: Types of Bivariate analysis -Choice of different plots - Data Preprocessing Techniques: Need of Data preprocessing - Missing Value Imputation: Reason for Missing values – MCAR, MAR, MNAR. Data Transformations: Need of transforming data - Types of transformation techniques -Data Scaling with example -Identifying the Outlier: Through IQR and Z Score method.

Learning Resources	*1. Dr. Ossama Embarak Apress, "Data Analysis and Visualization Using Python: Analyze Data to Create Visualizations for BI Systems" "A press"1st ed. Edition, 2018* *2. Suresh Kumar Mukhiya, Usman Ahmed, "Hands-On Exploratory Data Analysis with Python"," Packt Publishing",2020* *3. Glenn J. Myatt, "Making Sense of Data", "Wiley" 2007*	*4.Grus, J. "Data Science from Scratch", "O'Reilly Media, Inc", 2nd Edition 2019* *5. McKinney, W. "Python for data analysis: Data wrangling with pandas, NumPy, and IPython". "O'Reilly Media, Inc.,", 2018.* *6.Vanderplas, J. T. "Python data science handbook: Essential tools for working with data". "O'Reilly Media, Inc.," 2017*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 2	*Understand*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 3	*Apply*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 5	*Evaluate*						
Level 6	*Create*						
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd, Chennai	*1. Dr. Lima Rose Miranda, Anna University, Chennai*	*1.Dr.P. Muthamilselvi, SRMIST*
2. Mr. S. Stalin, Course Director, Chem Skill Development Centre, Chennai	*2. Dr. N. Anantharaman, Former Professor, NIT Trichy*	*2. Dr. K. Suresh, SRMIST*

Course Code	21CHE553T	Course Name	ADVANCED THERMODYNAMICS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Chemical Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*introduce the concepts of statistical thermodynamics to the learners*
CLR-2:	*relate the concepts of classical thermodynamics to statistical thermodynamics*
CLR-3:	*correlate the principles and laws of classical thermodynamics to statistical thermodynamics*
CLR-4:	*delineate chemical equilibrium as per statistical thermodynamics*
CLR-5:	*depict the rates of chemical reactions as per statistical thermodynamics*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*identify statistical-mechanical ensembles and postulates*	*1*	*3*	*2*
CO-2:	*relate classical thermodynamics variables and laws to ensembles*	*1*	*3*	*2*
CO-3:	*apply statistical thermodynamics principles to monoatomic and diatomic gases*	*1*	*3*	*2*
CO-4:	*express statistical thermodynamics for chemical equilibrium of ideal mixtures*	*1*	*3*	*2*
CO-5:	*demonstrate statistical thermodynamics based rates of chemical reaction in ideal mixtures*	*1*	*3*	*2*

Module-1 - Statistical-Mechanical Ensembles and Thermodynamics	***9 Hour***
Ensembles and Postulates, Canonical Ensemble and Thermodynamics, Grand Canonical Ensemble, Microcanonical Ensemble, Entropy, Other ensembles, characteristic equations, Fluctuations	
Module-2 - General Relations for Independent Molecules	**9 Hour**
Thermodynamic equivalence of ensembles, Second law, Criteria for spontaneous change, Systems of distinguishable and indistinguishable particles, Boltzmann Statistics, Translational Partition Function	
Module-3 - Ideal Monoatomic and Diatomic Gas	**9 Hour**
Ideal Monatomic Gas, Density of States, Thermodynamic Functions, Internal Degrees of Freedom, Homonuclear Diatomics, Molecular Partition Functions, Ideal Diatomic Gas, Vibrational, Rotational, Gas of Homonuclear Diatomics at Low Temperature, Quantum Statistics, Polyatomic Molecules	
Module-4 - Chemical Equilibrium in Ideal Mixtures	**9 Hour**
Chemical Equilibrium, General Relations, Statistical Derivation in a Special Case, Fluctuations in a Simple Chemical Equilibrium, Examples of Chemical Equilibria	
Module-5 - Rates of Chemical Reactions in Ideal Mixtures	**9 Hour**
Potential Surfaces, Absolute Rate Theory, A Non-Chemical Application of the Eyering Theory	

Learning Resources	*1. Terrel L. Hill, "An Introduction to Statistical Thermodynamics," "Dover Publications", 2012*	*2. Donald A. McQuarirre , "Statistical Mechanics", "University Science Books Publishers", 2nd Edition, 2000*

Learning Assessment							
	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	50%	-	25%	-	25%	-
Level 2	Understand	25%	-	25%	-	25%	-
Level 3	Apply	25%	-	50%	-	50%	-
Level 4	Analyze						
Level 5	Evaluate						
Level 6	Create						
	Total	100 %		100 %		100 %	

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd, Chennai	1. Dr. Lima Rose Miranda, Anna University, Chennai	1. Dr. M. P. Rajesh, SRM IST
2. Mr. S. Stalin, Course Director, Chem Skill Development Centre, Chennai	2. Dr. N. Anantharaman, Former Professor, NIT Trichy	2. Dr. K. Tamilarasan, SRM IST

Course Code	21CHE554T	Course Name	CHEMICAL PROCESS OPTIMIZATION	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Chemical Engineering*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the concepts and importance of optimization*
CLR-2:	*expose the learners to various methods of optimization*
CLR-3:	*enable the learners to optimize different functions*
CLR-4:	*understand the solution strategy for linear programming problems*
CLR-5:	*familiarize the applications of optimization methods in chemical processes and industries*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*model the process and optimize the process conditions*	*3*	*2*	*2*
CO-2:	*formulate the objective function, constraints and identify the variables type*	*3*	*2*	*2*
CO-3:	*optimize single variable and multi variable function*	*3*	*2*	*2*
CO-4:	*find the extreme values of functions with different types of constraints*	*3*	*2*	*2*
CO-5:	*understand the applications of optimization principles in process industries*	*3*	*2*	*3*

Module-1 - Nature and Organization of Optimization Problems	**9 Hour**
Introduction to optimization concepts, need for optimization in chemical industries, scope and hierarchy of optimization, examples of applications of optimization, essential features of optimization problems, general procedure for solving optimization problems, obstacles to optimization, developing models for optimization, classification of models, major activities and phases in model building prior to application, Selecting functions to fit empirical data, procedure to determine the form of a model, typical mathematical forms of models, fitting models and solving problems by least square method, degrees of freedom analysis in model solving, examples of equality and inequality constraints in models, problems based on formulation of equality and inequality constraints in industrial operations.	
Module-2 - Objective Function Formulation and Condition for Optimum	**9 Hour**
Formulation of the objective function, economic objective functions, time value of money in objective functions, problems based on operating profits and capital costs as objective function, optimum thickness of insulation, optimization involving an integer – valued variable, nonlinear program (NLP) problem statement, NLP geometry, convexity and its applications, convex and concave function, determination of convexity and concavity of functions, positive definiteness and negative definiteness of a function, Hessian matrix and Eigen values concept. Interpretation of the objective function in terms of its quadratic approximation, Necessary and sufficient conditions for an extremum of an unconstrained single variable and multivariable function, mathematical conditions of unimodal and multimodal functions, Problems based on finding extreme values of multi variable functions using partial derivatives	
Module-3 - Optimization of Unconstrained Functions: One Dimensional Search and Multivariable Optimization	**9 Hour**
Numerical methods for optimizing a function of one variable, Scanning and bracketing procedures, Newton and Quasi-Newton methods of uni-dimensional search, Finite difference approximations to derivatives, polynomial approximation methods – Quadratic interpolation and Cubic interpolation methods, Region elimination methods – Golden section and Fibonacci methods, problems based on optimizing a function of one variable, unconstrained multivariable optimization, Methods using function values – random search, grid search, univariate search, Simplex search method and conjugate search directions, Methods that use first derivatives – steepest descent method and conjugate gradient method, problems on unconstrained multivariable optimization, Newton's method and Quasi – Newton	

method for multivariable function optimization, forcing the Hessian matrix to be positive-definite, problems based on Newton and Quasi – Newton method
Module-4 - Linear Programming and Applications **9 Hour**
Geometry of linear programs (LP), standard form for linear programs, transformation of linear program into standard form, basic linear programming definitions, concept of equivalent systems and pivoting operations, Simplex algorithm, canonical form and test for optimality, degeneracy and unboundedness in LP, iterative solution of an LP problem, graphical representation and solution of LP problems, problems based on Simplex algorithm for LP problems, non – linear programming (NLP) with constraints, direct substitution method, graphic interpretation of constrained optimization problem, Lagrange multipliers concepts and problems, first order necessary conditions for an extremum, problems containing only equality constraints, sensitivity interpretation of Lagrange multipliers, Kuhn-Tucker conditions for inequality constraints - geometrical interpretation, and algebraic statement, problems containing both equality and inequality constraints, second-order necessary and sufficiency conditions for optimality
Module-5 - Applications of Optimization **9 Hour**
Examples for optimizing heat transfer rate and energy conservation in chemical plants, case studies and examples, Optimal Shell-and-Tube heat exchanger design, Optimization of a multi-effect evaporator, optimization of flow rates in a liquid-liquid extraction column, fitting vapor-liquid equilibrium data via nonlinear regression, optimal pipe diameter, minimum work of compression, economic operation of a fixed bed filter, modeling and optimization of chemical reactors, optimization of a thermal cracker via linear programming, optimal design of an ammonia reactor, optimization in large scale plant design and operations, process simulators and optimization codes, optimization using equation-based process simulators, optimization using modular – based simulators, plant optimization hierarchy

Learning Resources	*1.Thomas F. Edgar, David Mautner Himmelblau, Leon S. Lasdon, "Optimization of chemical processes","McGraw-Hill", 2nd edition, 2001.* *2. Rao S.S., "Optimization: Theory and Applications", "Wiley Eastern", New Delhi, 2nd Edition. 1984.*	*3. Reklaitis, G.V., Ravindran, A., Ragsdell, K.M., "Engineering Optimization", "John Wiley", New York, 2006, ISBN-13 9780471558149* *4.Suman Dutta, "Optimization in Chemical Engineering", "Cambridge University Press", 1st edition 2016.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 2	*Understand*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 3	*Apply*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 5	*Evaluate*						
Level 6	*Create*						
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd., Chennai	*1. Dr. Lima Rose Miranda, Former Professor, Anna University, Chennai*	*1. Dr. M. Magesh Kumar, SRMIST*
2. Mr. S. Stalin, Course Director, Chem Skill Development Centre, Chennai	*2. Dr. N. Anantharaman, Former Professor, NIT Trichy*	*2. Dr. S. Vishali, SRMIST*

Course Code	21CHE555T	Course Name	ARTIFICIAL INTELLIGENCE IN PROCESS ENGINEERING	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Chemical Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*analyze the various characteristics of Intelligent agents*
CLR-2:	*organize different search strategies in AI*
CLR-3:	*incorporate knowledge in solving AI problems*
CLR-4:	*construct in different ways of designing software agents*
CLR-5:	*plan various applications of AI*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*use appropriate search algorithms for any AI problem*	*2*		*1*
CO-2:	*represent a problem using first order and predicate logic*	*1*		*2*
CO-3:	*provide the apt agent strategy to solve a given problem*	*2*		*1*
CO-4:	*design software agents to solve a problem*	*2*		*1*
CO-5:	*develop application that uses Artificial Intelligence*	*1*		*2*

Module-1 - Introduction	**9 Hour**
What is Artificial Intelligence? Types of problems AI addresses like Computer Vision, Natural Language Processing, Robotics, Expert Systems, Object detection and Image segmentation. Applications of AI in chemical engineering areas like fault diagnosis, Process control, Process design, Planning and operations, Modeling and simulation and Product design, development and selection like Separation Design, Heat-Exchanger Network Synthesis, Thermodynamic Model Selection and Physical Property Estimation, Oil reservoir image segmentation, Corrosion and crack predictions based on image detection. Early applications of AI techniques in chemical engineering. The FALCON, CATDEX, BIOEXPERT and the ExSep algorithms	
Module-2 - Deep Artificial Neural Networks	**9 Hour**
Deep Artificial neural networks (DNN). The working of the Rosenblatt perceptron, multilayer perceptrons. Activation functions and their importance in incorporating nonlinearities into the predictive models. The feedforward process in ANN layers with dense fully connected layers. The error (loss) functions as a measure of the ANN performance. Backpropagation algorithm for neuron learning. Various optimization algorithms for neuron learning like Adams, Stochastic Gradient Descent and their variations. The role of learning rate in backpropagation and learning rate scheduling algorithms	
Module-3 - Convolution Neural Networks (CNN)	**9 Hour**
The drawbacks of Deep ANN. How CNN take into account the spatial patterns. The working of the CNN in pattern recognition. The role of kernels, pooling, padding and stride in CNN learning. How the kernels help in reducing the learning parameters (weight sharing). One, two and three dimensional convolutions. The problems of vanishing and exploding gradients in deep networks. The concept of dropouts and batch renormalization in overcoming some problems in CNN learning.	
Module-4 - Sequence Modeling using the Recurrent Neural Networks (RNN)	**9 Hour**
The application of this architecture in predictions based on sequential data. Various RNN architectures proposed like many to one, One to many and Many to many. The variants of RNN like Gated Recurrent Units (GRU) and the Long Short Term Memory (LSTM) architectures. Object Detection with the R-CNN, Fast and Faster R-CNN algorithms. The working of the YOLO algorithm.	

Module-5 - Case Study	**9 Hour**
Some outstanding deep networks proposed like AlexNet, VGGNet, Inception, GoogleNet and ResNets. The problems they faced and how they resolved the problems. The concept of Transfer Learning and how one can use these proposed networks to solve other relevant problems. Autoencoders for dimensionality reduction.	

Learning Resources	*1. Raff, Edward, "Inside Deep Learning: Math, Algorithms and Models", " Manning Publications", 2022.* *2. Quantrile, Thomas, Liu, Y. A, "Artificial Intelligence in Chemical Engineering", "Academic Press", 1991.*	*3. Ian Goodfellow, Yoshua Bengio, Aaron Courville. "Deep Learning. (Adaptive Computation and Machine Learning series)". 2015.* *4. Deepak Khemani, "A First Course in Artificial Intelligence", "McGraw Hill Education", 2013*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 2	*Understand*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 3	*Apply*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 5	*Evaluate*						
Level 6	*Create*						
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd, Chennai	*1. Dr. Lima Rose Miranda, Anna University, Chennai*	*1. Dr. K. Suresh, SRMIST*
2. Mr. S. Stalin, Course Director, Chem Skill Development Centre, Chennai	*2. Dr. N. Anantharaman, Former Professor, NIT Trichy*	*2. Dr. P. Muthamilselvi, SRMIST*

Course Code	21CHE556T	Course Name	STRATEGIES FOR CO_2 UTILIZATION	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Chemical Engineering*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the sources of CO_2 emission along with its physical and chemical properties*
CLR-2:	*exploit on the methods of CO_2 capture, storage and conversion*
CLR-3:	*comprehend on various biological carbonization methods*
CLR-4:	*understand various techniques of thermo and electrocatalytic conversion of CO_2*
CLR-5:	*analyze the carbon capture by renewable energy-based process*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*understand the sources and treatment strategies for CO_2 reduction*	*3*		*2*
CO-2:	*analyze the methods of CO_2 capture and sequestration methods*	*3*	*2*	
CO-3:	*develop the biological methods to carbonize CO_2*	*3*	*2*	
CO-4:	*illustrate the method of thermocatalytic and electrocatalytic conversion of CO_2*	*3*		*3*
CO-5:	*illustration of carbon capture by solar, photocatalytic and plasma activated process*	*2*		*3*

Module-1 - Introduction to CO_2 Related Pollution Sources	**9 Hour**
Sources of Carbon Dioxide Emission-Physical and Chemical Properties of CO_2-Challenges for Treatment of Carbon Dioxide Emission-Treatment Strategies for CO_2	
Module-2 - Conventional Techniques of Carbon Capture	**9 Hour**
Methods for Carbon Dioxide Capture, Physical and Chemical Separations and Concentrate Technologies- Transportation of Captured CO_2-CO_2 Sequestration Methods-Direct Utilization of CO_2, Storage of CO_2	
Module-3 – Non- Conventional Techniques of Carbon Capture	**9 Hour**
Carbon Capture by Mineral Carbonation and Production of Construction Materials-Methods of Carbonation-Challenges and Perspectives for Carbonation Processing- Biological Conversion of Carbon Dioxide-Photosynthetic CO_2 Reduction by Algae-Green Algae-Microalgae-Biorefinery Concept of Microalgal Biomass	
Module-4 - CO_2 Conversion by Conventional Techniques	**9 Hour**
CO_2 Conversion to Fuels and Chemicals by Thermal and Electro-Catalysis – Principle, Developments and future scope on thermo and electro catalysis	
Module-5 - CO_2 Conversion by Novel Techniques	**9 Hour**
Carbon Dioxide Conversion Using Solar, Thermal and Photo Catalytic Processes. Plasma-Activated Catalysis for CO_2 Conversion	

Learning Resources	*1. Yatish T. Shah, "Sustainable Energy Strategies book on CO_2 Capture, Utilization, and Sequestration Strategies", "Taylor and Francis", CRC PRESS, First edition, 2022* *2. Dr. Sonil Nanda, Dai-Viet N. Vo, Van-Huy Nguyen, "Carbon Dioxide Capture and Conversion: Advanced Materials and Processes", "Elsevier" 2022,*	*3. Zhicheng Zhang, Wiley-VCH Verlag, "CO_2 Conversion and Utilization - Photocatalytical and Electrochemical Methods and Applications", "Wiley", First edition, 2023*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 2	*Understand*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 3	*Apply*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 5	*Evaluate*						
Level 6	*Create*						
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd, Chennai	*1. Dr. Lima Rose Miranda, Anna University, Chennai*	*1.Dr. G.Keerthiga, SRMIST*
2. Mr. S. Stalin, Course Director, Chem Skill Development Centre, Chennai	*2. Dr. N. Anantharaman, Former Professor, NIT Trichy*	*2.Dr. S. Anandhakumar, SRM IST*

Course Code	21CHE557T	Course Name	MODERN SEPARATION PROCESSES	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Chemical Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*outline the modern processes applied in the separation of various components from different phases based on size, physical, chemical characteristic, ionic, thermal principles.*
CLR-2:	*provide an overview of the concepts of membrane separation techniques*
CLR-3:	*expose the learners to know the separation by sorption techniques*
CLR-4:	*import the knowledge of various chromatographic techniques*
CLR-5:	*understand the various other techniques involved in separation process*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*appreciate the importance of the concepts involved in separation methods and understand the need for modern separation process*	*2*	*3*	*3*
CO-2:	*understand the working mechanism of various membrane separation processes and their application*	*3*	*2*	*3*
CO-3:	*recognize the mechanism of adsorption and design the fixed bed adsorber*	*3*	*2*	*3*
CO-4:	*recognize the various chromatographic techniques used for analysis and separation*	*2*	*3*	*3*
CO-5:	*understand the advanced extraction techniques and other methods used for separation*	*2*	*3*	*3*

Module-1 – Separation Processes	**9 Hour**
Batch, continuous and semi continuous process, key operation and auxiliary operation, block flow diagram, process flow diagram, mechanism of separation, general separation process, characteristics of separation processes, separating agent, energy-separating-agent vs. mass-separating-agent processes, categorizations of separation processes, mechanical vs. diffusional processes, equilibration processes vs. rate-governed processes. Basic separation techniques: Separations by phase addition, phase creation, barriers, solid agents, external field or gradient. Component recoveries and product purities, split fractions and split ratios, purity and composition designations, separation sequences, separation factor, selection of feasible separation process. Conventional separation processes-limitations – need for modern separation processes.	
Module-2 - Membrane Separations	**9 Hour**
Membrane: classification. Membrane separation processes: classification, advantages and limitations. Membrane modules, concepts and mechanism of separations. Mechanism and applications of microfiltration, ultrafiltration, nanofiltration, Reverse Osmosis. SWRO, pretreatment and post treatment, design of RO plant. Mechanism and applications of dialysis & electrodialysis. Design of ED Unit	
Module-3 - Adsorption and Ion Exchange	**9 Hour**
Adsorption: types, mechanism, industrial Applications; Adsorbents: characteristics, properties, selection, types, preparation and activation methods. Adsorption isotherms (Freundlich, Langmuir, BET); Principle and applications of: Pressure swing adsorption and thermal swing adsorption. Regeneration methods. Fixed bed adsorption: Design, Mass Transfer Zone (MTZ), breakthrough curve, length of unused bed (LUB). Ion Exchange, ion exchange equilibria, ion exchange resins, separation factors in ion exchange, ion exchange in a column, mixed bed exchanger, regeneration of resins.	
Module-4 - Chromatography	**9 Hour**
Chromatography basic principle - static/mobile phase, Classification of chromatographic systems, general description of a column chromatography, partition coefficient, retention time, retention volume, capacity factor, retention ratio, relative retention, column efficiency, resolution, peak asymmetry, column processes and band broadening, extra column broadening, LC, HPLC, GC, planar	

chromatographic techniques- paper chromatography, thin layer chromatography, high performance thin layer chromatography, preparative chromatography, ion exchange chromatography, applications of chromatographic techniques
Module-5 - Other Separation Techniques **9 Hour**
Advanced methods of extraction- ultrasound-assisted extraction, microwave-assisted extraction, super critical fluid extraction, emulsion liquid membrane, supported liquid membrane. Pervaporation, permeation, membrane distillation, forward osmosis, lyophilization

Learning Resources	*1.J.D. Seader, Ernest J Henley and D. Keith Roper, "Separation Process Principles – Chemical and Biochemical Operations", "John Wiley & Sons", United States of America, 3rd edition, 2011.* *2.Kaushik Nath, "Membrane Separation Processes", "PHI Learning Private Limited", New Delhi, Second Edition 2017.* *3. K V Narayanan and B Lakshmikutty, "Mass Transfer Theory and Applications," CBS Publishers and Distributers Private Limited", First Edition New Delhi, 2018.* *4.Binay K. Dutta, "Principles of Mass transfer and Separation Processes", "Prentice- Hall of India", New Delhi, 2011*	*5.C. J. King, "Separation Processes", "Mc Graw Hill", Second Edition, USA, 1980.* *6. Ronald W. Roussel, "Handbook of Separation Process Technology" "John Wiley", New York, 1987.* *7. Richard W. Baker, "Membrane Technology and Applications", "John Wiley", England, Second Edition 2004.* *8.B. Sivasankar, Bioseparations, "Principles and Techniques", "Prentice Hall of India Pvt. Ltd", New Delhi, 2010* *9.M. Mulder, "Basic Principles of Membrane Technology", "Kluwer Academic Publishers", Netherlands, 1996.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	*-*	*10%*	*-*	*15%*	*-*
Level 2	*Understand*	*25%*	*-*	*30%*	*-*	*25%*	*-*
Level 3	*Apply*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 5	*Evaluate*						
Level 6	*Create*						
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd, Chennai	*1. Dr. Lima Rose Miranda, Anna University, Chennai*	*1. Dr. E. Poonguzhali, SRMIST*
2. Mr. S. Stalin, Course Director, Chem Skill Development Centre, Chennai	*2. Dr. N. Anantharaman, Former Professor, NIT Trichy*	*2. Dr. S. Prabhakar, SRMIST*

Course Code	21CHE558T	Course Name	FLUIDIZATION ENGINEERING	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Chemical Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*establish the foundational understanding of fluidization and its role in chemical engineering processes*
CLR-2:	*explore the practical applications of fluidized bed technology across various industrial sectors*
CLR-3:	*investigate the characteristics of fluidization regimes and their mapping*
CLR-4:	*analyze the operational aspects and characteristics of fluidized beds*
CLR-5:	*introduce mathematical models for simulating fluidized bed behavior*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*understand the principles underlying different fluidized bed models and their assumptions.*	*2*		*3*
CO-2:	*apply CSTR models and two-region models to simulate fluidized bed behavior under various operating conditions.*	*1*		*2*
CO-3:	*evaluate the accuracy and limitations of fluidized bed models in predicting bed performance.*	*3*		*1*
CO-4:	*utilize the Kunii-Levenspiel model to optimize fluidized bed reactor design and operation.*	*2*		*3*
CO-5:	*demonstrate proficiency in using mathematical modeling software to simulate and analyze fluidized bed systems.*	*2*		*3*

Module-1 - Introduction to Fluidization Phenomenon	**9 Hour**
Introduction: Fluidization phenomenon, Liquid-like behavior of a fluidized bed	
Module-2 - Industrial Applications of Fluidized Beds	***9 Hour***
Industrial Applications: Physical operations, Synthesis reaction, cracking of hydrocarbons, Combustion, Incineration, and gasification	
Module-3 - Fluidization and Mapping of Regimes	**9 Hour**
Fluidization and Mapping of Regimes: Distributors, Gas jets in fluidized beds, Pressure drop in fixed beds, Geldart classification of particles, Gas fluidization with and without entrainment, Mapping of fluidization regimes.	
Module-4 - Fluidized Beds and Their Characteristics	**9 Hour**
Fluidized Beds: Dense beds, Bubbling fluidized beds, Entrainment from fluidized beds, High velocity fluidization, Solids mixing, segregation, and staging, Gas dispersion and Interchange in bubbling beds, Heat and mass transfer, Industrial applications.	
Module-5 - Fluidized Bed Models	**9 Hour**
Fluidized Bed Models: CSTR model, two region model, Kunii-Levenspiel model	

Learning Resources	*1.Kunii, D., Levenspiel, O. and Robert, E., "Fluidization Engineering", "Butterworth-Heinemann", 1991.* *2.Coulson, J.M., and Richardson, J.F., "Chemical Engineering", "Asian Books Private Limited", Vol. 2, , 2002.*	*3.Yates, J.G., "Fundamentals of Fluidized Bed Chemical Processes", "Butterworth-Heinemann" Butterworth's Monographs in Chemical Engineering, 1983.* *4.Yang, W. and Amin, N.D., "Fluidization engineering: fundamentals and applications", "American Institute of Chemical Engineers",1988.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 2	*Understand*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 3	*Apply*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 5	*Evaluate*						
Level 6	*Create*						
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd, Chennai	*1. Dr. Lima Rose Miranda, Anna University, Chennai*	*1. Dr. S. Sam David, SRM IST*
2. Mr. S. Stalin, Course Director, Chem Skill Development Centre, Chennai	*2. Dr. N. Anantharaman, Former Professor, NIT Trichy*	*2. Dr.K.Suresh, SRM IST*

Course Code	21CHE559T	Course Name	BIOMASS CONVERSION AND BIO-REFINERY	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Chemical Engineering*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*examine the significance of bioenergy and the availability of biomass resources utilization in bio refinery process*
CLR-2:	*elucidates effective methods for the fractionation and conversion of the biomass feedstock.*
CLR-3:	*decipher an understanding on the biofuels production from biomass by biochemical process*
CLR-4:	*comprehend the importance and production of various platform chemicals with commercial significance*
CLR-5:	*apprehend the photocatalytic process for the production of fuels and chemicals with industrial importance*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*understand basic concepts about biomass derived energy*	*1*	*3*	*1*
CO-2:	*understand and evaluate various biomass pre-treatment and thermochemical conversion techniques*	*3*	*2*	*3*
CO-3:	*able to understand the various biochemical techniques in biomasses conversion*	*2*	*3*	*2*
CO-4:	*ability to design a sustainable bio refinery for biofuels and biochemical production by combining various processes*	*2*	*3*	*2*
CO-5:	*accomplish knowledge on the various engineering basics of photocatalytic techniques in bio refinery process*	*3*	*2*	*2*

Module -1 – Biomass Resources	**7 Hour**
Importance of Bioenergy and bio-fuels, Global and Indian scenario, Availability of biomass, composition and energy potential, waste biomass (municipal, industrial, agricultural and forestry) availability. First, second and third generation biofuels and biomass as energy resources. Oil crops and microalgae as feedstock for biofuels and biochemical productions. Advantages and Challenges of Using Agro-industrial Wastes as the Feedstock for Bio refinery, Agro-industrial Waste Biorefinery: Engineering Breakthroughs, Enhancing biomass properties for biofuels productions, and challenges	
Module-2 - Thermo-Chemical Conversion	**10 Hour**
Biomass pre-processing: size reduction and densification, Fundamentals of thermal conversion process: pyrolysis, gasification, combustion, hydrothermal liquefaction. Biofuel productions from oils, microalgae and seaweeds production. Barriers in lignocellulose biomass conversion, different pre-treatment technologies in the bio refinery concept.	
Module-3 - Biochemical Conversion	**10 Hour**
Lignocellulosic biofuels, direct fermentation for ethanol and butanol production. Biogas plants/systems; classification and models of biogas plant; Types of bio-digesters; floating and fixed dome reactors; Design concept and construction of biogas plant. Bio hydrogen generation from biomass feedstock's, Integration process for bio hydrogen with fuel cell system. Enzymes in Biorefinery, Pretreatment Process in Biorefinery, Enzyme Technology in Bio refineries.	
Module-4 - Bio Refinery-Based Platform Chemicals	**10 Hour**
Platform Chemical for Biofuel and High-Value Biochemicals, Potential C3 and C4 Platform Chemicals production, Process Development Strategies for Enhanced chemicals Production, Application Aspects of C3 and C4 chemicals. Potential of C5 Platform Chemicals and Process Development Strategies, Potential Applications and Market Potential of C5 Platform Chemicals.	
Module-5 - Photo Bio-Refinery Concept	**8 Hour**

Types of photo catalyst, Photocatalytic reactor development, Photo thermal system, Photocatalytic Reforming of Biomass; Photo biorefinery Routes for platform Chemicals and hydrogen Production

Learning Resources	*1. Alain A. Vertès, Nasib Qureshi, Hans P. Blaschek, Hideaki Yukawa, "Biomass to Biofuels: Strategies for Global Industries", "John Wiley & Sons, Ltd", 2010* *2. Satinder Kaur Brar, Saurabh Jyoti Sarma, Kannan Pakshirajan, "Platform Chemical Biorefinery, Future Green Chemistry", "Hardback", 1st Edition, ISBN: 9780128029800*	*3. Hongzhang Chen., "Lignocellulose Biorefinery Engineering - Principles and Applications", "Elsevier Inc Publishers", 2015.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*30%*	*-*	*20%*	*-*
Level 2	*Understand*	*20%*	*-*	*40%*	*-*	*20%*	*-*
Level 3	*Apply*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*		*-*	*30%*	
Level 5	*Evaluate*						
Level 6	*Create*						
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd, Chennai	*1. Dr. Lima Rose Miranda, Anna University, Chennai*	*1. Dr. K. Tamilarasan, SRMIST*
2. Mr. S. Stalin, Course Director, Chem Skill Development Centre, Chennai	*2. Dr. N. Anantharaman, Former Professor, NIT Trichy*	*2. Dr.S.Kiruthika, SRM IST*

Course Code	21CHE560T	Course Name	ADVANCED BIOCHEMICAL ENGINEERING	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Chemical Engineering*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*analyze and compare various bioreactors and accessory types and their characteristics*
CLR-2:	*identify problems associated with bioprocess scale-up*
CLR-3:	*distinguish different bioprocess control requirements and associated instrumentation*
CLR-4:	*discern the different methods of product recovery and purification*
CLR-5:	*comprehend process design of biotechnology processes and techno-economic analysis*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*evaluate and select bioreactors based on bioprocess requirements*	*1*	*3*	*1*
CO-2:	*demonstrate ability to scale-up of bioreactor in industrial bioprocesses*	*3*	*2*	*3*
CO-3:	*understand and apply control systems for maintaining optimal bioreactor conditions to enhance bioprocess efficiency*	*2*	*3*	*2*
CO-4:	*integrate knowledge of cell disruption, separation, isolation, and purification techniques for efficient bioprocessing*	*2*	*3*	*2*
CO-5:	*develop bioprocesses incorporating sustainability and techno-economic analysis concept*	*3*	*2*	*2*

Module-1 - Overview of Biochemical Process	**7 Hour**
General requirements of biochemical process, Upstream process unit operation, Downstream unit operation, Components - of bioreactor - Classification and configuration of bioreactors - Analysis of batch bioreactors - Analysis of batch bioreactors - Analysis of continuous flow bioreactors	
Module-2 - ***Mass and Heat Transfer in Bioprocess Scale-Up***	**10 Hour**
Biochemical reactor scale-up - Transport phenomena in Bioprocess - systems - Gas-liquid mass transfer - Determination of oxygen transfer rates - Measurement of kLa - Measurement of kLa - Key dimensionless groups - Correlations for mass transfer co-efficients and interfacial area - Overall kLa estimates and power requirement for sparged and agitated vessels - Overall kLa estimates and power requirement for sparged and agitated vessels - Heat transfer - Heat transfer correlations - Scaling of mass transfer equipment - Scaling of mass transfer equipment - Regime analysis of Biochemical reactor processes - Regime analysis of Biochemical reactor processes - Scale-up criteria for bioreactors based on oxygen transfer and power consumption - Scale-up criteria for bioreactors based on oxygen transfer and power consumption	
Module-3 - Bioreactor Monitoring and Control	**10 Hour**
Instrumentation control of bioreactors - Measurement of physical and chemical parameters in bioreactors - Bioreactor sensor s for temperature control - Principles of dissolved oxygen measurement and control - Principles of pH control - Principles of redox measurement and control - On-line sensors Off-line analytical methods - Measurement of medium properties - Analysis of cell population composition - Prevention of foam - Determination of biomass Application of biosensors - Application of biosensors	
Module-4 - Biomolecule Recovery and Purification	**10 Hour**
Product recovery operation - Separation of biomolecules - Cell disruption for release of products - Cell disruption for release of products - Mechanical methods of cell disruption - Enzymatic methods of cell disruption - Chemical methods of cell disruption - Cells and solid particle separation – Filtration; Filtration - Centrifugation - Centrifugation - Product isolation - Product isolation, Adsorption - Liquid-	

liquid extraction - Product purification- Chromatography - Product purification- Chromatography
Module-5 - Economic Analysis of Bioproducts **8 Hour**
Techno-economic analysis: Techno-economic assessment of biofuels and value added products in industrial process, Process design, Equipment sizing, Capital cost estimation, Operating cost estimation, Cash flow analysis

Learning Resources	*1.Bailey, J.E. and Ollis, D.F. "Biochemical Engineering Fundamentals", "McGraw– Hill", 2nd edition, 1988.* *2.Shuler, M.L. and Kargi, F. "Bioprocess Engineering: Basic Concepts", "PHI", 2002.*	*3. Magnus Frohling, Michael Hiete,"Sustainability and Life Cycle Assessment in Industrial Biotechnology", "Springer", 2020.*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*30%*	*-*	*20%*	*-*
Level 2	*Understand*	*20%*	*-*	*40%*	*-*	*20%*	*-*
Level 3	*Apply*	*30%*		*30%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*				*30%*	
Level 5	*Evaluate*						
Level 6	*Create*						
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd, Chennai	*1. Dr. Lima Rose Miranda, Anna University, Chennai*	*1. Dr. K. Tamilarasan, SRMIST*
2. Mr. S. Stalin, Course Director, Chem Skill Development Centre, Chennai	*2. Dr. N. Anantharaman, Former Professor, NIT Trichy*	*2. Dr. M.P. Rajesh, SRM IST*

Course Code	21CHE561T	Course Name	CLEANER TECHNOLOGIES AND SUSTAINABILITY	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Chemical Engineering*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*elaborate the concepts of clean technology to achieve sustainability*
CLR-2:	*provide acquaintance with modern, cleaner production processes and emerging energy technologies*
CLR-3:	*facilitate the understanding of the need for clean technologies in power generation*
CLR-4:	*familiarize the concepts of energy audit*
CLR-5:	*comprehend the applications of cleaner production in chemical process industries*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*analyze the environmental pollutants, comprehend the concepts of clean technology and cleaner production*	*2*		
CO-2:	*apply the cleaner production assessment and waste management techniques*	*2*	*3*	
CO-3:	*develop and implement clean technologies for power generation*	*2*		*2*
CO-4:	*conduct the energy audit and prepare the energy audit report*	*2*	*3*	
CO-5:	*apply cleaner production in chemical process industries*	*3*	*3*	*2*

Module-1 - Sustainability	**9 Hour**
Sustainability and biodiversity, the problem of environmental pollutants, clean technology and clean-up technology, environmental life cycle assessment, materials reuse: the new industrial ecology, cleaner production definition, evaluation of cleaner production, cleaner production network, and the area covered by cleaner production. Role of cleaner production in achieving sustainability, role of industry, institutions, and Government. Outline about greenhouse gas emission.	
Module-2 - Cleaner Production	**9 Hour**
Overview of cleaner production assessment steps and skills, preparing for the site visit, information gathering, and process flow diagram, material balance, waste reduction at source. Practical techniques for waste minimization: good housekeeping; input material changes; product changes; technical changes, recycling: on-site and off-site recovery.	
Module-3 - Clean Technologies for Power Generation	**10 Hour**
Environmental Issues, emission control in power plants: pre-combustion controls; combustion control techniques; post-combustion technologies, clean power plant configurations: Integrated Gasification Combined Cycle (IGCC) Power Plant. Production of hydrogen: steam reforming, partial oxidation, water electrolysis: reverse fuel cell operation, direct thermal or catalytic splitting of water. Fuel cell: electrochemistry and thermodynamics of fuel cells; proton exchange membrane fuel cell. Use of clean fuels.	
Module-4 - Energy Audit	**7 Hour**
Types of energy audit, energy audit process: pre-site work; site visit; and post-site work, energy audit report preparation, energy conservation via cleaner technology	
Module-5 - Case Studies and Cleaner Production Applications	**10 Hour**
Application of cleaner production in chemical process industries: Ammoniacal nitrogen recovery from wastewater, carbon capture, reuse of water from the sewage treatment plant, practical ways for energy saving in industries, sustainable aviation fuel. Case Studies of cleaner production in chemical process industries	

Learning Resources	*1.R.C. Kirkwood and A.J. Longley, "Clean Technology and the Environment", "Chapman & Hall", 2012.* *2.P. M. Randall, "Engineers Guide to Cleaner Production Technologies", "CRC Press" 1st edition 1996.* *3.W. Hoyle and M. Lancaster, "Clean Technology for the manufacture of Specialty Chemicals", Royal Society of Chemistry, 2004.*	*4. Bent Sorensen, "Hydrogen and Fuel Cells: Emerging technologies and applications", "Elsevier Academic Press", 3rd edition, 2018.* *5. Albert Thumann P.E., William J. Younger, "Handbook of energy audits", "Fairmont Press", 9th edition, 2012.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 2	*Understand*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 3	*Apply*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 5	*Evaluate*						
Level 6	*Create*						
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	*Experts from Higher Technical Institutions*	*Internal Experts*
1. Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd, Chennai	*1. Dr. Lima Rose Miranda, Anna University, Chennai*	*1. Dr. E.Kavitha, SRMIST*
2. Mr. S. Stalin, Course Director, Chem Skill Development Centre, Chennai	*2. Dr. N. Anantharaman, Former Professor, NIT Trichy*	*2. Dr.K.Anbalagan, SRM IST*

Course Code	21CHE562T	Course Name	NANOSCIENCE AND NANOTECHNOLOGY	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Chemical Engineering*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the various types of nanomaterials based on their composition*
CLR-2:	*understand the approaches for synthesizing nanomaterials*
CLR-3:	*explain the concepts of different characterization tools and techniques*
CLR-4:	*familiarize the role of nanosensors*
CLR-5:	*gain insight into the diverse applications of nanotechnology*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*describe the properties of different nanomaterials*	*3*		
CO-2:	*elaborate the principles of different synthesis strategies*	*2*		*1*
CO-3:	*choose the appropriate method of characterization*	*2*		*1*
CO-4:	*illustrate the working mechanism of nanosensors*	*2*		*1*
CO-5:	*comprehend the applications of nanotechnology in various fields*	*2*		*1*

Module-1 - Types of Nanomaterials	**9 Hour**
Metal nanoparticles, Semiconductor nanoparticles, Magnetic nanoparticles, Organic nanoparticles, Carbon- based nanomaterials - Carbon dots, carbon nanotubes, graphene, Polymeric nanoparticles, Hydrogels, Dendrimers, Nanocomposites	
Module-2 - Approaches for the Synthesis of Nanomaterials	**9 Hour**
Physical approaches - Photolithography, Optical lithography, Chemical approaches - Precipitation, Co-precipitation, Sol-gel synthesis, Microemulsions, Solvothermal synthesis, Thermolysis, Microwave assisted synthesis, Sonochemical synthesis, Photochemical synthesis, Synthesis in supercritical fluids, biological approaches	
Module-3 - Characterization of Nanomaterials	**9 Hour**
X-ray diffraction, Transmission electron microscopy, scanning electron microscopy, Scanning probe microscope (AFM and STM), Small Angle X-ray scattering, Vibrating Sample Magnetometry, Electron Spin Resonance, UV-Visible Spectrophotometer; FT-IR Spectrophotometer; Micro-Raman Spectrometer, Dynamic light scattering	
Module-4 - Nanosensors	**9 Hour**
Sensing principles, Types of sensors - Mechanical, acoustic, magnetic, thermal, chemical, radiation, Design, fabrication and characterization of nanosensors, Chemical nanosensors, Optical nanosensors, Nanobiosensors	
Module-5 - Applications of Nanotechnology	**9 Hour**
Everyday materials and processes, Electronics and Information Technology, Medicine and Healthcare, Energy, Environment, Future transportation	

Learning Resources	*1. Geoffrey A. Ozin, Andre C. Arsenault, "Nanochemistry: A Chemical Approach to Nanomaterials", Royal Society of Chemistry, Cambridge, UK, 2005.* *2. C. N. R. Rao, Achim Muller, A. K Cheetham, "Chemistry of nanomaterials : Synthesis, properties and applications" , "Wiely-VCH", 2004* *3. Daniel L. Fedlheim, Colby A. Foss, Marcel Dekker, "Metal Nanoparticles: Synthesis Characterization & Applications", 2002* *4. Cao Guozhong, ying Wang, "Nanostructures and Nanomaterials - Synthesis, Properties and Applications", "World Scientific", 2011.*	*5. N. John DiNardo, "Nanoscale Characterization of Surfaces and Interfaces", "Wiley", 2008.* *6. B. D Cullity, S.R. Stock, "Elements of X Ray Diffraction", "Prentice Hall", 2001.* *7.Yang Leng,"Materials Characterization: Introduction to Microscopic and Spectroscopic Methods", "John Wiley & Sons", 2013.* *8. Vinod Kumar Khanna, "Nanosensors: Physical, Chemical, and Biological", "CRC", 2012.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*20%*	*-*	*10%*	*-*
Level 2	*Understand*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 3	*Apply*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 5	*Evaluate*					*10%*	*-*
Level 6	*Create*						
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd, Chennai	*1. Dr. Lima Rose Miranda, Anna University, Chennai*	*1. Dr. K. Deepa, SRMIST*
2. Mr. S. Stalin, Course Director, Chem Skill Development Centre, Chennai	*2. Dr. N. Anantharaman, Former Professor, NIT Trichy*	*2. Dr. S. Anandhakumar, SRMIST*

Course Code	21CHE563T	Course Name	COLLOIDS AND SURFACES	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Chemical Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the concepts of surface, inter particle and inter molecular forces*
CLR-2:	*familiarize the concepts of surface wetting, flotation and electrokinetic properties of colloids*
CLR-3:	*understand the concepts of adsorption, monolayer and multilayer film formation on surfaces*
CLR-4:	*formation of gels, foams, aerosols and emulsions, and their characterization*
CLR-5:	*understanding various applications of colloids in different chemical industries*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*summarize the concepts of colloid chemistry using surface forces and electrochemical double layers*	*3*		*1*
CO-2:	*understand the concepts of wetting and their role in flotation and aggregation*	*2*		*1*
CO-3:	*understand the concepts of self-assembly process and formation of various colloidal structures*	*2*		*1*
CO-4:	*characterization of different colloidal structures*	*1*		*2*
CO-5:	*application of colloids in petrochemical, paint, food, pharma, and cosmetic industries*	*2*		*1*

Module-1 - Theory and Colloidal Stability	**9 Hour**
Introduction to Colloids—Surface Free Energy, Surface Tension, Contact Angle and Young-Laplace Equations and Surface Potential—Surface Forces: Double Layer Forces, Van der Waal's Forces, Steric Forces, and Hydration Forces—Colloidal Stability—Gecko Effect.	
Module-2 - Wetting and Electrokinetics	**9 Hour**
Wetting of Surfaces by Liquids—Lotus Effect—Flotation—Aggregation and Flocculation—Detergency—Friction and Lubrication—Electroosmosis—Electrophoresis—Dielectrophoresis	
Module-3 - Adsorption and Self Assembly	**9 Hour**
Adsorption from Liquids and Gases (including Polymers, Polyelectrolytes and Formation of Polyelectrolyte Complexes)—Surface Films on Liquid and Solid Substrates—Monomolecular Films, Langmuir-Blodgett Films, and Layer-by-Layer Assembled Films—Solution behavior of Micelles, Vesicles, Polyelectrolytes and Free Standing Films.	
Module-4 - Dual Systems and Characterization of Colloids	**9 Hour**
Formation of Gels, Emulsions, Foams and Aerosols—Characterization of Colloids: Zeta Potential and Size, Optical Microscopy, UV-Visible Spectroscopy, Scanning Electron Microscopy and Transmission Electron Microscopy.	
Module-5 - Industrial Applications	**9 Hour**
Exploring the Potential Applications of Colloids and Surface Chemistry in Petrochemical, Paint, Food, Pharma, and Cosmetic Industries.	

Learning Resources	*1.Drew Myers, "Surfaces, Interfaces, and Colloids: Principles and Applications". "Wiley-VCH", 2nd Ed., 2002.* *2.D. J. Shaw, "Colloid & Surface Chemistry", "Butterworth-Hienemann", 4th Edition,1992.* *3.Jacob N. Israelachvili, "Intermolecular and Surface Forces", "Academic Press" Third Edition, 2011.*	*4. Rodney Priestley and Robert Prud'homme, "Polymer Colloids: Formation, Characterization and Applications", Royal Society of Chemistry, 2019.* *5. Tharwat F. Tadros, "Handbook of Colloid and Interface Science, Volume 4: Industrial Applications: Agroochemicals, Paints, Coatings and Food Systems", "De Gruyter", 2018.* *6. Tharwat F. Tadros, "Handbook of Colloid and Interface Science, Volume 3: Industrial Applications: Pharmaceuticals, Cosmetics, and Personal Care", "De Gruyter", 2018.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 2	*Understand*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 3	*Apply*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 5	*Evaluate*						
Level 6	*Create*						
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd, Chennai	*1. Dr. Lima Rose Miranda, Anna University, Chennai*	*1. Dr. K. Deepa, SRMIST*
2. Mr. S. Stalin, Course Director, Chem Skill Development Centre, Chennai	*2. Dr. N. Anantharaman, Former Professor, NIT Trichy*	*2. Dr. S. Anandhakumar, SRMIST*

Course Code	21CHE564T	Course Name	INTERFACIAL SCIENCE AND ENGINEERING	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Chemical Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the concepts of surface forces, adhesion, cohesion, wetting and adsorption isotherms*
CLR-2:	*familiarize the concepts of colloidal stability, rheology and optical properties of colloids*
CLR-3:	*understand the concepts of self assembly, their kinetics, and formation of colloidal structures*
CLR-4:	*investigation on interactions and confinements at engineered interfaces and surfaces*
CLR-5:	*understanding the concepts of interfacial phenomenon in chemical and biological separations*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*understanding the surface forces and adsorption isotherms of colloids*	*3*		*1*
CO-2:	*understand the concepts of colloidal stability, optical and rheological properties of colloids*	*2*		*1*
CO-3:	*understand the concepts of self assembly process and formation of various colloidal structures*	*2*		*1*
CO-4:	*investigation of ion and molecular confinements at engineered surfaces, and their adsorption and desorption kinetics*	*1*		*2*
CO-5:	*the role of interfacial phenomenon in chemical and biological separations*	*2*		*1*

Module-1 - Surface Forces and Adsorption Isotherms of Colloids	**9 Hour**
Introduction to Intermolecular Forces and Interparticle Forces, and Hamaker Constant—Contact Angle and Marangoni Flow—Adhesion, Cohesion, Wetting and Spreading—Adsorption at Interfaces—Physisorption and Chemisorption—Gibbs free energy—Gibbs, Langmuir and BET Isotherms, and Surface Area Calculations.	
Module-2 - Stability, Optical and Rheological Properties of Colloids	**9 Hour**
Colloidal Stability—DLVO Theory—Types of Aggregation, Sedimentation and Kinetics—Smoluchowski Equation—Optical Properties: Theories, Scattering by large and Small Particles and Turbidity—Rheological Properties: Viscosity, Newtonian/Non-Newtonian Fluids and Electroviscous Effects.	
Module-3 - Formation and Kinetics of Colloidal Structures	**9 Hour**
Introduction to Surfactants, Micelles and Self-Assembly—Nucleation, Flocculation and Oswald Ripening—Kelvin Equation—Foams, Gels and Aerosols: Their Preparation and Stability, Mechanisms of Breakup Under Shear and Rheological Properties—Polymers at Interfaces, Blends, Composites and Polymeric Surfactants.	
Module-4 - Interactions and Confinements at Engineered Interfaces and Surfaces	**9 Hour**
Introduction to Chemical Process Systems—Complex Interactions of Ions and Molecules at Engineered Surfaces —Adsorption, Desorption Kinetics Within Common Chemical Engineering Processes—Nanoconfinement at Interfaces—Theory and Approaches of Investigation of Transport and Thermodynamic Properties Within Nanopores at Engineered - Porous Surfaces in Common Chemical Engineering Processes.	
Module-5 - Interfacial Phenomenon in Chemical and Biological Separations	**9 Hour**

Estimation of Mass Separating Agents at Industrial Scales (E.g., Sorbents and Membranes)—Field Induced Separation Processes with Lower Energy and Material Requirements—Colloidal and Interfacial Phenomenon in Bioprocesses to Improve Yield and Purity (E.g., Processes for Bio-derived Chemicals and Proteins)—Engineering Interfaces for Molecular Recognition to Improve the Specificity.

Learning Resources	*1.Drew Myers, "Surfaces, Interfaces, and Colloids: Principles and Applications". "Wiley-VCH", 2nd Ed., 2002.* *2.D. J. Shaw, "Colloid & Surface Chemistry", "Butterworth-Hienemann", 4th Edition, 1992.* *3.Jacob N. Israelachvili, "Intermolecular and Surface Forces", "Academic Press", Third Edition, 2011.*	*4.Richard I. Masel, "Principles of Adsorption and Reaction on Solid Surfaces", "Wiley Series in Chemical Engineering", 1996.* *5.Simone Napolitano, "Non-equilibrium Phenomena in Confined Soft Matter", "Springer", 2015.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*						
Level 6	*Create*						
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd, Chennai	*1. Dr. Lima Rose Miranda, Anna University, Chennai*	*1. Dr. K. Deepa, SRMIST*
2. Mr. S. Stalin, Course Director, Chem Skill Development Centre, Chennai	*2. Dr. N. Anantharaman, Former Professor, NIT Trichy*	*2. Dr. S. Anandhakumar, SRMIST*

Course Code	21CHE565T	Course Name	BIOMATERIALS AND DRUG DELIVERY SYSTEMS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Chemical Engineering*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the fundamental principles in biomaterials, material science and chemistry, and how they contribute to biomaterial development and performance.*
CLR-2:	*learn more about implant materials and their design along with different regulations.*
CLR-3:	*understand the fundamentals of various characterization techniques involved in evaluating biomaterials.*
CLR-4:	*earn more about drug delivery systems, and different approaches of drug delivery.*
CLR-5:	*learn more about the emerging drug delivery systems and technologies that can provide better health care and patient compliance.*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*learn more about biomaterials and their properties and requirements.*	*2*		*1*
CO-2:	*understand more details about the design and other requirements of biomaterials.*	*1*		*2*
CO-3:	*learn more about various characterization techniques of biomaterials.*	*3*		*1*
CO-4:	*understand the fundamentals of drug delivery systems*	*1*		*2*
CO-5:	*understand different materials and technologies that are being used in drug delivery*	*2*		*1*

Module-1 - Introduction to Biomaterials	***9 Hour***
Biomaterials—Classification—Metals, Ceramics, Polymers and Composites—Surface and Bulk Properties—Surface modification and types—Cell surface Interactions—Protein Absorption—Biocompatibility—Immune responses—In-vitro and In-vivo Analysis of Biocompatibility	
Module-2 - Implants and Their Requirements	***9 Hour***
Introduction to Implant Materials—Permanent and Absorbable Devices—Criteria for Materials Selection—Survey of Biomaterials and Case Studies—Biocompatibility: Contraction, Scar Formation, Tissue Bonding, Modulus Matching, Corrosion, Wear and Tear—Ethical Clearance and Medical Device Regulations.	
Module-3 - Characterization of Biomaterials	***9 Hour***
Contact Angle—Universal Testing Machine—Optical Microscopy—X-ray Diffraction—Atomic Force Spectroscopy—Scanning Electron Microscopy—Transmission Electron Microscopy—X-ray Photoelectron Spectroscopy—Secondary Ion Mass Spectrometry (SIMS) —Auger Electron Spectroscopy.	
Module-4 - Drug Delivery	***9 Hour***
Introduction to Drug Delivery Systems—Therapeutic Window—Route Specific Drug Delivery: Oral, Subcutaneous, Intramuscular, Transdermal, Inhalation and Intravenous—Sustained and Controlled Drug Delivery—Targeted Drug Delivery—Prodrugs—Diffusion Controlled Systems: Principle, Fick's Law, Non-Erodible Matrix Systems—Bio-erodible Systems—Drug Conjugates—PEGylation.	
Module-5 - Novel Drug Delivery Systems	***9 Hour***
Introduction to Different Drug Delivery Systems—Emulsions: Types and Applications—Hydrogels: Physical and Chemical Systems, Cross-linking and Pore Size Calculations—Dendrimers—Liposomes—Niosomes—Micelles—Different Novel Systems: Metal, Ceramic, Polymeric and Hybrid Micro and Nano Particles—Cell and Gene Delivery—Applications of Drug Delivery Systems.	

Learning Resources	1.J. S. Temenoff and A. G. Mikos, "Biomaterials", "Pearson Prentice Hall", 2008. 2.W. D. Callister, "Materials Science and Engineering: An Introduction", "John Wiley and Sons", New York, 2001.	3.I. V. Yannas, "Tissue and Organ Regeneration in Adults", "Springer", ISBN: 9780387952147,2001 4. N. K. Jain, "Controlled and Novel Drug Delivery", "CBS Publisher and Distributors Pvt. Ltd.", 2nd Edition 2023.

Learning Assessment							
	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	20%	-	20%	-	20%	-
Level 2	Understand	20%	-	20%	-	20%	-
Level 3	Apply	30%	-	30%	-	30%	-
Level 4	Analyze	30%	-	30%	-	30%	-
Level 5	Evaluate						
Level 6	Create						
	Total	100 %		100 %		100 %	

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd, Chennai	1. Dr. Lima Rose Miranda, Anna University, Chennai	1.Dr. K. Deepa, SRM IST
2. Mr. S. Stalin, Course Director, Chem Skill Development Centre, Chennai	2. Dr. N. Anantharaman, Former Professor, NIT Trichy	2. Dr. S. Anandhakumar, SRM IST

ACADEMIC CURRICULA

Food and Nutritional Biotechnology

Professional Core Courses

Regulations 2021

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

Course Code	21FPC501J	Course Name	FOOD SAFETY SYSTEM AND QUALITY MONITORING	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Food Process Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*impart knowledge on food safety and quality*
CLR-2:	*create and enhance awareness on food safety issues and its monitoring activities*
CLR-3:	*make an awareness and knowledge in food labeling*
CLR-4:	*know and implement good manufacturing practices in industries*
CLR-5:	*implement good health and hygiene practices*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*understand the basic principles and concepts of food safety and quality.*		√	
CO-2:	*know more on contaminants and toxicants.*	√		
CO-3:	*enhance the knowledge on food additives and adulterants.*			√
CO-4:	*understand the concept on monitoring and implementing FSSAI regulations.*			√
CO-5:	*implement risk assessment and risk management.*		√	

Module-1 – Introduction to Food Safety	***10 Hour***
Overview of food quality and food safety; Scope of food quality and food safety; Responsibility for food quality and food safety; The distinction between food quality and food safety; Food safety as part of food quality; Food quality.	
Module-2 – Food Safety and Hazards in Foods	***10 Hour***
Introduction and overview - Food safety hazards and health risk; Biological hazards in foods; Chemical hazards in foods; Physical hazards in foods; Other food safety concerns.	
Module-3 – Quality Programs and Quality Systems for the Food Industry	***15 Hour***
Introduction and overview: The distinction between quality programs and quality systems; Quality control programs; Quality assurance systems; Quality management systems; Total quality management; Quality system standards; The ISO 9000 quality system standards; The evolution of the ISO 9000 quality system standards; ISO 9000:2000 quality management systems — fundamentals; ISO 9000:2000 quality management principles.	
Module-4 – GMP and HACCP Requirements	***15 Hour***
Introduction and overview: The distinction between quality programs and quality systems; Quality control programs; Quality assurance systems; Quality management systems; Total quality management; Quality system standards; The ISO 9000 quality system standards; The evolution of the ISO 9000 quality system standards; ISO 9000:2000 quality management systems — fundamentals; ISO 9000:2000 quality management principles.	
Module-5 – Total Quality Management	***10 Hour***
Quality Management; Understanding Some Basic Concepts; Safety Management; Statistical Quality Control, Statistical Product control; Risk Assessment through Hazard Identification and Job Safety Analysis. Assessment and mitigation of risk.	

Learning Resources	1. *Inteaz Ali: Food Safety Quality Assurance: Principles and Practices, CRC Press, 2004.* 2. *Carol A. Wallace, William H. Sperber, Sara E. Mortimore. (2011) Food safety for the 21st century: managing HACCP and food safety throughout the global supply chain. Aimes, Iowa : Blackwell Pub.,.*	3. *Schmidt, R.H. and Rodrick, G.E. (2005). Food Safety handbook. John Wiley & Sons, Inc.* 4. *Mortimre, S., and Wallace, C., (2005) HACCP: A practical approach, 2nd Ed, Aspen Publication*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of Module test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	-	-	*15%*	-
Level 2	*Understand*	*25%*	-	-	-	*25%*	-
Level 3	*Apply*	*30%*	-	-	*15%*	*30%*	-
Level 4	*Analyze*	*30%*	-	-	*25%*	*30%*	-
Level 5	*Evaluate*	-	-	-	*30%*	-	-
Level 6	*Create*	-	-	-	*30%*	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	*Experts from Higher Technical Institutions*	*Internal Experts*
		Dr. P. Gurumoorthi, SRM IST

Course Code	21FPC502T	Course Name	NUTRITION AND CLINICAL STUDIES	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Food Process Engineering	Data Book / Codes / Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*socially committed nutritional educators in various institutions.*
CLR-2:	*train on innovative recipe development considering the science of food*
CLR-3:	*develop feasible solutions against major nutrition related health issues in the country.*
CLR-4:	*gain a deeper understanding of critical conditions and treatment routine*
CLR-5:	*gain knowledge on hospital management*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	*Programme Outcomes (PO)*		
		1	*2*	*3*
CO-1:	*equip and inculcate an interest in research in the field of nutrition.*			√
CO-2:	*give opportunity and job experience through hospital internships*		√	
CO-3:	*proficiency in lifestyle disease management*			√
CO-4:	*independent to access, analyze and plan nutritional management for disease*			√
CO-5:	*understand the nutrients in terms of changes during digestion, absorption etc.*		√	

Module-1 Human Nutrient Requirements	***10 Hour***
Macronutrients, methods of assessment of nutrient needs – a critical review, Critical evaluation of sensitive methods and derivations of requirements and recommended dietary allowances of macronutrients for all age groups: - Energy - Carbohydrates and dietary fibre - Proteins and amino acids - Lipids – Water, critical evaluation of National and International nutrient allowances; factors affecting the requirements.	
Module-2 Diet Associated Diseases	***10 Hour***
Nutritional Aspects of Eating Disorders and Nutritional management of eating disorders - Anorexia Nervosa, Bulimia Nervosa, Binge eating disorders, Anorexia athletic, Body dysmorphic disorder, Muscle dysmorphic disorder (bigorexia), Orthorexia nervosa, Pregorexia, Drunkorexia, Infection-triggered, auto immune subtype of anorexia nervosa in young children, Night-eating syndrome, Rumination syndrome, Gourmand syndrome, Prader-Willi syndrome, Pica, Cyclic vomiting syndrome, Chewing and spitting.	
Module-3 Nutrigenetics and Nutrigenomics	***12 Hour***
Introduction, Definition, Gene Expression, role of specific nutrients in controlling gene expression: Proteins, Lipids, Fuel molecules and lipogenesis, Minerals, Vitamins, Genes and diseases. Genetic variation and dietary response. Human genome Project, Epigenomics and Types of diet: liquid, semi solid, solid.	
Module-4 Medical Nutrition Therapy	***13 Hour***
Introduction to MNT, MNT for Nutritional Anemia, MNT for Diabetes Mellitus and MNT for Gastrointestinal Tract Disorders. MNT for Liver and Gall Bladder disease, MNT for Cardiovascular Diseases, MNT for Renal Diseases, MNT for Respiratory diseases, MNT for Fever and Infectious Diseases. Balanced Meal Designing; Diet chart preparation for anemia, Diet chart preparation for Renal Diseases, Diet chart preparation for diabetes	

Learning Resources	1. *Bharat B. Aggarwal, David Heber, (2014), "Immunonutrition: Interactions of Diet, Genetics, and Inflammation", CRC Press.* 2. *Sareen Gropper, Jack Smith, (2012), "Advanced Nutrition and Human Metabolism", Cengage Learning.*	3. *Anne Payne, Helen M. Barker, (2011), "Advancing Dietetics and Clinical Nutrition", Elsevier Health Sciences.* 4. *Krause' s Food and Nutrition Therapy, (2010), 12th Edition*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of Module test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	*-*	*15%*	*-*	*15%*	*-*
Level 2	*Understand*	*25%*	*-*	*20%*	*-*	*25%*	*-*
Level 3	*Apply*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*10%*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*5%*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	*Experts from Higher Technical Institutions*	*Internal Experts*
		Dr. R. Preetha, SRM IST

Course Code	21FPC503J	Course Name	FOOD BIOTECHNOLOGY	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Food Process Engineering	Data Book / Codes / Standards	NIL		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*apply the concepts in biotechnology in food*
CLR-2:	*use biotechnological products in food*
CLR-3:	*design of large-scale production of biotechnological products for food application*
CLR-4:	*apply the concepts of fermentation in fermented food preparation*
CLR-5:	*explain about design of biosensors and its application in food analysis*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	*Programme Outcomes (PO)*		
		1	*2*	*3*
CO-1:	*apply the knowledge of biotechnology in food*			√
CO-2:	*gain familiarity in applications of biotechnological products in food*			√
CO-3:	*analyze possibility of industrial scale production of biotechnological products for food application*		√	
CO-4:	*sustain in biotechnological product development industry*		√	
CO-5:	*demonstrate Design of biosensors and its application in food analysis*			√

Module-1 Food Biotechnology and Bioprocess Technology	***15 Hour***
Different biotechnological products. Biotechnological products applications in Food. Bio process engineering for biotechnological product development. Scale up and downstream process in bioprocess technology. Stain improvement and selection, optimization of product preparation using statistical models. Types of fermenters, Fermenters for preparation of wine and beer. Drying, filtration, precipitation, centrifugation methods to isolate, concentrate and purify intracellular metabolites concentration and purification of intracellular metabolites. Regulatory aspects of biotechnology in foods. Social aspects of biotechnology in foods. Scope and development of fermented products benefits of fermentation.	
Module-2 Biotechnological Products and Its Industrial Scale Production	***15 Hour***
Natural Food flavors, Natural Food colors, Bio-preservatives, acidulants, types of organic acids, Enzymes in food processing. Enzymes in food preservation and food industry waste water treatment, Bacteriocins. Probiotics. Mode of action of probiotic, Probiotic food products preparation guidelines and criteria. Prebiotics, Bio surfactants as, emulsifier, Biosurfactants as emulsifier Industrial production of following products –wine, industrial production of different types of wine. Technological aspects of industrial production of following products –beer. Types of beer and its ingredients, baker's yeast production. SCP types, advantages, disadvantages, industrial production of single cell protein, industrial production of enzymes, industrial production of organic acids, industrial production of organic acids, natural flavors production. Biocatalytic synthesis of food flavors. Biotechnological production of vitamins. Experiment on Natural colors isolation and preparation methods; Isolation of probiotic and evaluation of probiotic properties, Experiment on bacteriocin assay;	
Module-3 GM Food	***15 Hour***
Genetically modified Foods. Advantages of GM foods —– Insect resistance – Virus resistance. Herbicide tolerant crops. Frost resistance – Drought and salinity resistant crops. Plants – Transformation methods –Agrobacterium transformation and Direct gene transfer. Transgenic plants - Commercially available GM crops. Golden rice. Transgenic animals. Genetically engineered bacteria. Risk associated	

with GM foods – soil. Allergens, toxins, antibiotic resistance, contamination - Creation of superbugs and superweeds. Regulatory aspects of GMO. Social aspects of GMO. Experiment of Probiotic fermented food product development and Shelf-life analysis
Module-4 Biosensors for Food Borne Pathogen Identification and Food Analysis ***15 Hour***
Various methods for pathogen detection. Conventional methods for pathogen identification. Immunological methods for pathogen identification. ELISA polymerase chain reaction. Real-time PCR, multiplex PCR, reverse transcriptase PCR, general aspects of biosensors and their potential applications. Classification of biosensors, Components of biosensor and. Different types of bioreceptor. Different types of transducers, biosensors for food contaminant analysis, biosensors for food borne pathogen identification, commercially biosensors for food borne pathogens, commercially available biosensors for food analysis. Experiment on Identification of Pathogens in food and water samples, MPN method for water quality determination

Learning Resources	1. *Sarah Elderidge. "Food Biotechnology; Current issues and perspectives". Nova science pub. Inc. 2003.* 2. *Stanbury, P.F., Allan Whitaker and S.J. Hall. "Principles of Fermentation Technology" Elsevier Ltd.., 2016* 3. *John, M. de Man. Principles of Food Chemistry, Third edition. Aspen Publishers. . 2009.*	4. *Rita Singh. Food Biotechnology. Global vision publication house, Delhi. 2004* 5. *Gustavo F. Gutierre. "Food science and food biotechnology". GRC Pub. 2003.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of Module test (45%)		Life-Long Learning CLA-2 (15%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	*15%*	-	-	-	*15%*	-
Level 2	*Understand*	*25%*	-	-	-	*25%*	-
Level 3	*Apply*	*30%*	-	-	*15%*	*30%*	-
Level 4	*Analyze*	*30%*	-	-	*25%*	*30%*	-
Level 5	*Evaluate*	-	-	-	*30%*	-	-
Level 6	*Create*	-	-	-	*30%*	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course designer

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
		Dr. R. Preetha, SRM IST

Course Code	21FPC504J	Course Name	FOOD ENGINEERING	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Food Process Engineering*	Data Book / Codes/Standards	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*understand properties of the raw material used in food processing*
CLR-2 :	*calculate mass and energy balance*
CLR-3 :	*identify suitable processing equipment*
CLR-4 :	*know high temperature preservation techniques*
CLR-5 :	*understand low temperature preservation techniques*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*determine engineering properties of foods*		√	
CO-2:	*develop mass and energy balance sheet for food processing operations*			√
CO-3:	*trouble suits food processing equipment operation*		√	
CO-4:	*produce new food product by high temperature preservation technique*		√	
CO-5:	*implement freezing and refrigeration system for perishable products*			√

Module-1: Engineering Properties of Food	***12 Hour***
Introduction – Food Engineering - Engineering properties – importance and role - Physical properties - types and methods to measure - Graphical method, weight, water displacement method - Thermal properties - Latent heat, sensible heat - Frictional properties - Angle of repose, coefficient of friction - Lab Experiment on physical properties of fruits and vegetables - Aero and hydrodynamic properties - Terminal velocity and Flow rate - Mechanical properties and Rheological properties - Texture profile analyzer and viscometer - Electrical properties- types and methods to determine - Conductivity meter and diffusivity meter - Optical properties- types and methods to determine - Hunter colour meter - Role of engineering properties of food in process design - Role of engineering properties of food in product design	
Module-2: Mass and Energy Balance in Food Processing	***12 Hour***
Introduction to mass and energy - Law of Conservation - Energy conservation - Problems - Mass Balance - Concepts and application - Problems - Tutorial for mass and energy conservation - Energy Balance - Concepts and application - Mass and energy balance calculation - Mass and energy balance problems for evaporation - Mass and energy balance problems for drying - Mass and energy balance problems for chilling - Mass and energy balance problems for freezing - Mass and energy balance problems for cold storage - Mass and energy balance problems for Mixing - Mass and energy balance problems for size reduction	
Module-3: Food Processing Machines and Operations	***12 Hour***
Introduction – Food processing operations - Basic processing steps for plant foods - Basic processing steps for animal foods - Basic processing steps for dairy - Cleaning of raw materials - methods - Cleaning equipment operation - Sorting and grading – definition and types - Operation of sorters and graders - Lab Experiment preprocessing operations in foods - Size reduction – principles and problems - Size reduction for solids, liquid, and semi-solid foods - Peeling - definition, types, and importance - Description about peelers - Filtration and Centrifugation - Definition and types - Operation and application - Membrane separation – types - Operation and application - Extraction and Expression process - Operation and application - Lab Experiments on Handling of food Material - Lab Experiments on size reduction process	

Module-4: Food Engineering Concepts - High Temperature Processing	***12 Hour***
Evaporation - principle - Methods of operation - Evaporator - types - Design, construction, and operation - Moisture content – Definition and types - Determination of moisture content - Blanching – Definition and importance - Blanchers – Types and Operation - Lab Experiment on moisture content determination - Drying and dehydration – definition and concepts - Drying mechanism-constant rate and falling rate period - Drying Techniques – Solar and tray drying - Spray drying and Freeze drying - Foam mat drying and Osmotic dehydration - Pasteurization- Definition and methods - Design and operation of pasteurizers - Sterilization – Definition, Design, and operation - Canning– Definition, Design, and operation - Retorting- Definition, Design, and operation - Lab Experiments on high-temperature preservation for foods - Lab Experiments on D, Z, and F value	
Module-5: Food Engineering Concepts – Low Temperature Processing	***12 Hour***
Introduction – low temperature processing techniques - Refrigeration – Carnot cycle - Chilling or cooling - Application - Types and operation of Chillers - Freezing - Application - Types and operation of Freezers - Freezing - Theory and equipment - Ice crystal development - Lab Experiments on chilling of foods - Melting of ice - Freezing injuries, Frozen burn – Occurrence - Freezing injuries, Frozen burn - prevention - Freezing time calculation - Slow and blast freezing - Individual Quick-frozen foods - Definition and operation - Freeze drying- Definition and operation - Freeze concentration - Definition and operation - Problems on frozen food storage system - Problems on cold chain - Lab Experiments on freezing of foods - Lab Experiments on Thawing of foods	

Learning Resources	1. *Sahay, K.M. and K.K. Singh, "Module Operations in Agricultural Processing". Vikas Publishing House Pvt. Ltd., New Delhi, 2003.* 2. *McCabe. and Smith, J.C."Module Operations of Chemical Engineering". McGraw - Hill Book Co. New York, 2002.* 3. *Chakravarty A.and D.S.De." Post-harvest technology of cereals and pulses". Oxford & IBH Publishing Co., New Delhi, 1988.* 4. *Mohesenin. N.N, "Physical properties of Plant and Animal Materials". Gordon and Breach Science Publishers, New York, 1985.*	5. *P. Fellows, "Food Processing Technology. Principles and practice", Ellis Horwood International publishers, Chichester, England, 2005.* 6. *Earle R.L. "Module operations in Food Processing", Pergamon Press. 2000.* 7. *Repulsing, "Introduction to Food Engineering". Academic press, California, USA, 2001 .* 8. *Laboratory Manual for Food Engineering*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of Module test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	-	-	*15%*	-
Level 2	*Understand*	*25%*	-	-	-	*25%*	-
Level 3	*Apply*	*30%*	-	-	*15%*	*30%*	-
Level 4	*Analyze*	*30%*	-	-	*25%*	*30%*	-
Level 5	*Evaluate*	-	-	-	*30%*	-	-
Level 6	*Create*	-	-	-	*30%*	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designer

Experts from Industry	*Experts from Higher Technical Institutions*	*Internal Experts*
		Dr. G. Nagamaniammai, SRM IST

Course Code	21FPC505J	Course Name	ANALYTICAL TECHNIQUES AND INSTRUMENTS FOR FOOD PROCESSING	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Food Process Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*analyze extended use of spectroscopic techniques*
CLR-2:	*explain components of advanced instruments in food analysis*
CLR-3:	*explain principles and application of instruments in food industry*
CLR-4:	*use of analytical techniques in food analysis*
CLR-5:	*analyze the applications of advanced instrumentation techniques and e-sensor systems in food analysis*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*apply the knowledge spectroscopy in food analysis*			√
CO-2:	*gain familiarity with advanced analytical instruments in food processing*		√	
CO-3:	*analyze knowledge about, purification and analysis of food ingredients*		√	
CO-4:	*gain knowledge in instruments application in food industry*			√
CO-5:	*apply the knowledge about. advanced instrumentation techniques and e-sensor system in food analysis*		√	

Module-1 Understanding and Applying Spectroscopy in Food Analysis	***20 Hour***
Spectroscopy different types, Beer's Law and Deviations from Beer's Law, Theory spectroscopy, Visible spectrometry and Colorimetry, Instrumentation Colorimetry, Instrumentation Single beam UV-Visible spectrophotometers, Double beam spectrophotometer components, Working of double beam spectrophotometer -block diagram. Applications of UV-Visible spectrophotometer. Applications of UV-Visible spectrophotometer., Instrumentation FTIR, Application of NIR and FTIR in food analysis. Mass spectroscopy – Theory, Types of ionization. Types of ionization. Mass Spectrometers instrumentation Analyzers and Detector. Mass spectra Interpretation, Experimental examples, Limitations of Mass spectroscopy, Applications of Mass spectroscopy in food technology, X-ray diffraction – Mosely's law, K band. XRD Principle, Instrumentation, various types of X-ray detectors, XRD applications in food products. Spectrophotometric determination of antioxidant property by DPPH method, Estimation of vitamin c in various food items by spectrophotometer, Protein estimation by spectrophotometric method, Refractometric analysis to confirm freshness of fruits and vegetables, Determination of the crystallinity index of various food products by X-Ray diffraction.	
Module-2 Analytical Techniques in Food Processing	***20 Hour***
Thermal methods– Thermogravimetry. Differential Scanning Calorimetry-Differential Thermal Analysis, applications of thermal analysis in food. Polarimetry principle, Applications of polarimetry in food analysis, Applications of polarimetry in food analysis. Refractometry Principle, Snell's law, Refractometer instrumentation, Applications of polarimetry and refractometry in Food analysis. Applications of polarimetry and refractometry in Food analysis. Electrophoresis, Principle, Electrophoresis, procedure. Types of electrophoresis and applications in food sample analysis, SDS page and its application. Principles of chromatography, Classification of chromatography. Adsorption, partition, Molecular exclusion, ion exchange and affinity. Molecular exclusion, ion exchange and affinity. Applications of chromatographic technique in food technology. TLC and paper chromatography. Applications TLC and paper chromatography in food analysis, HPTLC instrumentation and its application in Food analysis	

Experiment on stimulation of various amino acids and colors by TLC: Estimation of amino acid by ascending Paper Chromatography, : Determination of the artificial colors of various food sample by radial paper chromatography, A study on TGA and DSC curve interpretation.
Module-3 Advanced Techniques in Food Analysis and E-sensors 20 Hour
Introduction, HPLC system; sample preparation, principle of separation, solvent system and degasser, Pump, injector, types of columns and Different types of HPLC detectors, recorder, Different types of HPLC detectors, recorder, Procedure for conducting qualitative and quantitative analysis using HPLC. Application of HPLC in food analysis. Gas chromatography- Introduction, sample preparation, principle of separation in GC types of carrier gases used, injection port, oven, Types of GC columns. Different types of detectors and recorder. Applications of GC in food sample analysis. Different types of detectors and recorder. E sensors- e nose and e tongue - instrumentation, application and working principles, Antibiotic residue analysis in meat using HPLC: Demonstration of GC-MS for quantitative estimation of composition of food samples

Learning Resources	1. *Darwin G. Caldwell, "Robotics and automation in the food industry Current and future technologies", Woodhead Publishing Limited, 2013* 2. *Sharma, B.K. Instrumental Methods of Chemical Analysis. Goel Publishing House, New Delhi. 2004.*	3. *Skoog Douglas A., West, Donald M., Holler, F. James., and Crouch Stanley R. "Analytical Chemistry: An Introduction". Seventh Edition: South-Western, Australia, 2000.* 4. *Nielsen, S.S. Introduction to the chemical analysis of foods. Jones and Bartlett Publishers, Boston, London.2004*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	-	-	*15%*	-
Level 2	*Understand*	*25%*	-	-	-	*25%*	-
Level 3	*Apply*	*30%*	-	-	*15%*	*30%*	-
Level 4	*Analyze*	*30%*	-	-	*25%*	*30%*	-
Level 5	*Evaluate*	-	-	-	*30%*	-	-
Level 6	*Create*	-	-	-	*30%*	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	*Experts from Higher Technical Institutions*	*Internal Experts*
		Dr. R. Preetha, SRM IST

ACADEMIC CURRICULA

Food and Nutritional Biotechnology

Professional Elective Courses

Regulations 2021



SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

Course Code	21FPE510T	Course Name	ADVANCED TECHNIQUES IN FOOD PRESERVATION	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Food Process Engineering*	**Data Book / Codes/Standards**		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*know irradiation techniques*
CLR-2 :	*understand high pressure processing (HPP) techniques in food preservation*
CLR-3 :	*use Pulsed electric field (PEF) in food processing applications*
CLR-4 :	*apply ohmic heat and ultrasound to preserve food*
CLR-5 :	*identify suitable combination preservation technique for specific foods*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*develop irradiation process technique for food products*			√
CO-2:	*apply HPP technique for liquid foods*		√	
CO-3:	*implement PEF to extent the stability of foods*			√
CO-4:	*interpret the effect of ohmic and ultrasound processing on foods*			√
CO-5:	*integrate combinational preservation approaches to preserve perishables*		√	

Module-1: Food Irradiation	***9 Hour***
Introduction to irradiation - Definitions - Radiation sources - Equipment to produce radiation - Operation - Mode of action - Measurement of radiation - Dosimetry - Lab - Experiments on Irradiated foods - Merits and demerits - Limitations of food irradiation - Nutritional changes in irradiated foods - Microbiological changes in irradiated foods - Recommended dosage for animal foods - Regulations for Processing plants - Regulations for Processing products - National standards for irradiated foods - International standards for irradiated foods	
Module-2: High Pressure Processing and Cold Plasma	***9 Hour***
HPP - Introduction – Principle of HPP processing - Types of processing Chambers - Description of HPP chambers - Mechanism for preservation - Applications to food systems - Effect of HPP on Microbes - Effect of HPP on Nutrients - Factors affecting the quality - High Pressure Freezing (HPF) - Principles - HPF processing - Applications - Limitation in implementation. Cold Plasma- Introduction- Principle- Mode of action- Equipment and tools to generate cold plasma- Applications in food industries.	
Module-3: Pulsed Electric Field and UV treatments	***9 Hour***
PEF - Introduction - Principle - Operation - Mechanism of action - PEF treatment systems - Main processing parameters - Design of PEF processing Module - Technology – equipment - Modeling - PEF processing system - Applications merit and demerits - Microbial disruption - Enzyme inactivation - Safety aspects - Limitation - Effect of processing on food composition - Pulsed electric field - Mode of action - Processing and operation - Oscillating magnetic field - Mode of action - Processing and operation. UV Treatment- Introduction- Principle - mode of action – Equipment and operations- Applications.	
Module-4: Ultrasound and Ohmic Heating	***9 Hour***
Ultrasound – Introduction - Principle - Fundamentals - Ultrasound treatment system Description - Ultrasound - processing - Mode of action - Application - Modeling – Ultrasound processing system - Effect on microbes - Ultrasound - preservation aid - Effect on properties of foods - Ohmic heating – Introduction, Principle - Role of electrical conductivity of material on processing - Processing and operation - Treatment of products - Effect of processing on food - Cold plasma - Mode of action - Processing and operation	

Module-5: Minimal Processing and Hurdle Technologies	***9 Hour***
Minimal processing -Introduction - Principle, Definition, Terminologies - Factors affecting minimal processing - Hurdle Technology - Concept - Basics consideration for hurdle technology - Mechanism - Mode of action - Effect on food composition - Practice -Hurdle technology development for fresh fruits, vegetables, and salad - Hurdle technology development for packed fruits, vegetables, and salad - Hurdle technology development for fresh-cut animal foods - Hurdle technology development for packed animal foods - Hurdle technology development for liquid foods - Multi – target preservation - Chemical and biochemical hurdle - Organic acids - Plant-derived antimicrobials – antimicrobial enzymes - Bio preservative - Bacteriocins - Chitin or chitosan	

Learning Resources	1. *Da-wen Sun, "Emerging Technologies for Food Processing", Elsevier Academic Press Marcel Dekker Inc. NY,1995.* 2. *Leistner L. and Gould G. "Hurdle Technologies – Combination treatments for food stability safety and quality", Kluwer Academics / Plenum Publishers, New York, 2002.* 3. *Gustavo V. Barbosa-Canovas, Maria S. Tapia, M. Soledad Tapia, M. Pelicano," Novel Food Processing Technologies "(Food Science and Technology Series), Publisher: CRC Press, November, 2004.*	4. *Barbosa-Canovas, G V, "Pulsed electric fields in food processing: Fundamental aspects and applications"– a volume in the Food Preservation Technology series, edited by Washington State University and Q H Zhang, Ohio State University, USA, Woodhead Publishing Limited, Abington Hall, Abington, Cambridge, CB1 6AH, England, 2001.* 5. *Laboratory Manual for advanced techniques in food preservation*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of Module test (50%)		*Life Long Learning CLA-2 – (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	*-*	*15%*	*-*	*15%*	*-*
Level 2	*Understand*	*25%*	*-*	*20%*	*-*	*25%*	*-*
Level 3	*Apply*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*10%*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*5%*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	*Experts from Higher Technical Institutions*	*Internal Experts*
		Dr. G. Nagamanaiammai, SRM IST

Course Code	21FPE511T	Course Name	HANDLING, PACKAGING AND STORAGE OF FOOD PRODUCTS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Ni	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Food Process Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	gain the knowledge about material handling system and equipment
CLR-2 :	understand the basic concepts in food packaging
CLR-3 :	obtain information about different types of food packages
CLR-4 :	understand about various food packaging equipment
CLR-5 :	attain information about different types of storage system for food commodities

Course Outcomes (CO):	At the end of this course, learners will be able to:	Programme Outcomes (PO)		
		1	2	3
CO-1:	understand the basic concepts of nutraceutical and its classification used as health supplements.		√	
CO-2:	learnt function of flavonoids health benefits for cardiovascular disease and bone health.			√
CO-3:	analyze about the important of plant derived bioactive compounds potential to control the risk of diseases.		√	
CO-4:	understood the vital role of phytosterol derived from plants source used to prevent cancer and other diseases.			√
CO-5:	described about role of Bioactive compound used for reducing the risk of CVD, Diabetics, CNS disorders and Respiratory disorder.			√

Module-1: Food Handling System	9 Hour
Introduction to material handling - Requirements of materials handling system - Classification of material - Mobility of a bulk material - Load Utilization Process - Various materials in load utilization - Classification of Materials - Handling Equipment - Film wrapping equipment - Conveyors and bulk handling equipment - Construction of Belt Conveyors - Design of chain Conveyors - Construction of Screw Conveyors - Design of pneumatic Conveyors - Construction of bucket elevator - Design of hoppers and ducts - Introduction to Newtonian fluids - Handling of semi-liquid materials - Applications of hydraulic conveyors.	
Module-2: Design of Food Packaging Machine	**9 Hour**
Introduction to food packaging - Explanation of food safety and security - Requirements of food packaging - Problems related to packaging - Functions of packaging - Selection of packaging materials - Brief on primary packaging - Design on secondary packaging - Design on tertiary packaging - Brief on quaternary packaging - Design and development of packaging material - Product Needs in packaging design - Distribution needs and wants of packaging - Role of Physical Environment in packaging - Role of Biological Environment in packaging - Consumer Needs and wants of Packaging - Factors affecting product quality - Methods of Shelf Life Estimation - Methods of Shelf Life Estimation.	
Module-3: Food Packaging Materials and Methods	**9 Hour**
Introduction to food packaging materials - Techniques involved in food packaging - Identification of appropriate packaging materials based on products - Properties of packaging material - Paper and paperboard packaging - Films: cellulose film, plastic films, aluminium foils and laminations - Different types of food packages - Concept of canning and equipment used - Designing parameters of steel cans - Introduction to special packaging - Active and intelligent packaging - Aseptic packaging and its packaging design - Concept of modified atmospheric packaging- design parameters - Vacuum, gas packaging - Concept of shrink wrap packaging - Retort pouch packaging - Advantage of biodegradable packaging - Recent updates in biodegradable packaging.	
Module-4: Selection of Food Packaging System	**9 Hour**

Introduction to food packaging equipment - Methods in food packaging - Recent equipment in food packaging - Packaging equipment for solid foods - Packaging equipment for liquid foods - Packaging equipment for semi-liquid foods - Concept of fillers and its uses - Types of fillers used in industries - Fillers used in glass bottles - Fillers used in paper bottles - Fillers used for pouch filling - Introduction to thermoforming equipment - Techniques in Plastic cup formation - Design of Form – Fill – Seal equipment - Sealing equipment for liquid foods - Sealing equipment for solid foods - Equipment used in labeling of packages - Operation of Capping equipment - Equipment used in cartooning.
Module-5: Storage Systems ***9 Hour***
Introduction of storage of food commodities - Need for storage of food commodities - Traditional storage structures - Modern storage bins- design and construction - Improved storage bins - Entomology in storage of food commodities - Concept of Bag storage method - Design of bulk storage - Methods in stacking of food grains - Concept of controlled atmosphere storage - Concept of modified atmosphere storage - Designing of MA storage system - Designing of CA storage systems - Limitations in MA and CA storage systems - Effect of nitrogen on perishable commodities - Effect of oxygen on perishable commodities - Effect of carbon dioxide on perishable commodities - Durability of storage structures - Recent advances in storage system.

Learning Resources	1. *Jacob John. "A handbook on Food packaging". Daya publishing House, Delhi. 2010.* 2. *K.M. Sahay and K. K. Singh "Module Operations of Agricultural processing". Edition II. Vikas Publishing House Pvt. Ltd, Noida. 2010.* 3. *Crosby, N. T. "Food packaging Materials" Applied Science Publishers, London. 1981.*	4. *Justice, O.I. and I.N. Bass. "Principles and practices of seed storage". Castle House Publication Ltd. 1995.* 5. *Multon, J.L. "Preservation and storage of grains, seeds and their by-products".CBS Publishers and Distributors, Delhi. 2001.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life Long Learning CLA-2 – (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	*-*	*15%*	*-*	*15%*	*-*
Level 2	*Understand*	*25%*	*-*	*20%*	*-*	*25%*	*-*
Level 3	*Apply*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*10%*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*5%*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	*Experts from Higher Technical Institutions*	*Internal Experts*
		D.G. Nagamaniammai, SRM IST

Course Code	21FPE512T	Course Name	FOOD MICROBIOLOGY AND FERMENTATION TECHNOLOGY	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co- requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Food Process Engineering	Data Book / Codes / Standards			

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*attain information about history of food microbiology and identification and preservation of microbes*
CLR-2:	*know the factors affecting the microbial growth and metabolism*
CLR-3:	*obtain knowledge about beneficial and harmful effect of microbes*
CLR-4:	*know the techniques employed to control the microbial growth in foods*
CLR-5:	*attain information relevant to multi target preservation and food safety tool to avoid the hazards*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	*Programme Outcomes (PO)*		
		1	*2*	*3*
CO-1:	*enrich the technical acquaintance for the isolation and identification of microbes*	√		
CO-2:	*control the microbes based on factors in foods*		√	
CO-3:	*employ the fermentation techniques with specific skill*		√	
CO-4:	*prevent food spoilage by using different control methods*		√	
CO-5:	*acquire technical knowledge for identifying food safety complications*			√

Module-1 Classification and Identification of Microbes	***10 Hour***
History of food microbiology, classification of bacteria based on morphological, cultural, colony, biochemical, physiological characteristics. Classification of molds and yeasts. Types of nutritional media, staining techniques, simple and differential techniques.	
Module-2 Factors Affecting the Growth of Microbes and Beneficial and Pathogenic Microbes in Food	***8 Hour***
Extrinsic factors, Intrinsic factors, Beneficial and Pathogenic effect of bacteria, yeast and mold in food, microbial growth kinetics and log reduction, microbial metabolism of food components.	
Module-3 Fermentation	***9 Hour***
Single cell protein - Advantages and disadvantages of single cell protein, Probiotic microbes, Fermented products - Sauerkraut fermentation, Vinegar fermentation, Lactic acid fermentation.	
Module-4 Food Borne Diseases and Control Methods	***9 Hour***
Food borne diseases - Food infection, Food intoxication. Measures to control the microbial growth – physical, chemical and radiation methods. Homeostasis of microorganism, Hurdle concept	
Module-5 Natural Antimicrobials from Microorganisms and Safety Practices	***9 Hour***
Natural antimicrobials from microorganisms - Bacteriocin structure, Bacteriocin function, Application of bacteriocins in food systems. Basic principles of food plant sanitation, Hazard Analysis and Critical Control Point (HACCP), Good manufacturing practices (GMP).	

Learning Resources	
	1. *Frazier W.C., Westhoff D.C. and Vanitha N.M., (2014). Food Microbiology, 5th Edition, Tata McGraw Hill Publishing Company.* 2. *Adams, M.R., Moss, M.O., Mcclure, P.J. and Society, R. (2016). Food Microbiology. 4th Edition. Cambridge, UK: Royal Society of Chemistry.* 3. *Erkmen, O., 2021. Microbiological analysis of Foods and Food Processing Environments. Academic Press* 4. *Hutkins, R.W. (2019). Microbiology and Technology of Fermented Foods. Hoboken, Nj, USA: John Wiley and Sons, Inc.* 5. *Shikha Ojha, K and Tiwari, B.K. (2016). Novel food fermentation technologies. Cham: Springer.*

Learning Assessment							
	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of Unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	20%	-	20%	-	20%	-
Level 2	Understand	20%	-	20%	-	20%	-
Level 3	Apply	30%	-	30%	-	30%	-
Level 4	Analyze	30%	-	30%	-	30%	-
Level 5	Evaluate	-	-	-	-	-	-
Level 6	Create	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
		Dr. S. Periyar Selvam, SRMIST

Course Code	21FPE513T	Course Name	BIOCHEMISTRY OF PROCESSING AND PRESERVATION	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Food Process Engineering*	Data Book / Codes / Standards			

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*explain about overview of food biochemistry and enzyme activity.*
CLR-2:	*describe about biomacromolecules in food sources.*
CLR-3:	*analyze about the biochemistry of nucleic acids and genomics application in food science.*
CLR-4:	*describe about biochemistry of muscle foods and sea foods.*
CLR-5:	*discuss about proteomics application in foods, dairy products and cereal and grains.*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*understand the basic concepts and functions of enzymatic activity in food sources.*	√		
CO-2:	*learnt function of carbohydrate, proteins, and lipid and fat content in food.*			√
CO-3:	*analyze about the various methods of genetic engineering application techniques in food.*		√	
CO-4:	*understood the organoleptic properties of food substance.*	√		
CO-5:	*described about biochemistry in meat and poultry, fish processing, and organic acids in foods.*			√

Module-1 Introductory of Biomolecules	***9 Hour***
Glycobiology of Foods: Food Carbohydrates—Occurrence, Production, Food Uses, and Healthful Properties; Amino Acids, Oligopeptides, Polypeptides, and Proteins.	
Module-2 Mechanisms of Biochemical Changes	***9 Hour***
Biological Oxidations: Enzymatic and Nonenzymatic Browning Reactions and Control Mechanisms; Lipid Oxidation and oxidation induced changes in foods. Control of Oxidation; caramelization.	
Module-3 Biochemistry of Processing of Nutritional Compounds	***9 Hour***
Chemical changes in food during processing: overview; food processing perspective; means of controlling chemical reactions in foods during processing and handling; principal changes in starch during food processing; changes in pectin and cellulose during processing; chemical reactions of proteins; changes in vitamins during processing.	
Module-4 Biochemical Changes in Foods Products of Animal and Plant Origin	***9 Hour***
Biochemistry of Raw Meat and Poultry; Biochemistry of sea food processing; Biochemistry of Milk Processing; Biochemistry of Vegetable processing and Biochemical changes in vegetables; Flavor Compounds in Foods; Food Acids: Organic Acids, Volatile Organic Acids, and Phenolic Acid; chemical changes in natural food pigments.	
Module-5 Application of Enzymes in Food Industries	***9 Hour***
Enzymes Applied in Food Technology; Plant derived enzymes – Papain, Bromelain, Ficin and Lipoxygenase; Specific Application in the Food Industry; Food Application and Benefits; Enzyme actions in beer production; Sugar Syrups; Corn Syrups; Dairy and bakery products.	

Learning Resources	1. *Y. H. Hui "Food Biochemistry and Food Processing, First edition, Blackwell publications, ISBN-13: 978-0-8138-0378-4, 2006.* 2. *Fatihyidiz, "Advances in Food Biochemistry", CRC Press (Taylor & Francis group), ISBN: 978-0-8493-7499-9, 2010.*	3. *Benjamin. K. Simpson, "Food Biochemistry and Food Processing", Second edition, Wiley- Blackwell publication, ISBN: 978-0-8138-0874-1, 2012.* 4. *J.Scott Smith and Y.H.Hui, "Food Processing: Principles and Applications" Blackwell publishing, 2004.* 5. *Thomas Richardson, John W. Finley. Chemical Changes in Food During Processing, Edited by Institute of food technolog1sts 221 N. Lasalle St. Chicago, Illinois*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of Unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	*-*	*15%*	*-*	*15%*	*-*
Level 2	*Understand*	*25%*	*-*	*20%*	*-*	*25%*	*-*
Level 3	*Apply*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*10%*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*5%*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	*Experts from Higher Technical Institutions*	*Internal Experts*
		Dr. P. Gurumoorthi, SRM IST

Course Code	21FPE514T	Course Name	CROP PROCESSING TECHNOLOGY	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3
Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil					
Course Offering Department	Food Process Engineering	Data Book / Codes/Standards	Nil							

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	demonstrate rice and pulse processing
CLR-2 :	understand wheat, corn and millet milling operations
CLR-3 :	illustrate edible oil processing plant operations
CLR-4 :	select appropriate processing methods for coffee and tea production
CLR-5 :	execute spices and plantation products production

Course Outcomes (CO):	At the end of this course, learners will be able to:	Programme Outcomes (PO)		
		1	2	3
CO-1:	plan rice and pulse processing plant operations			√
CO-2:	construct a new processing module for wheat, corn and millet products		√	
CO-3:	develop edible processing oil plant		√	
CO-4:	evaluate coffee and tea processing plant operations			√
CO-5:	construct spice mix and plantation products processing line		√	

Module-1: Cereals Processing	9 Hours
Introduction - Paddy - varieties - Structure - Composition – Milling process: Pre-milling equipment - Milling equipment - Cleaner and rice graders - Parboiling - definition - methods - Batch and continuous parboiling methods and processing equipment - Merits and demerits for parboiling and Changes in rice during parboiling - Layout for Modern rice mill; Structure and composition - Wheat milling - stages of milling processing - Milling equipment operation - Block diagram for wheat mills ; Corn - Structure and composition - Corn wet milling - Corn dry milling - High Fructose corn syrup production; Oats - Structure, composition - Oat processing	
Module-2: Millets and Pulses Processing	**9 Hours**
Millets – Structure and composition - Processing of sorghum - Processing of ragi - Breakfast cereals - Expanded snacks - Video presentation for processing plant operation for millets and cereal-based products; Pulse - Structure and composition - Milling process – methods of pretreatment - Traditional pulse milling - Modern pulse milling - Merits and demerits; Soybean processing	
Module-3: Oilseed Processing	**9 Hours**
Oil seed- Structure and composition - Pretreatment for oil seeds - Oil milling processes - Traditional and modern oil milling process - Mechanical Extraction - Solvent extraction - Oil pressing – Cold and hot – Expression; Oil refining process flow - Neutralization, degumming - Deodorization, hydrogenation, winterization - Oil processing waste utilization. Palm oil – structure, composition and uses - Palm oil extraction processes. Coconut Oil - structure, composition and uses - Coconut oil extraction processes. Health benefits of oils and blended oils with legal requirements.	
Module-4: Plantation Crops	**9 Hours**
Tea – Types and importance - Process flow chart for tea production - Differences in processing operation for varieties of tea - Tea processing equipment. Coffee – structure and importance - Process flow chart for coffee production - Differences in processing operation for varieties of tea - Tea processing equipment. Cocoa – structure and importance - Process flow chart for cocoa production - Traditional and modern methods - Chocolate processing. Cashew nut – Types and importance - Process flow chart for Cashew nut production - Traditional and modern methods - Cashew nut oil processing and applications.	

Module-5: Spices and Crop Products processing	***9 Hours***
Spices - Introduction, scope - Pepper – structure and composition - Milling - Oleoresin extraction- Application - Pepper – structure and composition - Milling - Spice blend milling - Oleoresin Extraction- Application - Demo – Pepper and chilling pre- and post-harvest treatments. Turmeric – structure, composition, and importance - Milling – Curcumin extraction. Cardamom - structure, composition, and importance - Flavour extraction and application. Tapioca - structure, composition, and importance - Sago processing. Potato - structure, composition, and importance - Potato Product processing	

Learning Resources	1. *Unit operations in Agricultural Processing by K.M. Sahay and K.K. Singh. 2nd revised and Enlarged Edition. Vikas Publishing House Pvt. Ltd. 2004.* 2. *Cereal Processing Technology Ed. By, Gavin Woens CRC Press, 2001.* 3. *Coffee Processing Technology, Michael Sivetz and Foote, "," Vol II, AVI Publishing Co.,2007.*	4. *Spice Production – A Text Book, S.P. Kanunjia, Raj Narayan, Akali Seema & Moakala, 2021.* 5. *Handbook of herbs and Spices, Ed K.V. Peter, CRC Publishers., 2001.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of Unit test (50%)		*Life Long Learning CLA-2 – (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	*-*	*15%*	*-*	*15%*	*-*
Level 2	*Understand*	*25%*	*-*	*20%*	*-*	*25%*	*-*
Level 3	*Apply*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*10%*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*5%*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	*Experts from Higher Technical Institutions*	*Internal Experts*
		Dr G. Nagamaniammai, SRM IST

Course Code	21FPE515T	Course Name	POST - HARVEST TECHNOLOGY OF FRUITS AND VEGETABLES	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co- requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Food Process Engineering	Data Book / Codes / Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*understand the concepts of physiological characteristics of fruits and vegetables*
CLR-2:	*gain knowledge about fruits and vegetable harvesting criteria*
CLR-3:	*obtain information about postharvest losses and preservation*
CLR-4:	*know the postharvest handling, transport and storage methods*
CLR-5:	*attain information relevant to fruits and vegetables processing and preservation*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	*Programme Outcomes (PO)*		
		1	*2*	*3*
CO-1:	*gain the knowledge of fruits and vegetables classification*	√		
CO-2:	*apply maturity indices for harvesting fruits and vegetables*			√
CO-3:	*employ specific preservation techniques based on the types of fruits and vegetables and reduce the postharvest losses*		√	
CO-4:	*use unique handling, transport and storage methods with subject to fruits and vegetables*		√	
CO-5:	*acquire technical knowledge for processing the fruits and vegetables*		√	

Module-1 Classification and Post - Harvest Physiology	***9 Hour***
Fruit and vegetable production in India, Postharvest losses of fruit and vegetable in India, Classification of fruit and vegetables, Importance of post-harvest physiology.	
Module-2 Maturity Criteria	***9 Hour***
Stages of growth, Maturity criteria, Determination of harvest maturity indices, Computational, Physical, Chemical and Physiological methods. Changes during fruit ripening.	
Module-3. Types of PHT Losses, Spoilage and Preservation Methods	***9 Hour***
Types of post-harvest losses, Mechanical injury types, Respiration and Transpiration losses, Methods to measure respiration and transpiration losses, Technologies to control post-harvest losses, Spoilage of fruits and vegetables, Methods for the preservation of fruits and vegetables. Enzymatic browning and control	
Module-4 Post-Harvest Handling	***9 Hour***
Post-harvest handling, transportation, precooling after Harvest, Cleaning, Trimming, Peeling, Grading, Sorting, Washing, Curing, Blanching methods. Storage methods for fruits and vegetables.	
Module-5 Processing Concepts for Fruits and Vegetables	***9 Hour***
Processing concepts for fruits and vegetables, Minimal processing concept - Processing methods, Equipment for fruits and vegetables products, Recent trends in fruits and vegetables processing.	

Learning Resources	
	1. *L.R. Verma and V.K. Joshi, "Post-Harvest Technology of Fruits and vegetables". Volume 1 and 2. Indus Publishing Company, New Delhi. 2006.* 2. *Joshi, V.K. (2021). Postharvest Management of Fruits and Vegetables. New India Publishing Agency.* 3. *Sudheer, K.P. and V Indira (2020). Postharvest Technology of Horticultural Crops. New India Publishing Agency.* 4. *Florkowski, W.J., Shewfelt, R.L., Prussia, S.E. and Banks, N. (2014). Postharvest Handling A Systems Approach. San Diego Elsevier Science and Technology Ann Arbor, Michigan Proquest.* 5. *Ramaswamy, H.S. (2015). Post-harvest Technologies of Fruits and Vegetables. Lancaster, Pennsylvania: Destech Publications, Inc..*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of Unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 2	*Understand*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 3	*Apply*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*-*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*-*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
		Dr. S. Periyar Selvam, SRMIST

Course Code	21FPE516T	Course Name	ADVANCED DAIRY TECHNOLOGY	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Food Process Engineering*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*explain about overview of dairy biotechnology.*
CLR-2:	*describe about preservation techniques in dairy industries.*
CLR-3:	*analyze about the enzyme activity in milk products, and application of drying techniques in dairy.*
CLR-4:	*describe about hurdle technology and other various techniques in dairy processing.*
CLR-5:	*discuss about application of biotechnology in dairy production.*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*understand the basic concepts and functions of different methods of heat treatment in dairy products*		√	
CO-2:	*learnt function of UHT processing of milk*		√	
CO-3:	*understood the Hurdle technology, merits and demerits*		√	
CO-4:	*described about application of Bio-peptides and Bio-preservation in dairy industry*		√	
CO-5:	*enhance the knowledge about CIP and sanitation maintained in dairy plant.*			√

Module-1 Thermal and Freeze Processing of Milk	***9 Hour***
Pasteurization, Batch/Holding process, Continuous process, Vacreation, Sacralization, Uperization, Heat processing of milk - Effect of heat on milk, salt system and acidity, milk proteins, Destabilization of caseinate system, freeze processing of milk - Effect of freezing on lactose and caseinate system.	
Module-2 Ultra-High-Temperature Processing and Hurdle Technology	***9 Hour***
Types of sterilization plants - Direct heating plant, Indirect type heating system. Application of drying mechanism in dairy industry, Application of freeze drying, Spray drying, Humectants, Application of Hurdle technology in dairy, List of Hurdle advantages, Microbial growth inhibition, Application and future directions of hurdle technology.	
Module-3 Dairy Product Processing	***9 Hour***
Demand and supply of dairy product in India. Cheese production, Enzyme modified cheese, Advantage of enzyme modified cheese ripening. Flavor generation in dairy product, Skimmed and Semi-skimmed milk, Controlling the texture of fermented dairy products.	
Module-4 Application of Biotechnology in Dairy Industry	***9 Hour***
Bio-Preservation, Bio-peptides, Bio-detergents, Application of genetic engineering in dairy starter culture, Types of packaging in dairy products - Aseptic packaging, Use of tetra pack in dairy industry.	
Module-5 Clean in Place (CIP) in Dairy Industry	***9 Hour***
Centralized CIP system, Sanitization in CIP system, Methodology for cleaning equipment used in dairy industry, Sanitization methods, Assessment of effective cleaning and sanitization.	

Learning Resources	1. *Jagrani Minj, Aparna Sudhakaran V, Anuradha Kumari and Springerlink (Online Service (2020). Dairy Processing: Advanced Research to Applications. Singapore: Springer Singapore, Imprint Springer.* 2. *Murlidhar Meghwal, Goyal, M.R. and Chavan, R.S. (2017). Dairy Engineering. CRC Press.* 3. *Megh Raj Goyal, Kumar, A. and Gupta, A.K. (2021). Novel dairy processing technologies: techniques, management, and energy conservation. Toronto: Apple Academic Press.*	4. *Shivashraya Singh (2014). Dairy technology. New Delhi: New India Pub. Agency.* 5. *Chavan, R.S. and Megh Raj Goyal (2018). Technological interventions in dairy science: innovative approaches in processing, preservation, and analysis of milk products. Waretown, N.J.: Apple Academic Press.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of Unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	*Experts from Higher Technical Institutions*	*Internal Experts*
		Dr. S. Periyar Selvam, SRMIST

Course Code	21FPE517T	Course Name	MEAT, POULTRY AND FISH PROCESSING TECHNOLOGY	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Food Process Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand Structure and composition of meat.*
CLR-2:	*attain information Processing and preservation of poultry meat.*
CLR-3:	*know the factors affecting Processing, preservation and transportation of fish.*
CLR-4:	*know the techniques Processing, preservation and transportation of egg.*
CLR-5:	*attain information relevant to multitarget preservation and food safety tool to avoid the hazards*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*enrich the technical acquaintance Chilling, freezing, canning, cooking, drying and pickling of meat.*		√	
CO-2:	*ascertain Slaughtering, dressing, handling, storage and preservation of poultry meat.*			√
CO-3:	*know Postmortem changes in fish muscle, freezing of fish and shell fish*	√		
CO-4:	*acquire the technical knowledge 0n intricacies' Storage and handling*		√	
CO-5:	*identify Hazard assessment*			√

Module-1 Meat Composition from Different Sources	***9 Hour***
Meat composition from different sources; muscle structure and compositions; post-mortem muscle chemistry; Factors influencing the quality of meat. Meat Microbiology and safety. Ante mortem inspection and handling, Stunning types, Slaughtering types. Steps in slaughtering (Pig, Cattle, Sheep/ Goat) and dressing, Slaughter house operations; Modern abattoirs, typical layout and features, Offal handling and inspection. Grading of meat – retail and wholesale cuts. Operational factors affecting meat quality. Byproduct utilization	
Module-2 Processing and Preservation Of Meat	***9 Hour***
Processing and preservation of meat: Chilling and freezing of meat, Canning, cooking, drying, pickling, curing and smoking; prepared meat products like sausages, kebabs, etc. Intermediate moisture and dried meat products, Packaging of meat products. Meat plant hygiene – GMP, ageing of meat	
Module-3 Poultry Processing	***9 Hour***
Poultry: methods of slaughtering, Slaughtering equipment and operations, dressing, handling, storage, and preservation of poultry meat. Spoilage and its control. Freezing and chilling of poultry. byproduct utilization	
Module-4 Eggs	***9 Hour***
Eggs: Composition, handling, candling, washing, coating, packaging and storage. Egg processing. Egg powder manufacturing and pasteurization. Egg spoilage and its control, Egg Products and their nutritive Value	
Module-5 Fish and Marine Products Technology	***9 Hour***
Fish and Marine Products Technology, Fish and Marine Products and their nutritive value, commercially important marine products from India, Proximate composition, Postmortem changes in fish muscle. Handling, preservation and transportation of fish, Microbial spoilage of fish, Freezing of fish and shell fish., Entrepreneurship Development in Meat and Seafood Industry	

Learning Resources	1. Fidel Toldrá. 2010. "Handbook of Meat Processing". Blackwell Publishing 2. .Legarreta,I.G. 2010. "Handbook of Poultry Science and Technology (Volume I and Volume II)". John Wiley & Sons, Inc., Hoboken, New Jersey. U.S 3. Sam, A.R. 2001. "Poultry meat processing". CRC Press Taylor & Francis Group 4. Hui YH. 2001. "Meat Science and Applications". Marcel Dekker. 5. Kerry, J. 2002. "Meat Processing". Woodhead Publ. CRC Press.	6. Mead M. 2004. "Poultry Meat Processing and Quality". Woodhead Publ. 7. Pearson, A.M. & Gillett, T.A. 2006. "Processed Meat". 3rd Ed. Chapman & Hall. 8. Lawrie, R.A. 2006. "Meat Science". 7th Edn. Woodhead publishers.UK. 9. K.Gopakumar. 2002. "Fish Processing Technology", Indian council of Agri metural research, New Delhi.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of Module test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	20%	-	20%	-	20%	-
Level 2	Understand	20%	-	20%	-	20%	-
Level 3	Apply	30%	-	30%	-	30%	-
Level 4	Analyze	30%	-	30%	-	30%	-
Level 5	Evaluate	-	-	-	-	-	-
Level 6	Create	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
		Dr. G.Sarathchandra, SRM IST
		Dr. P. Gurumoorthi, SRM IST

Course Code	21FPE518T	Course Name	NUTRACEUTICAL AND FUNCTIONAL FOODS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co- requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Food Process Engineering	Data Book / Codes / Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*explain about linking between nutrition and Medicine.*
CLR-2:	*describe about flavonoids and its health benefits.*
CLR-3:	*analyze about the bioactive compounds from plant sources used as health supplements.*
CLR-4:	*describe phytoestrogen and its role in health benefits as supplementary products.*
CLR-5:	*discuss about nutraceuticals, efficacy, safety and toxicity*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	*Programme Outcomes (PO)*		
		1	*2*	*3*
CO-1:	*understand the basic concepts of nutraceutical and its classification used as health supplements.*		√	
CO-2:	*learnt function of flavonoids health benefits for cardiovascular disease and bone health.*		√	
CO-3:	*analyze about the important of plant derived bioactive compounds potential to control the risk of diseases.*	√		
CO-4:	*understood the vital role of phytosterol derived from plants source used to prevent cancer and other diseases.*			√
CO-5:	*described about role of Bioactive compound used for reduce the risk of CVD, Diabetics, CNS disorders and Respiratory disorder.*			√

Module-1. Concepts of Nutraceutical: Introduction	***9 Hour***
Classification of Nutraceutical; Definition, History, Classification of Functional Foods: Probiotics, Prebiotics and Symbiotics; Nutrient vs. Non-nutrient; Prebiotics - Chemistry, Sources and Bioavailability, Effect of Processing, Effects on Human Health and Potential Applications in Risk Reduction of Diseases, Perspective for Food Applications for the Following: Non-Digestible Carbohydrates/Oligosaccharides: Dietary Fibre; Resistant Starch, Gums	
Module-2 Plant Metabolites and Non- Nutrients	***9 Hour***
Plant Metabolites and Non- Nutrient Effect of Specific Nutrients: Alkaloids, Glucosinolates, Terpenoids and Phenolics- Chemistry, Classes, Sources, Bioavailability and Effects on Human Health; Antinutrients Present in Food: Phytate, Saponin, Haemagglutinins, Protease, Amylase and Lipase Inhibitors. Spices and Condiments Nutritive Value and Uses in Cooking. Non- Nutrient Effect of Specific Nutrients: Proteins, Peptides and Nucleotides, Conjugated Linoleic Acid and n-3 Fatty Acids, Vitamins and Minerals	
Module-3** Properties**, Structures and Functions of Nutraceuticals	***9 Hour***
Introduction to Nutraceuticals as Science - Historical Perspective, Classification, Scope and Prospects; Applied Aspects of Nutraceutical Science: Sources of Nutraceuticals. Relation of Nutraceutical Science with Other Sciences: Medicine, Human Physiology, Genetics, Food Technology, Chemistry and Nutrition; Properties, Structure and Functions of Various Nutraceuticals Glucosamine, Octacosanol, Lycopene, Carnitine, Melatonin and Ornithine Alpha Ketoglutarate. Use of Proanthocyanidins, Grape Products, Flaxseed Oil as Nutraceuticals.	
Module-4 Nutraceutical: Applied Aspects and Relation with Science	***9 Hour***
Nutraceutical: Applied Aspects and Relation with Science: Relation of Nutraceutical Science with Other Sciences: Nutraceuticals in Medicine; Nutraceuticals for Cardiovascular Diseases; Nutraceuticals against Alzheimer's Diseases; Nutraceuticals for Diabetes; Nutraceuticals in Parkinson's diseases; Nutraceuticals in Cancer; Nutraceuticals and Gene Interactions.	

Module-5 Nutraceuticals in Food Processing Technology, Chemistry and Nutrition	***9 Hour***
Nutraceuticals in Food Processing Technology, Chemistry and Nutrition: Biotechnology in the Product Development of Nutraceuticals; Nanotechnology for Enhancing the Bioavailability and Delivery of Nutraceuticals; Nutraceutical Supplements and Remedies; Nutraceutical Supplements from Plant Sources; Nutraceutical Components from Animal Sources; Marine Sources as Nutraceutical Rich Supplements; Nutraceutical Remedies for Arthritis, Bronchitis, Circulatory Problems And Hypoglycemia.	

Learning Resources	1. *Vattem, Dhiraj A. and Vatsala Maitin. 2016. Functional Foods, Nutraceuticals and Natural Products, Concepts and Applications. USA: DEStech Publications, Inc.* 2. *Boye, Joyce I. 2015. Nutraceutical and Functional Food Processing Technology. New Jersey: Wiley-Blackwell.* 3. *Iwu, Maurice M. 2017. Food as Medicine: Functional Food Plants of Africa. US: CRC Press.*	4. *Cho, S. S. and M. L. Dreher. 2001. Handbook of Dietary Fiber. New York: Marcel Dekker Inc.* 5. *Wildman, R. E. C. 2000. Handbook of Nutraceuticals and Functional Foods. Boca Raton: CRC Press.* 6. *Aluko, Rotimi E. 2012. Functional Foods and Nutraceuticals. Germany: Springer*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of Unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	*-*	*15%*	*-*	*15%*	*-*
Level 2	*Understand*	*25%*	*-*	*20%*	*-*	*25%*	*-*
Level 3	*Apply*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*10%*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*5%*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
		Dr. P. Gurumoorthi, SRM IST

Course Code	21FPE519T	Course Name	FOOD INGREDIENTS, SUPPLEMENTS AND FORTIFICATION TECHNOLOGY	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Food Process Engineering*	**Data Book / Codes/Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1 :	*comprehend sensory modification, additive functions, and waste valorization for sustainable food production.*
CLR-2 :	*analyze fortification and supplementation principles, addressing nutrient deficiencies and regulatory compliance.*
CLR-3 :	*apply knowledge in developing health foods with optimized nutrition, packaging, and shelf life.*
CLR-4 :	*evaluate bioavailability, technological constraints, and safety considerations in fortification strategies.*
CLR-5 :	*explore the role of ingredients in sensory enhancement and preservation for quality food processing.*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*understand principles of sensory modification, additive functions, and waste valorization for sustainable food production.*			√
CO-2:	*analyze fortification and supplementation principles to address nutrient deficiencies and ensure regulatory compliance.*		√	
CO-3:	*apply knowledge to develop health foods with optimized nutrition, packaging, and shelf life.*		√	
CO-4:	*evaluate bioavailability, technological constraints, and safety considerations in fortification strategies.*			√
CO-5:	*explore ingredient roles in sensory enhancement and preservation for quality food processing.*			√

Module 1 . Introduction to Food Ingredients	***9 Hours***
Ingredients and processes that modify the color, Ingredients and processes that modify flavor and aroma, Ingredients and processes that modify the texture, Ingredients and processes that modify the sound, Preservatives, Antioxidants, Phosphates, Food and texture, Rheology, hydrocolloids, Emulsions, Oils and fats, Emulsions and emulsifiers; Industrial ingredients- Flour, starches and starch derivatives, fibers, Vegetable proteins, Milk proteins, Animal proteins	
Module 2 . Novel Food Ingredients	***9 Hours***
Novel bioactive ingredients and waste valorization of high value products extracted from food waste streams, Bioactive components for control of chronic disease conditions, Legislation and regulation, including health claims and EFSA definitions, Technologies for organoleptic property control and enhancement of ingredient bioavailability.	
Module 3. Food Fortification	***9 Hours***
Food Fortification Needs, objectives, principles and rationale, selection, and basis of fortificant. Technology of fortifying food products Characteristics of nutrients used in cereal fortification; Types and levels of micronutrients to be added; Fortification methods; Fortification premixes, Design and composition of premixes and quality control; Rationale for micronutrient fortification of snack products, Merits and demerits of fortification, Choice of products and selection of micronutrients, Fortification of cereal foods, beverages, oil, salt, sugar, Oil, Dairy products.	
Module 4. Food Supplementation	***9 Hours***
Food supplements, Need for supplementary foods, Technology for food supplementations, National and International regulatory requirements for supplementary foods and packs. Supplements and toxicity related to dose: common dietary supplements; relevance of the dose; possible toxic effects.	
Module 5. Regulatory Requirements for Health claims	***9 Hours***
Health *Foods Selection of nutrients, Technology of incorporation, Bioavailability, Packaging, Shelf life. Setting level of fortification, Safety limits, Technological and cost limits, Challenges in fortifying snack products, Nutrient interaction and bioavailability of fortified nutrients and supplements.*	

Learning Resources	1. *Klaassen, Curtis; Watkins III, John B. (2015), Casarett & Doull's Essentials of Toxicology, Third Edition, McGraw-Hill Medical, ISBN 10: 0071847081 ISBN 13: 9780071847087.* 2. *Tõnu Püssa (2013), Principles of Food Toxicology, Second Edition, CRC Press, ISBN 9781466504103.* 3. *S.S. Deshpande Ed (2013), Handbook of Food Toxicology, CRC Press, ISBN 9780824707606.* 4. *Helferich, W., and Winter, C.K. (2001) Food Toxicology, CRC Press, LLC. Boca Raton, FL*	5. *Shibamoto, T., and Bjeldanes, L. (2009) Introduction to Food Toxicology, 2nd Ed. Elsevier Inc., Burlington, MA* 6. *Watson, D.H. (1998) Natural Toxicants in Food, CRC Press, LLC. Boca Raton, FL* 7. *Duffus, J.H., and Worth, H.G. J. (2006) Fundamental Toxicology, The Royal Society of Chemistry* 8. *Stine, K.E., and Brown, T.M. (2006) Principles of Toxicology, 2nd Ed. CRC Press.* 9. *Tõnu, P. (2007) Principles of Food Toxicology. CRC Press, LLC. Boca Raton, FL.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of Unit test (50%)		*Life Long Learning CLA-2 – (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	*Experts from Higher Technical Institutions*	*Internal Experts*
		Dr. G. Nagamaniammai, SRM IST

Course Code	21FPE520T	Course Name	FOOD INDUSTRY WASTE MANAGEMENT FOR SUSTAINABILITY	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*NIL*	Co-requisite Courses	NIL	Progressive Courses	*NIL*
Course Offering Department	*Food Process Engineering*	Data Book / Codes / Standards	*NIL*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*apply the concepts in sustainable waste management for food industry waste management*
CLR-2:	*use waste management tools in fruit and vegetable industry waste management*
CLR-3:	*design of large-scale waste management methods and waste utilization in tuber crop and sugar industry*
CLR-4:	*apply large-scale waste management methods and waste utilization in fish processing, poultry and dairy industry*
CLR-5:	*explain about design of brewery industry waste management, solid waste management and coconut industry byproducts*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*apply the Knowledge of sustainable food industry waste management*		√	
CO-2:	*gain familiarity in fruit and vegetable industry waste management*			√
CO-3:	*gain familiarity in large-scale waste management methods and waste utilization in tuber crop and sugar industry*		√	
CO-4:	*gain the knowledge about fish processing, poultry and dairy industry*			√
CO-5:	*gain the knowledge of brewery industry waste management, solid waste management and coconut industry byproducts*			√

Module-1 Sustainable Development, Circular Economy and Waste Management in Food Industry	***15 Hour***
sustainable development in food sector, challenges and possibilities, circular economy in food waste management, the impact of food waste. main types of food losses and wastage. nature of food industry waste. biochemical composition of agriculture residues/food waste. uses of food-industrial residues. energy from `combustion, gasification and pyrolysis of solid agro or food waste. combustion and burning of waste for heat/energy generation thermo-chemical process. Technologies to convert rice biomass into energy, Bio-chemical process, Biodiesel and ethanol production, Waste Management in food Industries. food waste composting, benefits of compost to the environment and agriculture, environment composting methods. technologies to convert rice biomass into energy; utilization of lignocellulose waste from food industry, paper making from cellulosic waste.	
Module-2 Perishable Food Waste Management	***15 Hour***
global scenario of fruit and vegetable waste. different sources of fruit and vegetable wastes, fruit and vegetable processing industries and waste generation in India. utilization of fruit and vegetable waste for generation of biofuel. different steps in converting vegetable waste to biofuel production. biodiesel and bio-ethanol production from fruit and vegetable waste. bio-ethanol production from waste potatoes. types of byproducts of fruit and vegetable processing industry. isolation of cellulose from vegetable and fruit wastes and its utilization's production from fruit and vegetable waste organic acid production from vegetable waste. bioactive compounds from food industry waste. fish industry waste, applications of chitosan, methods and production of fish meal, fish oils, fish protein concentrate, types of waste from poultry, poultry waste utilization,	
Module-3 Food industry Waste Utilization and Waste Treatment	***15 Hour***
waste from rice mill industry. utilization of rice husk- cement preparation, ceramic materials. ceramic materials from rice husk. utilization of rice bran, problems in processing of rice bran, stabilization-methods of utilization, rice bran stabilizers, uses of bran, bran oil and defatted bran. waste from tuber crops, waste recycling plant. by products from tuber crop waste, potato and tapioca waste utilization, bio-ethanol production from potato waste, bio-ethanol production from waste potato's, biotechnological potential of cassava bagasse, dairy waste sources, characteristics of dairy waste, mechanical, and chemical treatment of dairy waste water, biological treatment of dairy waste water. advanced technologies for dairy effluent treatment, dairy industry by-products utilization of lignocellulose waste from	

food industry, sources of wastewater in a sugar industry, wastewater treatment of sugar industry, waste water treatment of sugar industry. waste water recycling, alcohol production from cane sugar industry waste from coconut processing units, uses of coir pith, biogas production- particle board, utilization of coconut husk-coir fiber, coconut shell utilization methods for production of shell charcoal, fuel briquette preparation, fuel briquette-machineries used.

Learning Resources	1. *.Lerwen Liu, and Ramakrishna. An Introduction to Circular Economy. Springer, New York, USA. 2021 ISBN: 978-981-15-8509-8* 2. *Ioannis Arvanitoyannis. Waste management for Food Industries, Academic Press , USA 2013*	3. *Ashok Panday Biotechnology of agro-industry waste utilization Springer, New York, USA, 2009.* 4. *Elina Närvänen , Nina Mesiranta, Malla Mattila, Anna Heikkinen . Food Waste Management: Solving the Wicked Problem Paperback pringer Nature Switzerland AG; 1st ed. 2020.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of Module test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	*-*	*15%*	*-*	*15%*	*-*
Level 2	*Understand*	*25%*	*-*	*20%*	*-*	*25%*	*-*
Level 3	*Apply*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*10%*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*5%*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
		Dr R Preetha, SRM IST

Course Code	21FPE521T	Course Name	BAKERY AND CONFECTIONERY TECHNOLOGY	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Food Process Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the concepts of baking technology*
CLR-2:	*know ingredients involved baking process*
CLR-3:	*understanding baking industrial requirements*
CLR-4:	*quality assurance of baking industries*
CLR-5:	*industrial lay out and structural requirement of baking industries.*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*demonstrate the baking process*		√	
CO-2:	*selection of ingredients, utensils and equipment*		√	
CO-3:	*food safety and quality aspects of baking industries*	√		
CO-4:	*plan for lay out design for bakery industry*			√
CO-5:	*extrusion technological aspects.*			√

Module-1 Introductory Aspects of Bakery and Confectionery Industries	***9 Hour***
Principles of Baking; Raw Material and their Role – flour, leavening agents, sugars, fats, additives, spice; Types of Bakery Products and Technology for their Manufacture – dough and batters; cakes, pies, pastries, bread, biscuits; Icings and Filling.	
Module-2 Manufacturing Process of Bakery and Confectionery Products	***9 Hour***
Principles of Confectionery Manufacture; Raw Material and their Role – interfering agents, inversion of sugars, etc.; Types of Confectionery Products and Technology for their Manufacture; Chocolate – raw material, types, and manufacture	
Module-3 Food Safety and Quality Aspects of Bakery and Confectionery Industries	***9 Hour***
Quality Parameters of Bakery Products - chemistry of dough and batters; rheological testing and interpretation of data; sensory evaluation; Staling and Nutrient Losses in Bakery Products; Sanitation and Hygiene in a Bakery Module.	
Module-4. Machinery and Equipment for Baking Technologies	***9 Hour***
Baking Tools and Equipment and their functions; Oven & Baking: Knowledge and working of various types of ovens. Baking temperatures for bread and confectionery goods. Methods of bread making: Straight dough method. delayed salt methods No time dough method. Sponge and dough methods. Characteristics of good bread: External characteristics; Volume, symmetry of shapes Internal characteristics - color, • texture, aroma, clarity and elasticity. Bread faults and their remedies	
Module-5 Status of Bakery and Confectionery Industries in India	***9 Hour***
Bakery layout: The required approvals for setting up of a Bakery, Government procedure and Bye laws. Selection of site, Selection of equipment, Layout design, Electricity, Quality control of raw material of finished products.	

Learning Resources	1. *Extrusion of Food, Vol 2; Harper JM; 1981, CRC Press.* 2. *Bakery Technology & Engineering; Matz SA; 1960; AVI Pub.* 3. *Hui, Y. H., Corke, H., De Leyn, I., Nip, W. K., & Cross, N. A. (Eds.). (2008). Bakery products: science and technology. John Wiley & Sons* 4. *Khetarpaul, N. (2005). Bakery science and cereal technology. Daya Books.*	5. *Up to-date Bread Making; Fance WJ & Wrogg BH; 1968, Maclasen & Sons Ltd.* 6. *4. Modern Cereal Chemistry; Kent-Jones DW & Amos AJ; 1967, Food Trade Press Ltd.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of Module test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	*-*	*15%*	*-*	*15%*	*-*
Level 2	*Understand*	*25%*	*-*	*20%*	*-*	*25%*	*-*
Level 3	*Apply*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*10%*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*5%*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	*Experts from Higher Technical Institutions*	*Internal Experts*
		Dr. P. Gurumoorthi, SRM IST

Course Code	21FPE522T	Course Name	BEVERAGE TECHNOLOGY	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Food Process Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*realize the concept of quality control in soft drink industries*
CLR-2:	*know the advantage and disadvantages of alcoholic beverages*
CLR-3:	*create awareness on functional beverages*
CLR-4:	*understand the beverages standards and regulation in India*
CLR-5:	*learn the risk and quality assessment methods*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*enhance the knowledge on types of beverages*	√		
CO-2:	*apply the knowledge on quality control in soft drink industries*		√	
CO-3:	*gain the knowledge on quality control in alcoholic beverages*		√	
CO-4:	*learn the different functional beverages*		√	
CO-5:	*know the implementation of GMP and HACCP in beverage industry*			√

Module-1 Types of Beverages and Raw Materials	***9 Hour***
Current status of the beverage industry in India and world, Types of beverages- Alcoholic and non-alcoholic, Nutritional and therapeutic benefits. Raw materials, Water, Acidulants, Emulsifiers, Stabilizers, Sweeteners, Bulking agents, Flavoring, Coloring agents, Threshold limits of ingredients, Threshold limits of water quality, Requirements of soluble solids and titratable acidity in beverages.	
Module-2 Non-Alcoholic Beverages	***9 Hour***
Non-Alcoholic Beverages, Natural Fruit based beverages, Synthetic/Artificial beverages, Carbonated beverages, Dairy-based beverages, Whey based beverages, Flavored milk, Advantages and Disadvantages of soft drinks.	
Module-3 Alcoholic Beverages	***9 Hour***
Alcoholic Beverages, Types of wine, Types of beer, Distilled beverages, Brandy, Whiskey, Rum, Gin, Production and defects, Advantages and Disadvantages alcoholic beverages.	
Module-4 Speciality Beverages	***9 Hour***
Speciality Beverages, Coffee, Tea, Probiotics as ingredient in functional beverage – production, Probiotics health benefits, Fortification of beverages, Specific nutrients in fortification.	
Module-5 Safety and Quality Control in Beverages	***9 Hour***
Sport beverages, Physiological needs, Formulation, Foodborne Pathogens in Beverages, Quality control in soft drink industries, Sanitation and hygienic in Beverage industries, GMP in the Beverage Industry, Hazard Analysis and Critical Control Points (HACCP).	

Learning Resources	
	1. *Charles Bamforth —Brewing: New Technologies, Woodhead Publishing Limited, England, 2006.* 2. *Varnam AH and Sutherland JM - Beverages: Technology, Chemistry and Microbiology, Springe Publishers, 1999.* 3. *Debby Newslow. Food Safety Management Programs - Applications, Best Practices, and Compliance, CRC Press, 2013.* 4. *Veslemøy Andersen, Huub Lelieveld, Yasmine Motarjemi. Food Safety Management - A Practical Guide for the Food Industry. 2nd Edition. Elsevier, 2023.*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of Unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 2	*Understand*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 3	*Apply*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*-*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*-*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
		Dr. S. Periyar Selvam, SRMIST

Course Code	21FPE523T	Course Name	INNOVATIVE DESIGNER FOOD DEVELOPMENT TECHNOLOGY	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	Nil
Course Offering Department	Food Process Engineering	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*understand the concept and significance of designer food products in meeting consumer needs and market demands.*
CLR-2 :	*explore the process of ideation, feasibility studies, and consumer research in the development of designer food products.*
CLR-3 :	*analyze quality assessment techniques, including sensory evaluation and shelf life testing, for new food product development.*
CLR-4 :	*investigate the role of technology, such as 3D food printing and encapsulation, in the production of designer food products.*
CLR-5 :	*examine the characteristics, consumers, and ethical considerations in food ingredient and service industries.*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	*Programme Outcomes (PO)*		
		1	*2*	*3*
CO-1:	*explains about significance and need of new food product development.*		√	
CO-2:	*develop a design of food product development.*		√	
CO-3:	*make qualitative evaluation of new food product development.*			√
CO-4:	*awareness about food service industries*			√
CO-5:	*know about various special foods*		√	

Module 1. Designer Food Product	***9 Hour***
Definition, Characteristics, Need for designer food product development. Classification: Line extensions - Repositioning of existing products - new form of existing product - Reformulation - New packaging – Smart packing- Innovative products - Creative products and Value added products	
Module 2. Ideation and Technologies	***9 Hour***
Idea generation, Sources, Screening, Feasibility studies, Consumer research, Product design and Formulation, Process development: Prototype development and scale up. Technologies: 3D food printing – Extrusion – Super critical fluid extraction- Encapsulation- Drying	
Module 3. Food Product Commercialization	***9 Hour***
Quality assessment of new developed products -Sensory Evaluation- Shelf-life Testing- Packaging and labeling Trends- Product life cycle, Product Commercialization and Marketing: Costing and Pricing, Test Market, Product launching and Entrepreneurship.	
Module 4. Development of Designer Foods	***9 Hour***
Health foods, medical foods, Therapeutic foods, Herbal foods, Fortified foods. Infant foods, Geriatric foods, Sports drink, Infertility. Functional foods, Designer foods and Nutraceuticals. Prebiotics, Prebiotics and Symbiotics.	
Module 5. Food Safety and Regulation	***9 Hour***
In Food Ingredient Industry: Characteristics, Consumers, Product development and Quality in food ingredient industry. In Food Service Industry: Characteristics, Consumers, Product development and quality in food service industry. Ethics and Intellectual property/ Patents in food product development	

Learning Resources	1. *Andrew, J.Taylor.(2002). Food Flavor Technology, Sheffield Academic Press.* 2. *Debashri, Ray. (2002). Nutritional Challenge and Total Quality Management, 1st edition; Sarup and Sons, New Delhi.* 3. *Man, C.M.D. and Jomes, A.A. (1994). Shelf-life Evaluation of Foods, Blackie Academic and Professional, London.*	4. *Mike Stringer and Colin Dennis. (2002). Chilled foods A comprehensive guide, 2ndedition, Woodhead publishing limited, Cambridge, England, 2000.* 5. *Rita Singh. (2004). Food Biotechnology. Volume 1, 1st edition, Global Vision publishing house, Delhi.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of Module test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
		Dr. G. Nagamaniammai, SRM IST

ACADEMIC CURRICULA

Food Safety and Quality Management

Professional Core Courses

Regulations 2021

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

Course Code	21FPC511T	Course Name	FOOD TOXICOLOGY	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Food Process Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*gaining the knowledge about Principles of toxicology*
CLR-2:	*know the information about food allergy and food toxicants*
CLR-3:	*obtain information about food safety of GMO*
CLR-4:	*know the impact of environmental toxicology*
CLR-5:	*attain information relevant to mycotoxins and food safety implications*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*obtain the knowledge of carcinogens in food*			√
CO-2:	*create aware about food allergy and natural toxins*		√	
CO-3:	*analyses food safety regulations of GMO*		√	
CO-4:	*understand impact environmental toxicology in food*			√
CO-5:	*analyses concept of mycotoxin and mycotoxin control strategies*			√

Module-1 Toxicology	***12 Hour***
Principles of toxicology - Principles of toxicology - Absorption - Distribution - Metabolism - Excretion of toxic chemicals - General mechanisms by which toxic chemicals cause disease in humans - General mechanisms by which toxic chemicals cause disease in humans - Molecular mechanisms behind chemical-induced toxicities - Carcinogens in Food - Common carcinogens found in food - Effect on health - Effect on health - Sources and levels of exposure - Approaches to minimize carcinogens in food - Approaches to minimize carcinogens in food - Assessment of carcinogenic safety of food - Assessment of carcinogenic safety of food.	
Module-2 Food Allergy and Food Toxicants	***12 Hour***
Food Allergy and Food Toxicants - Food allergy - Hypersensitivity - Introduction to the immune system - Introduction to the immune system - Mechanisms of allergic Type reactions - Allergenic components in foods - Allergenic components in foods - Natural toxins in food - Natural plant toxins - Natural plant toxins - Natural plant toxins effects in humans - Natural plant toxins effects in humans - Natural toxins in mushrooms - Toxicity of poisonous mushrooms in humans -. Methods to reduce food contamination with pesticides - Methods to reduce food contamination with pesticides - Contaminant interaction - Drug - Pesticide - Heavy metal. Toxic environmental inorganic food contaminants - Toxic environmental organometallic food contaminants - Sources and their impact on human health	
Module-3 Genetically Modified Organisms	***10 Hour***
Food safety of GMO - Definition of GMOs - Definition of LMO - Safety of genetically modified organisms (GMOs) - Safety of genetically modified organisms (GMOs) - Food safety regulations of GMOs - Food safety regulations of GMOs - GM Foods - Experiments on detection of pesticide residue - GM Foods - RCGM - GEAC - GMO applications in food and agriculture - GMO applications in food and agriculture - Environmental release of GMOs - Environmental release of GMOs - International rules and regulations in export and import of GMOs - Lab 6: Experiments on detection of antibiotic residues - International rules and regulations in export and import of GMOs.	
Module-4 HACCP, GMP, GLP	***11 Hour***
Mycotoxins - Mycotoxins impacting food production and manufacturing - Patulin, Ochratoxin, Zearalenone, Aflatoxins, Trichothecenes, and Fumonisins - Guidance and regulations on mycotoxins in food and feed - Mycotoxin control strategies - Good agricultural practices (GAPs)/Good manufacturing practices (GMPs) - HACCP - VACCP - TACCP - Biological control measures - Transgenic approaches - Bioterrorism - Risk Assessment - Food safety implications - Statistical methods used in toxicological studies - Toxicological testing: LD50 and LC50 oral dermal and inhaled, feeding trials - In vitro tests for toxicology - Analysis of food toxins by gas chromatography and HPLC - Analysis of food toxins by mass spectrometry.	

Learning Resources	1. *Shibamoto, T. and Bjeldanes, L. 2016. Introduction to Food Toxicology, 2nd Ed. Elsevier Inc., Burlington, MA. -- (SB).* 2. *Stine, K. and Brown, T. 1996. Principles of Toxicology. CRC Press, Inc. Boca Raton, FL.* 3. *Essentials of Environmental Toxicology. W. William Hughes. Taylor & Francis, Philadelphia, PA. ISBN 1-56032-470-4.*	4. *A Textbook of Modern Toxicology (3rd Ed 2004). Ernest Hodgson (Ed.), USA, Wiley & Sons. ISBN 0-471-26508-X.* 5. *Food Toxicology. W. Helferich and C. K. Winter (Ed.), CRC Press, London. ISBN 0-8493-2760-1. 20.* 6. *Klaassen, Curtis (Ed.). 2008. Caserett and Doull's Toxicology, 7th Edition. McGraw-Hill. New York, NY.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of Unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
		Dr R Preetha, SRM IST

Course Code	21FPC512J	Course Name	FOOD PROCESSING AND PRESERVATION TECHNIQUES	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Food Process Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	know about properties of raw materials used in food processing
CLR-2 :	know different processing and preservation techniques.
CLR-3 :	drying techniques of food material
CLR-4 :	low temperature and high temperature of preservation of foods
CLR-5 :	preservation by fermentation
CLR-6 :	modern food preservation techniques

Course Outcomes (CO):	At the end of this course, learners will be able to:	Programme Outcomes (PO)		
		1	2	3
CO-1:	understand the basic concepts of physical, chemical and biological properties of preservatives.	√		
CO-2:	theories involved in various processing and preservation techniques.		√	
CO-3:	understand the concepts and theory behind the preservation mechanisms.			√
CO-4:	the concept of traditional processing and preservation methods.		√	
CO-5:	know the application of radiation in preservation methods.			√

Module-1: Food Preservation and Preservatives	12 Hour
Scope and importance of food processing - Food Preservation mechanisms and types - Properties of food preservatives - Physical properties of preservatives - Thermal properties - Mechanical properties - Biological properties - Mechanism of preservation - Sensory evaluation pattern - Raw material – preparation Grading, Sorting, Cleaning, Profiling, Peeling, Selection - Regulations for food preservatives - Usage of common food preservatives - Usage of Natural Food preservatives - Usage Synthetic food preservatives - Specification and regulatory guidelines - Health implications	
Module-2: Thermal Processing and Preservation	**12 Hour**
Preservation by altering the temperature - Low temperature preservation - Method of freezing - Effect of low temperature preservation - High temperature preservation - Concepts of thermal preservation - Thermal destruction of microbes - Microbes vs high & low temperature - D, Z, F, values - Blanching - Pasteurization techniques - Sterilization techniques - ETO - Canning - Aseptic processing - Evaporation - Modern preservation techniques-ETO - Regulations of usage of sterilizing agents - Country wise specifications - Mechanism and theory - Salmonella issue - Rapid detections techniques - Modern analytical techniques	
Module-3: Fermentation and Bio Preservation	**12 Hour**
Preservation by fermentation - Fermentation techniques - Mechanisms - Technology of fermentation - Application in food processing sector - Type of fermented food products - Yogurt - Pickling - Curing - Usages of probiotics - Types of probiotics - Characterization of probiotics - Sources of probiotic microbes - Role and Application of probiotics - Evaluation of probiotics foods - Health and food safety of probiotics - International norms - Concept of symbiotics - Studies on probiotic microbes - Dehydration - Evaporation - Sorption isotherm studies - Water activity and shelf life	
Module-4: Non- Thermal Preservation	**12 Hour**
Radiation – as a preservation method - Concepts of radiation techniques - Sources of radiation - Application in food industries - Mode of action - Effect on microorganisms and nutrients - Dose and duration of radio preservation techniques - Detection of radiated foods - Measurement of radiation dose - Safety measures of radiation technique - Safety of irradiated foods - Gamma irradiation - IR – Irradiation - Concepts and industrial set up - Evaluation of radiation efficiency - Effect of irradiation on nutritional and bioactive profile - Regulatory requirement on irradiation - Country wise specification on food irradiation - Advantages and limitations of modern preservation techniques - Pulsed electric field - PEF technology and application - Dose and duration of exposure - Industrial safety and set up - Evaluation of pattern	
Module-5: Advanced Preservation Technology and Regulations	**12 Hour**
Modern / advanced preservation techniques - Principles and theories behind the techniques - Edible coating - FSSAI norms of edible coating - High pressure processing - Principles and basic concepts - Microwave processing - Ultrasonic processing - Principles and application in food systems - Ultrasound mediated processing - Ohmic heating - Principles of ohmic heating - Electrical conductivity - Generic configuration -	

Application in food systems - INS numbering - Efficiency of preservation - Preservatives as per FSSAI - Specifications of preservatives - FSSAI norms - GMP concept

Learning Resources	1. *Sivasankar, B. 2011. Food Processing and preservation, Eastern Economy Edition, BHI Publishers, New Delhi.* 2. *Shafiur Rahman, M. 2007. Handbook of Food Preservation, Second Edition, CRC Press, Muscat, Sultanate of Oman.*	3. *NeelamKhetarpaul, 2005. Food Processing and Preservation, Daya Publication House, New Delhi.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life Long Learning CLA-2- Practice (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	-	*15%*	*15%*	-
Level 2	*Understand*	*25%*	-	-	*20%*	*25%*	-
Level 3	*Apply*	*30%*	-	-	*25%*	*30%*	-
Level 4	*Analyze*	*30%*	-	-	*25%*	*30%*	-
Level 5	*Evaluate*	-	-	-	*10%*	-	-
Level 6	*Create*	-	-	-	*5%*	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
		Dr. G. Nagamaniammai, SRM IST

Course Code	21FPC513J	Course Name	ADVANCED FOOD MICROBIOLOGY	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

Pre-requisite Courses	Nil	Co- requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Food Process Engineering	Data Book / Codes / Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1:	attain information about substrate for microbes
CLR-2:	know the factors affecting the microbial growth and metabolism
CLR-3:	gain the information about spoilage and preservation of different kinds of food products
CLR-4:	obtain knowledge about beneficial and harmful effect of microbes
CLR-5:	attain the advance techniques for the detection of specific toxin and microbes

Course Outcomes (CO):	At the end of this course, learners will be able to:	Programme Outcomes (PO)		
		1	2	3
CO-1:	enrich the technical association substrate and microbes	√		
CO-2:	control the microbes based on factors		√	
CO-3:	prevent food spoilage by using different control methods		√	
CO-4:	employ the fermentation techniques with specific skill			√
CO-5:	Technical knowledge for identifying the toxin and microbes through advance techniques			√

Module-1 Food as a Substrate for Microorganisms	**10 Hour**
Food as a substrate for microorganisms - Hydrogen ion concentration, water activity, oxidation reduction potential of food, nutritional content	
Module-2 - Factors Affecting the Growth of Microorganisms	**12 Hour**
Extrinsic factors, intrinsic factors, beneficial effect of microbes in food, pathogenic effect of microbes in food, microbial growth kinetics and log reduction, microbial metabolism of food components.	
Module-3 – Fermentation	**13 Hour**
Single cell protein - Advantages and disadvantages of single cell protein, probiotic microbes, fermented products, sauerkraut fermentation, vinegar fermentation, lactic acid fermentation	
Module-4 - Food Borne Diseases, Food Spoilage and Preservation	**12 Hour**
Food borne diseases - Food infection, food intoxication, spoilage and preservation of different kinds of food products, fruits and vegetable products, meat and poultry products, dairy products	
Module-5 - Methods for the Microbial Examinations of Foods	**13 Hour**
Methods for the microbial examinations of foods - Direct examinations, cultural techniques, enumeration techniques, rapid methods for the detection of specific organisms and toxins.	

Learning Resources

1. Frazier W.C., Westhoff D.C. and Vanitha N.M., (2014). Food Microbiology, 5th Edition, Tata McGraw Hill Publishing Company.
2. Adams, M.R., Moss, M.O., Mcclure, P.J. and Society, R. (2016). Food Microbiology. 4th Edition. Cambridge, UK: Royal Society of Chemistry.
3. Erkmen, O., (2021). Microbiological Analysis of Foods and Food Processing Environments. Academic Press.
4. Foster, W. (2016). Food Microbiology. New Delhi: CBS Publishers and Distributors.
5. Doyle, M.P., Diez-Gonzalez, F. and Hill, C. (2019). Food Microbiology: Fundamentals and Frontiers. Washington, DC: ASM Press.

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life Long Learning CLA-2- Practice (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	-	*15%*	*15%*	-
Level 2	*Understand*	*25%*	-	-	*20%*	*25%*	-
Level 3	*Apply*	*30%*	-	-	*25%*	*30%*	-
Level 4	*Analyze*	*30%*	-	-	*25%*	*30%*	-
Level 5	*Evaluate*	-	-	-	*10%*	-	-
Level 6	*Create*	-	-	-	*5%*	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
		Dr. S. Periyar Selvam, SRMIST

Course Code	21FPC514J	Course Name	FOOD LAWS AND REGULATIONS	Course Category		PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Food Process Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand applicable food safety laws in India and international*
CLR-2:	*know the concept of food safety laws and its implications*
CLR-3:	*enhance and create awareness on health and hygiene*
CLR-4:	*know more about food safety systems*
CLR-5:	*understand food regulations in neighborhood countries*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*understand our country food laws and regulations*	√		
CO-2:	*know more about on food safety specifications*	√		
CO-3:	*apply knowledge on food safety regulations in food industries*		√	
CO-4:	*implement food safety and quality in industries*			√
CO-5:	*country wise specification on standards*		√	

Module-1 - National Food Safety Regulations: Background Food Law	***10 Hour***
FSSAI scenario, Multiplicity of laws and regulations. Prevention of Food Adulteration Act, FPO, milk and milk product order. Agmark, Case studies on Food Adulteration. Common Food Adulterants.	
Module-2 – Genesis of Food Safety and Standard Authority of India:	***10 Hours***
Licensing and registration regulation Food Safety and Standards (Food Products Standards and Food Additives) Regulation, Food Safety and Standards (Prohibition and Restriction of Sales) Regulation; Food Safety and Standards (Contaminants, Toxins and Residues) Regulation; Food Safety and Standards (Health Supplements, Nutraceuticals, Food for Special Dietary Use, Food for Special Medical Purpose, Functional Food and Novel Food) Regulations; Food Safety and Standards (Organic Food) Regulation; Food Safety and Standards (Fortification of Food) Regulation. Case Study: Food Product Standards and Specifications; Food: Labelling	
Module-3 - Food Safety and Standards (Advertising and Claims) Regulation	***10 Hour***
Food Safety and Standards (Advertising and Claims) Regulation; Food Safety and Standards (Packaging) Regulation; Food Safety and Standards (Recovery and Distribution of Surplus food) Regulation; Food Safety and Standards (Safe food and balanced diets for children in school) Regulations; Food Safety and Standards (Foods for Infant Nutrition) Regulations; Food Safety and Standards (Labelling and Display) Regulations; Food Safety and Standards (Ayurveda Aahara) Regulations; Food Safety and Standards (Vegan Foods) Regulations. Case Studies on Food Safety Specification and standards of different products.	
Module-4 – Recent FSSAI Initiatives	***20 Hour***
Food Safety Compliance System (FoSCOS); Food Import Clearance System (FICS); Eat Right India, FoSTAC, Food Safety Mithra Case Study: Attending training program on FoSTAC. (Two Day Training).	
Module-5 – Brief Introduction about Other National Regulatory Bodies	***10 Hour***
Bureau of Indian Standards (BIS) in water licensing and product certification, Export regulations of Food, Role of Export Inspection council, Role of Agricultural and Processed Food Export Development Authority (APEDA), marine Product Export Development Authority, Other Boards in regulations: Spices Board, Coffee board, Tea board; Indian Oil Seeds And Produce Export Promotion Council (IOPEPC); Cashew Export Promotion Council of India(CEPC). International Food Law; Consumer Protection Act, 1986 and International Organization and Agreements in the Area of Food Standardization and Quality Control	

Learning Resources	1. *T. Tamil Selvan, FSSAI: Food Safety Handbook Paperback: 2023* **2.** *Neal D. Fortin. 2009. Food Regulations, Wiley Publications*	3. *Naomi Rees, David Watson. 2000. International Standard for Food safety. An Aspen Publications*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life Long Learning CLA-2- Practice (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	-	*15%*	*15%*	-
Level 2	*Understand*	*25%*	-	-	*20%*	*25%*	-
Level 3	*Apply*	*30%*	-	-	*25%*	*30%*	-
Level 4	*Analyze*	*30%*	-	-	*25%*	*30%*	-
Level 5	*Evaluate*	-	-	-	*10%*	-	-
Level 6	*Create*	-	-	-	*5%*	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
		Dr. P. Gurumoorthi, SRM IST

Course Code	21FPC515J	Course Name	FOOD SAFETY AND QUALITY AUDITING	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Food Process Engineering	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	impart knowledge on food safety and quality
CLR-2 :	create and enhance awareness on food safety issues and its monitoring activities
CLR-3 :	know and implement good manufacturing practices in industries
CLR-4 :	implement good health and hygiene practices
CLR-5 :	understand the regulatory requirement on food safety

Course Outcomes (CO):	At the end of this course, learners will be able to:	Programme Outcomes (PO)		
		1	2	3
CO-1:	understand the basic principles and concepts of food safety and Quality.		√	
CO-2:	understand the concept on monitoring and implementing FSSAI regulations.			√
CO-3:	implement risk assessment and risk management.		√	
CO-4:	understand and implement food safety systems in industries			√
CO-5:	enhance knowledge in quality tools and its monitoring activities			√

Module-1: Food Plant Layout and Design	12 Hour
Food plant safety - Food Plant layout - Requirements – Plant facilities - Construction - Management - Maintenance - Equipment - Storage and maintenance - Transportation - FSAAI requirements. Case Studies.	
Module-2: Quality Management System and Environment Management System	**12 Hour**
GMP; GHP; GAP; ISO 9001 - Clause-wise discussion; OHSAS - Clause-wise discussion; Environmental management – 14000; Interpretation of ISO 9001 - EIC requirements - BRC, IMS – Studies - FSSAI checklist - Case studies - Interpretation of OHSAS 45001; Implementation model - Importance of the tool - Statistical Process Control - Statistical Quality Control - Quality management system - Bar Chart - Pareto analysis - Fishbone model - Run charts - Scatter plots - Control charts.	
Module-3:Implementation of HACCP, ISO/FSSC 22000 and BRC GS	**12 Hour**
HACCP - Principles - Implementation and maintenance; Hazard identification - CCP - OPRP - PRP - HACCP worksheet - HACCP case studies – Practice - HACCP case studies - - FSSAI – HACCP Checklist HACCP – Case studies. FSSC/ ISO 22000 - Context of the organization - Leadership - Planning - Support - Resources - Infrastructure - Operation - Pre-Requisite Program - Hazard control & Plan - Control of monitoring and measures - Verification and validation - Control of product and process Non-conformities - Correction - Corrective action - Root Cause Analysis - Performance evaluation - Internal audit - Management review - Improvement; Food Fraud and Traceability and authentication - Food product recall- VACCP- TACCP. BRC-GC –Sections. Practice – Clause wise - Identification of NC's – Practice with Case Studies.	
Module-4: Documentation and Auditing	**12 Hour**
Documentation: Standard operating procedure - Quality policy - Quality objectives - Quality manual - SOP for procurement - SOP for verification of procurement - SOP for storage - Personal hygiene - Resources management - Product management - Process management - Developing SOP and implementation. Auditing: Attributes of Auditor; Preparation of audit checklist – QMS, EMS and FSMS; Conducting audit - Opening meeting - Day briefing - Closing meeting - Preparation of audit report - NC statement - Case studies - Internal audit – Trial	
Module-5: Risk Assessment and Management	**12 Hour**
Food quality evaluation - Methods of quality evaluation - Quality management principles - Risk classification - Risk identification - Risk evaluation - Risk mitigation - Risk management - Risk Management worksheet – Practice - Risk assessment - Risk-based auditing - Microbial risk assessment. Contaminants - Naturally occurring toxic substances - Specification of NOTS - Pesticide residue - Analysis of pesticide residue. Risk management worksheet – practice	

Learning Resources	1. *ISO 22000* 2. *FSSAI Food safety Inspection Checklist https://archive.fssai.gov.in/home/compliance/FOOD-SAFETY-INSPECTION-C FSSAI* 3. *Andres, V.J. 2005. Quality Assurance for Food Industries – A practical approach CRC press.*	4. *Inteaz Ali. 2004. Food Quality Assurance – Principles and Practice, CRC press* 5. *Sara Mortimore and Carol Wallace. 2013. HACCP practical approach. 3rd edition. Chapman and Hall London.*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life Long Learning CLA-2- Practice (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	*-*	*-*	*15%*	*15%*	*-*
Level 2	*Understand*	*25%*	*-*	*-*	*20%*	*25%*	*-*
Level 3	*Apply*	*30%*	*-*	*-*	*25%*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*-*	*25%*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*-*	*10%*	*-*	*-*
Level 6	*Create*	*-*	*-*	*-*	*5%*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
		Dr. G.Nagamaniammai, SRM IST

ACADEMIC CURRICULA

Food Safety and Quality Management

Professional Elective Courses

Regulations 2021



SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

Course Code	21FPE551T	Course Name	ADVANCED FOOD CHEMISTRY	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Food Process Engineering*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*provide an understanding of the chemical function and properties of major food components.*
CLR-2:	*provide an understanding of the chemical interactions of food components and their effects on sensory and nutritional quality, functional properties, and safety of foods.*
CLR-3:	*provide an understanding of the chemical basis of food preservation and the effects of processing and storage on food quality.*
CLR-4:	*provide an understanding of Biochemical Changes During Processing of Food and Biochemical Reactions*
CLR-5:	*provide an understanding of nutritional properties of food*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*apply the knowledge on water and water quality standards*			√
CO-2:	*gain familiarity in protein chemistry and enzymes in food*		√	
CO-3:	*gain familiarity in fat/oil chemistry for food application*		√	
CO-4:	*gain the knowledge about Carbohydrate chemistry*			√
CO-5:	*gain the knowledge on processing induced changes in food*			√

Module-1 Introduction About Physical and Chemical Properties of Food Components	***15 Hour***
Physical and Chemical Properties of Water - Water activity: principles, measurement, control, effects. Acid-base chemistry of foods and common additives. Composition of food and nutritional value. Moisture in foods. Biological oxidation, electron transport chain; oxidative phosphorylation. Assessment of quality of food by instrumental and chemical methods. Nutritive value of foods. Energy value and energy requirements and their estimation. Water, electrolytic and acid-base balance. Nutritive value of proteins PER, BV digestibility coefficient, NPU values, pepsin digestibility. Role of fibre in human nutrition.	
Module-2 Proteins, Carbohydrates and Lipids	***15 Hour***
Proteins - Physical properties of proteins in relation to protein structure, Analytical methods for estimation of protein, Characterization, Functional properties. Proteins: metabolism, deamination, decarboxylation, metabolic fate of amino acids, nitrogen balance. Deamination reactions and nitrogen excretion with special reference to fish. Fish muscle proteins, chemical changes in muscle during contraction. Proteins in foods, role in hydration- native and denatured proteins, gel formation, functional properties of proteins, changes during heat treatment and processing, texturized proteins. Carbohydrates: Naturally occurring polysaccharides in foods. Seaweed polysaccharides – sources and uses. Basic structures and properties: starches, celluloses, gums, modification techniques Browning reactions – enzymatic and non-enzymatic Basic chemistry - Simple sugars, sugar derivatives and oligosaccharides, sweetness, Sugar derivatives: sugar alcohols, glycosides, etc. Dietary fiber: components, properties, analysis. Lipids - Content and role in foods, Analytical methods Chemical, nutritional and physical properties, Processing of fats and oils. Lipids: metabolism of lipids, oxidation of fatty acids, lipoproteins; VLDL and HDL and their importance	
Module-3 Biochemical Changes During Processing of Food and Biochemical Reactions	***15 Hour***
Effects of food processing: changes occurring in chemical, functional and nutritional properties of proteins, Lipids and carbohydrates. Changes occurred in food during preservation and storage. Enzymatic reactions in food during storage Browning and related reactions, Case studies - acryl amide and furan formation in foods.	

Learning Resources	1. *Srinivasan Damodaran, Kirk L. Parkin, Owen R. Fennema. 2007. Food Chemistry, 4th Edition (Food Science and Technology). CRC Press, New York.* 2. *H.-D. Belitz, Werner Grosch, Peter Schieberle. Food Chemistry4th Revised and extended Edition, 2009. Springer Publications. The Netherlands.*	3. *Connie M. Weaver, James R. Daniel. 2003. The Food Chemistry Laboratory: A Manual for Experimental Foods, Dietetics, and Food Scientists, Second Edition, CRC Press. London.* 4. *John, M. de Man. 2009. Principles of Food Chemistry, Third edition. Aspen Publishers.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of Unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
		Dr R Preetha, SRM IST

Course Code	21FPE552T	Course Name	FOOD ADDITIVES AND INGREDIENTS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Food Process Engineering*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*gaining the knowledge about food additives*
CLR-2:	*know the information about types of food additives*
CLR-3:	*obtain information about pesticides and toxicants*
CLR-4:	*understand about various safety and standards for food additives*
CLR-5:	*attain information about common adulterants in food*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*gain the information about Classification and terminology of food additives*		√	
CO-2:	*obtain the knowledge of types of food additives*			√
CO-3:	*understand the possible of pesticides and toxicants residues in food*		√	
CO-4:	*know various specifications for food additives*		√	
CO-5:	*identify the common possible food adulterants*		√	

Module-1 Food Additives and Preservatives	***15 Hours***
Introduction to food additives - Classification/Terminology - Classification/Terminology - Stabilizers of physical characteristics - Inhibitors of chemical and biological alterations - Modifiers of organoleptic characters - Improvers and correctors - Purity and specifications of a food additive - Setting the Acceptable Daily Intake - Need - Properties - Properties - Functions - Functions - Usage of food additives - Usage of food additives - Toxicological evaluation of food additives - Toxicological evaluation of food additives. Chemical preservatives - Biopreservatives - Fortification - Antioxidants - Emulsifiers - pH control agents - Acidulants - Texturizing agents - Flavor enhancers - Enzymes - Gases - Honey and its adulteration - Honey adulteration detection and regulations - Ingredient - Colouring Agents - Sweeteners - Flavoring agents - Food processing aids.	
Module-2 Food Additives Standards	***15 Hours***
Safety and standards for food additives - Food additives and food labeling - European Union - European Union - FDA - FDA - FPO - FPO - FSSA specifications for food additives - FSSA specifications for food additives - Revised FSS Additives Regulations - Revised FSS Additives Regulations - Regulations related to sweeteners - Regulations related to food colors - Regulations related to flavors - Laws for food additives and ingredients in processed foods - Laws for food additives and ingredients in processed foods - Regulations for food additives and ingredients in processed foods - Regulations for food additives and ingredients in processed foods.	
Module-3 Adulterants, Pesticides and Toxicants	***15 hours***
Common adulterants in food - Milk and milk products - Milk and milk products - Atta - Edible oils - Cereals - Condiments - Whole and ground pulses - Coffee - Tea - Confectionery - Baking powder - Non-alcoholic beverages - Vinegar - Besan and curry powder - Types of adulterants - Intentional and incidental adulterants - Metallic contaminants. Pesticides and Toxicants - Pesticide residues in food - Chlorpyrifos and DDTs - Food contaminants from industrial wastes - Heavy metals - Lead - Cadmium - Arsenic - Nickel - Mercury - Polychlorinated polyphenols - Dioxins - Polycyclic aromatic hydrocarbons - Toxicants formed during food processing polycyclic aromatic hydrocarbons - Nitrosamines - Veterinary drug residues - Melamine contaminations.	

Learning Resources	*1. Jim Smith and Hong Shum (2011). Food Additives data book. Second edition, Wiley- Blackwell publishers (e-Book). http://www.taylorandfrancis.com/books/textbooks/SCFS10* *2. D Baines. Natural food additives, ingredients and flavourings. Woodhead Publishing website. http://www.woodheadpublishing.com/en/book.aspx/bookID=2063.*	*3. World Health Organization (WHO), 1995. Guidelines for Risk Assessment; Application of Risk Analysis to Food Standards Issues, a Joint FAO/WHO Expert Consultation, Geneva, Switzerland, 13–17 March 1995. http://www.who.int/foodsafety/publications/micro/march1995/en/ index.html*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of Unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	*-*	*15%*	*-*	*15%*	*-*
Level 2	*Understand*	*25%*	*-*	*20%*	*-*	*25%*	*-*
Level 3	*Apply*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*10%*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*5%*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
		Dr R Preetha, SRM IST

Course Code	21FPE553T	Course Name	INSTRUMENTATION AND DATA ACQUISITION FOR FOOD INDUSTRIES	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Food Process Engineering*	**Data Book / Codes/Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1 :	*explain virtual instrument concepts.*
CLR-2 :	*select proper data acquisition hardware.*
CLR-3 :	*configure data acquisition hardware in LabVIEW.*
CLR-4 :	*use LabVIEW and configure the related hardware like DAQ and transducers.*
CLR-5 :	*create virtual instruments for practical works.*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*understand the principles of operation and limitations of common measuring instruments.*		√	
CO-2:	*model instruments and their operating conditions to use the instruments correctly*			√
CO-3:	*design and use signal conditioning devices*		√	
CO-4:	*program computers to automate the acquisition and processing of data*		√	
CO-5:	*design systems for the acquisition, analysis, and communication of data*		√	

Module-1 Measurement Systems	***9 Hour***
Introduction, Temperature; Pressure, Motion and displacement, flow, force- static and dynamic characteristics.	
Module-2 Data Acquisition - Fundamentals	***12 Hour***
PC-Based DAQ System: PC, transducers and signal conditioners, DAQ hardware. Data acquisition specifications: Analog input: sampling rate, multiplexing, resolution, relative accuracy, noise, Analog output, Triggers, Real-Time system integration, Digital I/O. Timing I/O, Software, Multichannel analog DAQ system, Set up for data acquisition universal DAQ card, Use of timer-counter and analog outputs on the universal DAQ card.	
Module-3 Data Acquisition – Signal Processing	***12 Hour***
Environmental measurement- Signal Transmission, Signal Conditioning, Signal sampling, and Signal Acquisition. Resistive sensor, reactance variation and electromagnetic sensors, self-generating sensors, remote sensing, Wireless transmission, diagnosing sensor system.	
Module-4 Data Processing	***12 Hour***
Data bases and Management in Food Processing, Data storage and distribution by using various information technology tools and methods, Computer vision for food detection, Segmentation and recognition.	

Learning Resources	1. Doebelin, E., Measurement Systems, 5th ed., McGraw-Hill, New York, 2004. 2. Rizzoni, G., Principles and Applications of Electrical Engineering, 5th Ed. McGraw-Hill, New York, 2005. 3. Webster, J. G. (editor), The Measurement, Instrumentation, and Sensors Handbook, CRC Press and IEEE Press, 1999.	4. Fraden, J., Handbook of Modern Sensors: Physics, Designs and Applications, 3rd. ed., AIP Press and Springer, New York, 2004. 5. Lancaster, D., Active Filter Cookbook, 2nd ed., Newnes, New York, 2003. 6. Various instruments catalogs 7. Gupta S.and Gupta J.P, PC Interfacing for Data Acquisition and Process Control. Instrument society of America, 1994 8. Paton Barry E., Sensor,transducer and labview, Tata McGraw Hill, New Delhi 2012

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of Unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	15%	-	15%	-	15%	-
Level 2	Understand	25%	-	20%	-	25%	-
Level 3	Apply	30%	-	25%	-	30%	-
Level 4	Analyze	30%	-	25%	-	30%	-
Level 5	Evaluate	-	-	10%	-	-	-
Level 6	Create	-	-	5%	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
		Dr G. Nagamaniammai, SRM IST

Course Code	21FPE554T	Course Name	HYGIENE, PUBLIC HEALTH AND INDUSTRY SAFETY	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Department of Food Process Engineering*	**Data Book / Codes / Standards**			

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*explain the meaning of health and hygiene.*
CLR-2:	*understand the indigenous health system in India*
CLR-3:	*indicate the various health and hygiene problems in India*
CLR-4:	*describe the health care delivery system in India*
CLR-5:	*understand the role of social-workers in prevention*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*know about public health and hygiene*	√		
CO-2:	*industrial safety requirements*		√	
CO-3:	*implementation challenges for industrial safety*		√	
CO-4:	*health care delivery*			√
CO-5:	*social responsibility*			√

Module-1 – Introduction	***9 Hour***
Introduction: Health Vs Hygiene; Definition of Health; Definition of Hygiene; Dimensions of Health; Factors Influencing Health.	
Module-2 - Personal Hygiene	***9 Hour***
Personal Hygiene; Washing Hands; Genital Hygiene; Keeping the Community Healthy; Immunization: An Introduction; National Immunization Schedule; Environmental Hygiene; Keeping Environment Healthy	
Module-3 – Development of the Safety and Health Functions	***9 Hour***
Development of the safety and health functions: Workers' compensations; record keeping; accident / incident cause analysis; organization of committees; safety and health economics; training.	
Module-4 –. Concepts of Hazards	***9 Hour***
concepts of hazard avoidance: process safety and disaster management; process information; process analysis; building and facilities; ergonomics; health and toxic substances; personal protection and first aid; material handling and storage	
Module-5 – International Requirements for Safety Health and Requirements	***9 Hour***
OSHA permissible exposure limits; Safety Management; standard industrial classification; Factories Act and Case Law; Safety in food processing Industry	

Learning Resources	1. *Dr. K.U. Mistry, Fundamentals of Industrial Safety and Health; Siddharth Prakash an, 2008*	2. *C. Ray Asfahl David W. Rieske, Industrial Safety and Health Management, 6th Edn. Printice Hall Publishers, 2010.*

Learning Assessment							
	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of Unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	15%	-	15%	-	15%	-
Level 2	Understand	25%	-	20%	-	25%	-
Level 3	Apply	30%	-	25%	-	30%	-
Level 4	Analyze	30%	-	25%	-	30%	-
Level 5	Evaluate	-	-	10%	-	-	-
Level 6	Create	-	-	5%	-	-	-
	Total	100 %		100 %		100 %	

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
		Dr. P. Gurumoorthi, SRM IST

Course Code	21FPE555T	Course Name	FOOD SAFETY SYSTEMS IN DAIRY INDUSTRIES	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Food Process Engineering*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*gaining the knowledge about milk composition, nutritional value and milk reception dock*
CLR-2:	*know the thermal processing techniques employed in milk*
CLR-3:	*know the sanitization and CIP process in dairy industries*
CLR-4:	*attain information relevant to possible adulterants, preservatives and naturalizer in milk*
CLR-5:	*provide fundamental theoretical concepts on food safety systems; technical knowledge for identifying food safety problems.*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*gain the knowledge of milk composition and process in the milk reception*	√		
CO-2:	*implement strong control systems through different techniques*			√
CO-3:	*improve the best sanitization and CIP process in dairy industries*			√
CO-4:	*identify food safety problems*		√	
CO-5:	*gain more exposure and awareness on food safety systems in dairy industries*		√	

Module-1 Milk Composition, Reception Operation and Raw Milk Examination	***9 Hour***
Milk composition, Nutritional importance, Milk reception operations, Layout of reception dock, Equipment unloading, Conveying, Examination of raw milk, Organoleptic tests, Preliminary tests, Laboratory testing of milk samples, Chemical analysis, Microbiological analysis.	
Module 2 – Thermal and Freeze Processing	***9 Hour***
Thermal processing of milk - Pasteurization, Batch, Holding process, Continuous process, Vacreation, Stassanization, Uperization, Heat processing of milk - Effect of heat on milk, salt system and acidity, milk proteins, Destabilization of caseinate system, Browning of milk. Factors affecting browning of milk. Freeze processing of milk - Effect of freezing on lactose and caseinate system.	
Module 3 - Ultra-High-Temperature Processing	***9 Hour***
Ultra-high-temperature processing - Types of sterilization plants - Direct and indirect type heating system, Advantages and Disadvantages of direct and indirect heating system, Changes in milk during processing and storage.	
Module-4 - Cleaning In Place Process	***9 Hour***
Centralized CIP system, Standalone type cleaning-in-place system, Sanitization in CIP process, Important Instructions and precautions for CIP system, Cleaning and sanitization methods and consideration, Cleaning and sanitization effectiveness factors, Assessment of effectiveness of cleaning and sanitizations.	
Module 5 – Preservatives, Neutralizers and Adulterants	***9 Hour***
Common preservatives added to milk and detection methods, Neutralizers in milk and detection methods, Adulterants in milk and detection methods. Dairy product certification and licensing.	

Learning Resources	1. *Chandan, R.C., Arun Kilara and Shah, N.P. (2016). Dairy Processing and Quality Assurance. Chichester, West Sussex; Hoboken, Nj Wiley Blackwell.* 2. *Webb, B.H., Johnson, A.H. and Alford, J.A. (2005). Fundamentals of Dairy Chemistry. New Delhi: CBS Publishers and Distributors.*	3. *Chavan, R.S. and Goyal, M.R. (2018). Technological Interventions in Dairy Science: innovative approaches in processing, preservation, and analysis of milk products. Oakville, ON: Apple Academic Press Inc.* 4. *Photis Papademas (2015). Dairy microbiology a practical approach. Boca Raton, Fla. CRC Press.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of Unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
		Dr. S. Periyar Selvam, SRMIST

Course Code	21FPE556T	Course Name	FOOD SAFETY SYSTEMS IN FRUITS AND VEGETABLES	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Food Process Engineering*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the importance of food safety in fruits and vegetables*
CLR-2:	*realize the concept of gap and implementation*
CLR-3:	*know the different preservation and storage methods*
CLR-4:	*understand the food safety regulations*
CLR-5:	*learn the risk and quality assessment methods*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*gain the knowledge of fruits and vegetables classification*	√		
CO-2:	*apply the knowledge on harvest and storage practices*		√	
CO-3:	*employ specific preservation techniques based on the types of fruits and vegetables and reduce the postharvest losses*		√	
CO-4:	*quality and risk assessment methods for fruits and vegetables*			√
CO-5:	*know the rapid method and consumer awareness, compliance and regulation*		√	

Module-1 - Overview of Food Safety	***9 Hour***
Overview of Food Safety - Importance in the context of fruits and vegetables, Historical perspectives and evolution of food safety standards, Pre-harvest Food Safety Practices, Pre-harvest Risk Assessment, Importance of Good Agricultural Practices.	
Module-2 Classification and Post - Harvest Physiology	***9 Hour***
Fruit and vegetable production in India, Classification of fruit and vegetables, Cellular components of plant cell, Importance of post-harvest physiology, Harvesting Practices.	
Module-3 - Types of Post-Harvest	***9 Hour***
Types of post-harvest losses - Mechanical injury types, Respiration and Transpiration losses, Technologies to control post-harvest losses, Spoilage of fruits and vegetables, Methods for the preservation of fruits and vegetables. Roles of regulatory agencies in ensuring fruits and vegetables safety.	
Module-4 – Post Harvest Handling and Quality Assessment	***9 Hour***
Post-harvest handling, transportation, precooling after Harvest, Cleaning or Disinfecting, Grading, Sorting, Washing, Curing, Blanching, Peeling, Trimming methods, storage methods for fruits and vegetables, Safe processing methods for fruits and vegetables, Quality assurance in the production of value-added products, Assessment of safety and quality of value-added products.	
Module-5 - Common Contaminants Detection Methods	***9 Hour***
Common Contaminants in Fruits and Vegetables - Pesticide residues, Heavy metals, other contaminants. Monitoring and control strategies for various contaminants, Rapid Detection Methods - contaminants. Consumer Awareness- Educating consumers about food safety for fruits and vegetables. Future Trends in Produce Safety- Emerging technologies and trends in ensuring produce safety. Anticipating and preparing for future challenges.	

Learning Resources	1. *Verma L.R and V.K. Joshi, "Post-Harvest Technology of Fruits and vegetables". Volume 1 and 2. Indus Publishing Company, New Delhi. 2006.* 2. *Siddiqui, M.W., & Ali, A. (Eds.). (2016). Postharvest Management of Horticultural Crops: Practices for Quality Preservation (1st Edition). Apple Academic Press. https://doi.org/10.1201/b19992.* 3. *Joshi, V.K. (2021). Postharvest Management Of Fruits And Vegetables. New India Publishing Agency.*	4. *Wills R, Golding W, Graham D and B. McGlasson. 2016 "Postharvest: An Introduction to the Physiology and Handling of Fruit and Vegetables". 293.* 5. *Florkowski, W.J., Shewfelt, R.L., Prussia, S.E. and Banks, N. (2014). Postharvest Handling A Systems Approach. San Diego Elsevier Science and Technology Ann Arbor, Michigan Proquest.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of Unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
		Dr. S. Periyar Selvam, SRMIST

Course Code	21FPE557T	Course Name	FOOD PROCESSING PLANT DESIGN	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Food Process Engineering*	Data Book / Codes/Standards		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*identify plant location food industry*
CLR-2:	*understand the construction requirement for food plant*
CLR-3:	*prepare processing plant design*
CLR-4:	*apply designing skills on equipment fabrication and arrangements*
CLR-5:	*find suitable process flow and layout for processed foods*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*outline the food plant design*		√	
CO-2:	*design floor, drain and ventilation for food processing plant*	√		
CO-3:	*design pipes, fittings and equipment as per process flow*			√
CO-4:	*evaluate the layout for equipment installation*			√
CO-5:	*construct food plant design for different categories of foods*		√	

Module-1: Plant Layout	***9 Hour***
Introduction - Processing plant design – Definition - Scope and importance - Classification of food plants - Based on process - Based on product - Location selection for food plant - Site selection for food plant - General points of considerations for designing food plant - Types of layouts - Demo - Principles of food layout - Consideration for building layout - Consideration for building materials - Food building layout - Legal approval for layout - Outline for area planning - Plant design - Design approval - Practice - Layout for building and floor	
Module-2: General Construction Requirements	***9 Hour***
Considerations for construction - Selection of construction materials - Materials for different food processing areas - Floor design - Floor material selection - Floors for different sections of food processing areas - Ventilation design - Case study - Illumination system for food plants - Selection of light intensity for processing areas - Wall and ceiling design - Personal hygiene practices in food plant design - Pest, Rodent Fly / insect control prevention - Microbial contamination prevention in processing plants - Drains and drain layout for fruits and vegetables - Drains and drain layout for animal foods - Drains and drain layout for dairy plants - Practice – Layout for Ventilation, fly control, mold control, and drains	
Module-3: Process Flowchart	***9 Hour***
Introduction - Definition and role in plant design - Types of Process Design - Materials for the food equipment - Material balance in food processing plant - Energy balance in food processing plant - Equipment design - Selection of materials and construction of equipment - Demo - Role and types of pipes and tubes - Materials selection for food processing pipes and tubes - Sanitary pipes and fittings - Selection of materials for sanitary pipes and fittings - Standard - glass piping, plastic tubing - Standard - fittings and gaskets - Installation of pipes, tubes, fittings, valves, and gaskets in food processing plants - Repair and replacement of pipes and fittings - Maintenance of pipes and fittings - Video presentation for different pipes, fittings, and sanitary pipes in food processing plants	
Module-4: Layout Plan for Equipment	***9 Hour***
Arrangement of equipment - Material selection for food processing equipment - Fabrication of equipment - Welding and fittings - Installation of process equipment - Material handling in dairies - Layout for preprocessing area - Video presentation for food processing equipment fabrication and erecting - Layout for processing area - Layout for laboratory - Layout for warehouse - Layout for office - Layout for effluent treatment plant boiler - Benefits of individual layout design - Common problems in processing area - Flexibility - Practice – Designing Food Processing plant	

Module-5: Identification of New Product	***9 Hour***
Product selection criteria - Product development - Stages of product development - Development of Process flow chart for new product - Introduction of new product from pilot plant - New food processing plant layout and design - Selection of equipment, fitting, and other accessories - 3D processing plant design development - Layout design – Fruits based products - Layout design – Vegetables based products - Layout design – Beverages - Layout design – Meat and poultry - Layout design – Fish - Layout design –Cereal mills - Layout design – Extrusion and Expanded foods - Layout design – Plantation foods - Food processing plant design Model	

Learning Resources	1. *Tufail Ahmed. "Dairy Plant Engineering and Management", CBS Publishers and Distributors, New Delhi, 2001.* 2. *Ananthakrishnan.C.P. and M.N.Sinha. "Technology and Engineering of Dairy Plant Operations", Laxmi Publications, New Delhi, 1997.*	3. *Groff, Gane K. and Muthu, John F., "Operations Management Selected Readings", D.B.Taraporevala Sons and Co, Bombay, 1975.* 4. *Thuesen, H.G., Febrycky, W.J. and Thuesen, G.J., "Engineering Economy", Prentice –Hall Inc, New Jersey, 1978.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of Unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
		Dr. G. Nagamaniammai, SRM IST

Course Code	21FPE558T	Course Name	SENSORS FOR FOOD SAFETY AND QUALITY	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Food Process Engineering*	**Data Book / Codes/Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*comprehending sensor principles is fundamental for effective utilization in food analysis.*
CLR-2:	*familiarity with sensor classification aids in selecting suitable technologies for specific applications.*
CLR-3:	*understanding sensor instrumentation enhances the ability to interpret data accurately.*
CLR-4:	*proficiency in sensor applications enables addressing real-world challenges in food safety and quality assurance.*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*analyze the classification of sensors based on proximity and working principles.*		√	
CO-2:	*evaluate the instrumentation and working principles of e-nose and e-tongue.*		√	
CO-3:	*assess the effectiveness of time-temperature indicators and non-invasive analysis methods.*			√
CO-4:	*apply sensor technologies in real-world scenarios such as pesticide detection, bioprocess monitoring, and smart packaging in the logistic supply chain.*			√

Module 1 Classification of Sensors	***15 Hour***
Sensors: their classification based on Proximity, working principle; examples of applications in process control – Calorimetric biosensors, Optical biosensors, Piezoelectric biosensors, electrochemical sensors, colorimetric biosensors, Nano biosensor. Requirements of on-line sensors: Construction, types, working principles, applications, merits and limitations	
Module 2 E Sensors	***15 Hour***
e nose and e tongue - instrumentation, application and working principles. Time-temperature indicators – partial-history and full-history indicators; Commercial devices; Applications and limitations. Non- invasive non-destructive methods of analysis- MS- FTIR analysis in food. ICPMS, HRMS, AAS. Principles and applications of NIR, NMR, X-ray diffraction analysis in food systems.	
Module 3 Application of Sensors	***15 Hour***
Pesticide and insecticide in food, Bioprocess monitoring and control- enzymes, culture and fermentation process for food and ingredients, Smart Packaging – perishable food –Logistic supply chain.	

Learning Resources		
	1. *Nielsen, S.S. Introduction to the chemical analysis of foods. Jones and Bartlett Publishers, Boston , London.2004.* 2. *Mahindru, S.N. Food additives. Characteristics, detection and estimation. Tata McGrawHill Publishing Company Limited, New Delhi.2000*	3. *Pearson, D. The Chemical Analysis of Foods. Churchill Livingstone, New York. 2002.* 4. *Sharma, B.K. Instrumental Methods of Chemical Analysis. Goel Publishing House, New Delhi. 2004.* 5. *Poonam Mishra and Partha Pratim Saha, Biosensors in Food Safety and Quality: Fundamentals and Applications. CRC Press, Taylor and Francis group, UK. 2022.*

Learning Assessment							
	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of Unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	15%	-	15%	-	15%	-
Level 2	Understand	25%	-	20%	-	25%	-
Level 3	Apply	30%	-	25%	-	30%	-
Level 4	Analyze	30%	-	25%	-	30%	-
Level 5	Evaluate	-	-	10%	-	-	-
Level 6	Create	-	-	5%	-	-	-
	Total	100 %		100 %		100 %	

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
		Dr. G. Nagamaniammai, SRM IST

Course Code	21FPE651T	Course Name	FOOD SAFETY AND QUALITY ASSURANCE FOR MEAT, POULTRY AND SEA FOOD INDUSTRIES.	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Food Process Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the meat processing concepts*
CLR-2:	*know the changes in the quality of poultry and egg*
CLR-3:	*conceptualize quality of sea foods*
CLR-4:	*demonstrate check list for risk management*
CLR-5:	*illustrate HACCP principles for animal foods*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*construct contamination free meat processing plant*	√		
CO-2:	*plan poultry and egg processing as per quality standards*		√	
CO-3:	*outline the quality of sea food on processing*		√	
CO-4:	*assess the risk management system for animal foods*		√	
CO-5:	*evaluate critical control point in animal processing plant*			√

Module-1 - Sources of Meat and Meat Products in India	***9 Hour***
Sources of meat and meat products in India, its importance in national economy. Chemical composition and microscopic structure of meat. Effect of feed, breed and management on meat production and quality, Slaughtering of animals and poultry, inspection and grading of meat, Factors affecting post-mortem changes, properties and shelf-life of meat	
Module-2 - Meat Quality Evaluation	***9 Hour***
Meat quality evaluation. Mechanical deboning, meat tenderization. Aging, pickling and smoking of meat. Meat plant sanitation and safety, Byproduct utilization., tenderization of meat, HACCP implementation in meat processing plant, quality assurance	
Module-3 – Poultry Processing	***9 Hour***
poultry processing, defeathering, evisceration, byproduct utilization, different types of poultry, spoilage and preservation technique, quality assurance system by APEDA, HACCP implementation in poultry plant	
Module-4 -. Structure, Composition, Nutritive Value and Functional Properties	***9 Hour***
Structure, composition, nutritive value and functional properties of eggs and its preservation by different methods. Factor affecting egg quality and measures of egg quality, preservation of eggs, quality control	
Module-5 - Types of Fish	***9 Hour***
Types of fish, composition, structure, post-mortem changes in fish. Handling of freshwater fish. Canning, smoking, freezing and dehydration of fish. Fish sausage and home making. MMPO, MFPO, radiation processing meat safety, HACCP implementation in fish processing Module, quality assurance system by MPEDA	

Learning Resources	1. *Pearson, A.M and Dutson,1 T.R.1995.HACCP in meat, poultry and fish processing, Advances in meat research series, Volume 10, Chapman & Hall Publisher, New York.* 2. *ShaiBarbut. 2002. Poultry Products Processing An industry Guide, CRC Press, Florida.* 3. *Gunter Heinz and Peter Hautzinger, 2007. Meat processing technology for small- to medium scale producers, Food and Agriculture Organization of the Moduleed nations regional office for Asia and the Pacific Bangkok, RAP publication.*	4. *Huss, H.H, Ababouch, L and Gram, L. 2003. Assessment and Management of Seafood Safety and Quality, FAO fisheries technical paper 444, Food and Agriculture Organization of the Moduleed Nations Rome.* 5. *William J. Stadelman, Owen J Cotterill.2002. Egg science and Technology. Fourth edition, CBS Publishers & Distributors, New Delhi.* 6. *Laboratory Manual for FSQM system for meat, poultry and sea foods*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of Module test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
		Dr P Gurumoorthi, SRM IST

Course Code	21FPE652T	Course Name	FOOD SAFETY AND QUALITY ASSURANCE FOR BAKERY AND CONFECTIONERY INDUSTRIES	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Food Process Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*explain about overview of bakery and confectionary industry safety regulations.*
CLR-2:	*describe about types of ingredients used in baking industry and quality evaluation.*
CLR-3:	*analyze about the quality parameter of confectionery products and its spoilages due to contamination.*
CLR-4:	*describe about inspection procedure in bakery and confectionery industry.*
CLR-5:	*discuss about HACCP implementation on various bakery and confectionary product processing.*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*understand the basic concepts and functions of Safety aspects of bakery product based on FSSAI standards.*	√		
CO-2:	*learnt function of bakery product formulation and quality evaluation.*	√		
CO-3:	*analyze about the baking quality, equipment used in bakery industry and preservation of baked products.*		√	
CO-4:	*understood the preparation of confectionary products, monitoring process control and inspection procedures.*			√
CO-5:	*described about role of HACCP in bakery and confectionery industries on various product productions, CCP.*			√

Module – 1: ***Bakary and Confectionery Industries Statuts in India***	***9 Hour***
Types of Ingredients in Bakery products; Essential Ingredients; Optional Ingredients; FSSAI regulation in bakery and confectionery products; Product specifications; Lab: Preparation of Bread and check quality parameter; Labeling procedures; Packaging regulation of bakery products; Food Safety and Management systems; Guideline implementation by FSMS; Bakery design and facility; Bakery personal hygienic; Bakery industrial hygienic; Basic cleaning and sanitation process in Bakery; Code of hygiene condition in bakery and confectionary; Preparation of Chocolate and evaluate its quality parameters; Preparation of Caramel	
Module – 2: *Bakery Products Technology; Baking Process*	***9 Hour***
Yeast made products; Cake preparation; Cake preparation; Biscuits; Cookies Doughnuts, *Pastry and its types; Bagels; Muffins; Quality evaluation of finished bakery products, internal evaluation; external characteristic evaluation, baking quality in yeast and chemical leavening products. Preparation and quality assessment*	
Module – 3: *Bakery Equipment for Preservation of Bakery Products*	***9 Hour***
Spoilage of Bakery products; Bread disease; Fault occur during processing of bakery products; Confectionary product technology; Sugar and Chocolate confectionery; Marshmallow; Production of types of chocolate; Ice creams and its types; List of confectionery equipment; Quality evaluation of confectionery products; Development of Toffee, Candy and evaluate its quality.	
Module – 4: *Bakery Product Quality and Safety*	***9 Hour***
Quality of Raw materials; Quality check on flours; Building inspection and routine; Monitoring process control Ingredient inspection and assessing; Bakery quality assurance.; HACCP implementation in bread industry; Food microbial testing on bakery and confectionery products	
Module – 5: Monitor the Control Points for a Range Confectionery Products	***9 Hour***
Bakery auditing procedure; Types of audit in bakery and confectionery industry; Scope of auditing; health and Safety standards in bakery and confectionery products; Cross contamination and how to control in Bakery Product; GMP in Bakery industry; ole of metal detector and X-ray scanners used in bakery industry	

Learning Resources	1. *Theodorasvarzakas, ConstantinaTzia, "Handbook of Food Processing, quality and manufacturing processes", CRC press, ISBN: 9781498721776, 2015.* 2. *FSMS Manual for Bakery and Confectionary Industry, 2014.*	3. *Assuring food safety and quality, 2012. FAO Food and Nutrition Manual, FAO Publication, Rome.* 4. *Yogambal Ashokkumar, "Textbook of Bakery and Confectionery Products", second edition (Revised), Published by PHI Learning Private Limited, New Delhi, ISBN: 978-81-203-4603-1, 2012.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of Unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	*Experts from Higher Technical Institutions*	*Internal Experts*
		Dr. P. Gurumoorthi, SRM IST

Course Code	21FPE653T	Course Name	FOOD SAFETY SYSTEMS IN BEVERAGE	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Food Process Engineering*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the importance of raw material and risk assessment in beverages production*
CLR-2:	*realize the concept of quality control in soft drink industries*
CLR-3:	*know the advantage and disadvantages of alcoholic beverages*
CLR-4:	*create awareness on functional beverages*
CLR-5:	*understand the beverages standards and regulation*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*enhance the knowledge on types of beverages*	√		
CO-2:	*gain the knowledge of risk assessment in beverage production*	√		
CO-3:	*apply the knowledge on quality control in soft drink industries*			√
CO-4:	*gain the knowledge on quality control in alcoholic beverages*			√
CO-5:	*know the implementation of GMP and HACCP in beverage industry*		√	

Module-1 – Types of Beverages and Regulatory Frame Works	***9 Hour***
Current status of the beverage industry in India, Types of beverages, Nutritional and therapeutic benefits, Regulatory Framework, National and Global regulations in the beverage industry.	
Module-2 - Non-Alcoholic Beverages	***10 Hour***
Non-Alcoholic Beverages, Natural Fruit based beverages, Synthetic/Artificial beverages, Carbonated beverages, Dairy-based beverages, Whey based beverages, Flavored milk, Advantages and disadvantages of soft drinks, Quality control in soft drink industries.	
Module-3 -. Alcoholic Beverages	***8 Hour***
Alcoholic Beverages, Types of wine, Types of beer, Distilled beverages - Brandy, Whiskey, Rum, Gin, Advantages and disadvantages of alcoholic beverages, Quality control in alcoholic beverages	
Module-4 - Specialty Beverages	***9 Hour***
Specialty Beverages - Coffee, Tea, Probiotics as ingredient in functional beverage, Probiotics health benefits, Fortification of beverages, Sport beverages. Quality control in functional beverages - Probiotics, fortified drinks, sport beverages.	
Module-5 – Safety and Quality Control in Beverages	***9 Hour***
Foodborne Pathogens in Beverages, Sanitation and Hygiene in Beverage industries, GMP in the Beverage Industry, Hazard Analysis and Critical Control Points (HACCP) in the Beverage Industry. Standards and regulation in India.	

Learning Resources	
	1. *Grumezescu, A.M. and Holban, A.M. (2020). Safety issues in beverage production. Duxford, United Kingdom: Woodhead Publishing, an imprint of Elsevier.* 2. *Alexandru Mihai Grumezescu and Alina Maria Holban (2019). Production and Management of Beverages. Volume 1. The Science of Beverages. Cambridge, Ma: Woodhead Publishing.* 3. *Wilson, T. and Temple, N.J. (2016). Beverage Impacts on Health and Nutrition Second Edition. Cham Springer International Publishing, Imprint: Humana Press.* 4. *Paquin, P. (2009). Functional and Speciality Beverage Technology. Elsevier.*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of Unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
		Dr. S. Periyar Selvam, SRMIST

Course Code	21FPE654T	Course Name	FOOD SAFETY AND QUALITY ASSURANCE FOR NUTRACEUTICAL AND FUNCTIONAL FOOD PRODUCTS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Food Process Engineering*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*explain about linking between nutrition and medicine.*
CLR-2:	*describe about flavonoids and its health benefits.*
CLR-3:	*analyze about the bioactive compounds from plant sources used as health supplements.*
CLR-4:	*describe phytoestrogen and its role in health benefits as supplementary products.*
CLR-5:	*discuss about nutraceuticals, efficacy, safety and toxicity*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*understand the basic concepts of nutraceutical and its classification used as health supplements.*		√	
CO-2:	*learn function of flavonoids health benefits for cardiovascular disease and bone health.*	√		
CO-3:	*analyze about the important of plant derived bioactive compounds potential to control the risk of diseases.*			√
CO-4:	*understand the vital role of phytosterol derived from plants source used to prevent cancer and other diseases.*			√
CO-5:	*describe about role of Bioactive compound used for reducing the risk of CVD, Diabetics, CNS disorders and Respiratory disorder.*		√	

Module-1 Concepts of Nutraceutical	***9 Hour***
Concepts of Nutraceutical: Introduction- Classification of Nutraceutical; Definition, History, Classification of Functional Foods: Nutrient vs. Non-nutrient; Prebiotics - Chemistry, Sources and Bioavailability, Effect of Processing, Effects on Human Health and Potential Applications in Risk Reduction of Diseases, Perspective for Food Applications for the Following: Non-Digestible Carbohydrates/Oligosaccharides: Dietary Fibre; Resistant Starch, Gums.	
Module-2 – Quality Assurance Aspects of Nutraceutical Industries and International Requirements	***9 Hour***
Quality Assurance of Nutraceuticals and Their Approval, Registration, Marketing; Nutraceutical Regulations; European Regulations (EFSA) (EC) No 1924/2006; USA Regulations (DSHEA and FDA).	
Module-3 – Regulatory Aspects of Nutraceutical Industries	***9 Hour***
Manufacturer Responsibility & Quality Control; Ingredients; Formula; Manufacturing; End-products Testing. Major contamination risks of nutraceuticals; detection of microbial contamination in nutraceuticals;	
Module-4 FSSAI Regulation for Nutraceutical Industry	***9 Hour***
Food Safety and Standards (Health Supplements, Nutraceuticals, Food for Special Dietary Use, Food for Special Medical Purpose, and Prebiotic and Probiotic Food) Regulations, 2022. [FSSAI (Nutra) Regulations, 2022]; FSSAI guidance and notification on nutraceuticals.	
Module-5 – Food Safety and Quality Guidelines for Nutraceutical and Functional Food Industry	***9 Hour***
Guidelines on FOOD SAFETY MANAGEMENT SYSTEMs for nutraceuticals and Food Supplements industries: Establishment – Design and Facilities; Control of Operation; Establishment – Maintenance & Sanitation; Establishment – Personal Hygiene; Establishment-Product information and consumer awareness.	

Learning Resources	1. *Vattem, Dhiraj A. and Vatsala Maitin. 2016. Functional Foods, Nutraceuticals and Natural Products, Concepts and Applications. USA: DEStech Publications, Inc.* 2. *Boye, Joyce I. 2015. Nutraceutical and Functional Food Processing Technology. New Jersey: Wiley-Blackwell.* 3. *Iwu, Maurice M. 2017. Food as Medicine: Functional Food Plants of Africa. US: CRC Press.*	4. *Cho, S. S. and M. L. Dreher. 2001. Handbook of Dietary Fiber. New York: Marcel Dekker Inc.* 5. *Wildman, R. E. C. 2000. Handbook of Nutraceuticals and Functional Foods. Boca Raton: CRC Press.* 6. *Aluko, Rotimi E. 2012. Functional Foods and Nutraceuticals. Germany: Springer*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of Unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	*Experts from Higher Technical Institutions*	*Internal Experts*
		Dr. P. Gurumoorthi, SRM IST

Course Code	21FPE655T	Course Name	AI AND ML BASED FOOD QUALITY MONITORING SYSTEM	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Food Process Engineering*	**Data Book / Codes/Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*explain Foundation in AI Concepts and Techniques.*
CLR-2:	*configure Problem Solving with AI.*
CLR-3:	*learn Introduction to Machine Learning.*
CLR-4:	*design Application of AI in the Food Industry.*
CLR-5:	*learn Food Quality Monitoring and Safety.*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*understand and apply fundamental AI techniques such as expert systems, neural networks, and fuzzy logic.*		√	
CO-2:	*systematically approach and solve complex problems using AI methodologies and models.*		√	
CO-3:	*implement and evaluate machine learning algorithms including PCA, KNN, and various classifiers.*			√
CO-4:	*utilize AI technologies in automating and optimizing production processes in the food industry.*			√

Module-1 AI Techniques	***12 Hour***
Problem solving with AI, AI Models, Data acquisition and learning aspects in AI, Problem solving- Problem solving process, formulating problems, Problem types and characteristics. AI Techniques- Expert system, Artificial Neural Network, Fuzzy logic, Adaptive neuro- fuzzy interspace system and machine learning.	
Module-2 ML Tools and Processes	***15 Hour***
PCA and Dimensionality Reduction, Nearest Neighbors and KNN. Linear Regression. Decision Tree, Classifiers, Notion of Generalization and concern of Over fitting, Notion of Training, Validation and Testing, Connect to generalization and over fitting. Ensembling and RF, Linear SVM, K Means, Logistic Regression, Naive Bayes. Role of Loss Functions and Optimization, Gradient Descent and Perceptron/Delta Learning, MLP, Back propagation, MLP for Classification and Regression, Regularization, Early Stopping, Introduction to Deep Learning, CNNs, Kernels (with SVM), Bayesian Methods, Generative Methods, HMM, EM, PAC learning.	
Module-3 IoT Based Process Control and AUTOMATION	***9 Hour***
Automation of the Control of Production Processes, Evaluation the Capability of Production Process and Machine. Interfacing data through Internet of Thongs (IoT), Sensors, RFID, QR codes, pesticides, food additives, Analytical instruments, Sensory parameter, material /physical parameters, biological parameters, packing materials, Label declaration, Logistics and Supply chain, Product development and formulation, Shelf life studies.	
Module-4 Application of IoT, AI and ML in Food Quality Monitoring Systems	***9 Hour***
Real time monitoring, Food sampling and testing, Risk assessment, Food fraud, Food defense, Food threat.	

Learning Resources	1. *Stuart Russel and Peter Norvig, "Artificial Intelligence: A Modern Approach", Fourth Edition, Pearson Education, 2020.* 2. *Deepak Kemhani,First course in Artificial Intelligence,McGraw Hill Pvt Ltd, 2013* 3. *Tom M. Mitchell- Machine Learning - McGraw Hill Education, International Edition*	4. *Ian Goodfellow, Yoshoua Bengio, and Aaron Courville Deep Learning MIT Press Ltd, Illustrated edition* 5. *Christopher M. Bishop Pattern Recognition and Machine Learning - Springer, 2nd edition* 6. *Rodríguez MEP. 2018. Process Monitoring and Improvement Handbook, Second* 7. *Edition2018 by ISBN: 978-0-87389-974-1 Food Process Monitoring Systems 1993, Springer.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of Unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	*-*	*15%*	*-*	*15%*	*-*
Level 2	*Understand*	*25%*	*-*	*20%*	*-*	*25%*	*-*
Level 3	*Apply*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*10%*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*5%*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	*Experts from Higher Technical Institutions*	*Internal Experts*
		Dr G Nagamaniammai, SRM IST

Course Code	21FPE656T	Course Name	LOGISTICS AND SUPPLY CHAIN MANAGEMENT	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Food Process Engineering*	**Data Book / Codes/Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1 :	*explain about overview of logistics and supply chain management.*
CLR-2 :	*describe about inventory management and customer service and order processing.*
CLR-3 :	*analyze about the demand forecasting techniques in logistics and supply chain management.*
CLR-4 :	*describe warehousing, Transportation in LSCM and Protective Packaging.*
CLR-5 :	*discuss about Logistics Administration and Logistics Information systems.*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*understand the basic concepts and functions of LSCM.*		√	
CO-2:	*learnt function of order processing cost, Inventory cost and types, and Customer service strategic Management.*	√		
CO-3:	*analyze about the effective forecasting Process and principle of demand forecasting.*			√
CO-4:	*understood the Warehousing strategy and warehouse design, Multi-modal transportation and Logistics packaging.*			√
CO-5:	*described about role of organization principles, Trends in LSCM organizations, and Logistics information systems.*		√	

Module 1: Introduction to Logistics	***9 Hour***
Nature and concepts - Logistics mission and Strategic Issues - International Logistics System - Growing Importance of Logistics Management - Operational objectives - Components of Logistics Management - Functions of Logistics Management - Integrated Logistics system - Total cost analysis and Trade-off - Function of Supply Chain Management - Supply chain and competitive performance - The changing competitive environment - The impact of out-of-stock - Introduction about Inventory Management - Concept and types of Inventory management - Functions of Inventory in LSCM - Elements of Inventory cost	
Module 2: Logistics in India	***9 Hour***
ABC Analysis - ABC-VED Matrix - Distribution Requirement Planning (DRP) - Material Requirement Planning Equation (MRP) - Just-in-Time system - Prerequisites of JIT System - Nature and Concept of customer service - Components of customer service - Customer Service Costs - Gap analysis for Customer Service Management - Customer Service Strategic Management - Marketing Strategy - Order Processing in LSCM - Major function in order processing - Elements of order processing cost - Zero defect delivery system - Customer relationship with supply chain manager - Role of Supply chain management in order processing	
Module 3: Flow Chart of Order Processing	***9 Hour***
Logistics and shareholder value - Direct product profitability - Customer Profitability analysis - Logistics and the bottom line - International supply chain strategies - Warehousing and distribution centers - Concept of Warehousing - Types of Warehousing - Function of Warehousing - Warehousing strategy - Warehouse design - Operational Mechanism of Warehouse - Element of Transportation in LSCM - Transportation cost - Modes of Transportation - Multi-Modal Transport	
Module 4: Cold Storage Facilities	***9 Hour***
Selection of Transportation Mode - Indian Transport infrastructure - Transportation decision in LSCM - Protective packaging - Forms of protective packaging - Protective packaging problems - Packaging policy - Types of Packaging materials - Primary and Secondary Packaging - Labeling procedure in Logistics - Logistics organizations - Trends of Logistics and Supply Chain Organization - Basic organization principles - Organizing for global logistics - Collaborative planning - Factors influencing organization structure - Internal and External Performance measurement	
Module 5: Outline of Logistics Functioning	***9 Hour***
Role of information in Logistics and Supply chain management - Value flow of information in LSCM - Operational flow of information - Logistics Information System (LIS) - Operational Logistics information system	

- Electronic Data Interchange (EDI) - Components of EDI - Bar code system (BCS) in Logistics and Supply Chain Management - Enterprise Resource Planning (ERP) - Supply chain relationship - Harmonious Relationship Marketing - The lead-time gap - Thinking global and acting local - Role of supply chain management in demand forecasting - Case studies in LSCM - Cutting-edge customer service - Challenges facing in customer satisfaction

Learning Resources	1. *Martin Christoper, "Logistics and Supply Chain Management" Fourth edition, Pearson education limited, ISBN: 978-0-273-73112-2, 2011.* 2. *D.K. Agarwal, "Textbook of Logistics and Supply Chain Management", revised edition, Trinity press, ISBN: 978-93-85750-04-5, 2016.*	3. *Michael Hugos, "Essentials of Supply chain Management" Fourth edition, John Wiley & Sons, Inc, ISBN: 9781119461104 (paper back), 2018.* 4. *Cecil B. Bozarth, Robert B. Handfield, "Introduction to operations and supply chain management", Fourth edition, Pearson publication, ISBN-13: 9780133871777, 2016.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of Unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	*-*	*15%*	*-*	*15%*	*-*
Level 2	*Understand*	*25%*	*-*	*20%*	*-*	*25%*	*-*
Level 3	*Apply*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*10%*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*5%*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	*Experts from Higher Technical Institutions*	*Internal Experts*
		K. Aravind raj, SRM IST

ACADEMIC CURRICULA

Genetic Engineering

Professional Core Courses

Regulations 2021



SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

Course Code	21GEC501J	Course Name	MOLECULAR TECHNIQUES	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Genetic Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the principles of DNA analytical techniques*
CLR-2:	*knowledge on RNA based techniques*
CLR-3:	*discuss various protein analytical methods*
CLR-4:	*restate various sequencing technologies*
CLR-5:	*explain the basic and advanced methods to analyse secondary metabolites*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*design primers and perform PCR*	*3*		*2*
CO-2:	*perform qualitative and quantitative analysis of RNA*	*3*	*2*	*3*
CO-3:	*investigate and characterize proteins*			*2*
CO-4:	*analyze DNA sequence using various sequencing strategies*	*2*		
CO-5:	*experiment and interpret secondary metabolites*	*2*	*2*	

Module-1 - DNA Techniques	***15 Hour***
Methods of DNA analysis - Principle, method and application: Polymerase Chain Reaction (PCR), inverse PCR, multiplex-PCR, Amplification-Refractory Mutation System (ARMS) PCR, Loop-mediated isothermal amplification (LAMP), Targeting induced local lesion in genomes (TILLING), Thermal asymmetric interlaced (Tail) PCR, PCR-RFLP (Restriction Fragment Length Polymorphism), Bisulphite PCR, nested PCR, and digital PCR. Principle, method, and application of site-directed mutagenesis ***Practice:*** *1. Isolation of DNA* *2. ARMS-PCR* *3. LAMP*	
Module -2 - RNA Techniques	***15 Hour***

Principle, method, and application: Reverse Transcription PCR, semi-quantitative PCR, Quantitative PCR, 5'-rapid amplification of cDNA ends, 3'-rapid amplification of cDNA ends, and Differential Display Reverse Transcription PCR. Principle, method, and application of in vitro transcription ***Practice:*** *1. Random amplified Polymorphic DNA* *2. Restriction Fragment Length Polymorphism* *3. Bacterial identification using 16srDNA*
Module -3 - Protein Techniques ***15 Hour***
Principle, method, and application: denaturing and non-denaturing Polyacrylamide gel electrophoresis, 2D electrophoresis – 2D-Difference in Gel Electrophoresis, Western blotting– far western, peptide fingerprinting, affinity purification - His-tag purification, GST-tag purification, Enzyme-Linked Immunosorbent assay, Radioimmunoassay, Chromosome Immunoprecipitation, Electrophoretic Mobility Shift Assay, Pull-down assay, Co-localization using fluorescent tags ***Practice:*** *1. In vitro transcription assay* *2. Quantification of protein using Bradford method*
Module -4 - Hybridization and Sequencing Techniques ***15 Hour***
Probes - Types of probes, types of labels, methods of labeling, methods of detection, Southern hybridization - Restriction Fragment Length Polymorphism, Dot Blot hybridization, Northern Blotting, In situ hybridization, Fluorescent in situ hybridization, DNA sequencing by Sanger, Maxam-Gilbert, Next-generation sequencing – Illumina, ion-torrent, nanopore sequencing, third generation sequencing ***Practice:*** *1. SDS-Polyacrylamide Gel Electrophoresis* *2. PCR-RFLP*
Module -5 -Bio-Analytical and High Through-put Techniques ***15 Hour***
Principle, method, and application: High-performance thin layer chromatography, High-Performance liquid chromatography, Gas chromatography, Mass spectrometry, Nuclear Magnetic Resonance, Fourier-transformed infrared spectroscopy, Matrix-Assisted Laser Desorption/ionization-Time of Flight, Fluorescent imaging, confocal imaging, cryogenic Electron Microscopy, Flow cytometry, High content screening – automated microscopy, High through-put screening – cell based assays, target based assays, reporter based assays, label free assays, microfluidic screening. ***Practice:*** *1. LC-MS analysis of protein/metabolite* *2. Reporter Gene based assays*

Learning Resources	*1. Frederick M. Ausubel, Roger Brent, Robert E. Kingston, David D. More, Seidman J. G., John A. Smith and Kevin Struhl, "Curent Protocols in Molecular Biology", John Wiley& Son, Inc.*	*2. Daniel C. Liebler "Introduction to Proteomics", Humana Press.*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	-		*15%*	
Level 2	*Understand*	*20%*	-	-	*20%*	*25%*	
Level 3	*Apply*	*25%*	-	-	*25%*	*30%*	
Level 4	*Analyze*	*25%*	-	-	*25%*	*30%*	
Level 5	*Evaluate*	15%	-	-	*15%*	-	
Level 6	*Create*		-	-	*15%*	-	
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Dr. Florida Tilton *Managing Director, Biozone Research Technologies*	*1. Dr. Subramanian Sankaranarayanan* *Associate Professor, IIT Gandhinagar*	*1. Dr. D. Rex Arunraj, SRMIST*
2. Dr. Aneesh, Head, Centre for Genomics Medicine NIMS Hospital, Trivandrum	*2. Prof. Gopalakrishnan* *Professor, IARI, New Delhi*	*2. Dr. Usha B , SRMIST*

Course Code	21GEC502T	Course Name	MOLECULAR BIOLOGY OF GENE	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Genetic Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*gain knowledge on genes and their structure*
CLR-2:	*obtain knowledge replication of DNA*
CLR-3:	*learn the process of DNA transcription into RNA*
CLR-4:	*gain knowledge on protein translation*
CLR-5:	*learn post-translational modification of proteins*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*explain the structure of genes*	*3*	*3*	*2*
CO-2:	*describe how DNA is replicated in prokaryotes and eukaryotes*	*3*	*3*	*2*
CO-3:	*interpret how DNA is transcribed in prokaryotes and eukaryotes*	*3*	*3*	*2*
CO-4:	*compare and contrast process of translation in prokaryotes and eukaryotes*	*3*	*3*	*2*
CO-5:	*investigate the process of post-translational modification of proteins*	*3*	*3*	*2*

Module -1 - Structure of Gene	***9 Hour***
Structure of DNA and RNA. Organization of chromosomes. Genes, alleles, and locus. Genes in DNA and RNA. Genome, genome size and non-coding DNA, Central dogma of life.	
Module -2 - Replication of DNA	***9 Hour***
Replication of small circular genomes and large linear chromosomes. Enzymes and proteins required for replication, chromosome remodeling for replication, leading and lagging strand synthesis for replication. Rolling circle replication of phage DNA, errors during replication, proofreading and DNA repair.	
Module -3 - Transcription of DNA	***9 Hour***
Promoters, RNA polymerases, and transcription factors. Transcription in E.coli. Transcription in eukaryotes. mRNA maturation and stability, alternative splicing, and RNA export to the cytoplasm	
Module -4 - Translation of RNA	***9 Hour***
Genetic code in DNA and RNA. Features of genetic code. Codons use frequency and its implication in genetic engineering. Components of translation. Translation in prokaryotes and eukaryotes; Protein degradation by ubiquitin-proteasome pathway and lysosomal proteolysis.	
Module -5 - Recombination of DNA	***9 Hour***
Models of homologous recombination, proteins involved in homologous recombination, homologous recombination in eukaryotes, site specific recombination, molecular biology of transposition	

Learning Resources	*1. James D Watson, Molecular Biology of Gene, Pearson Publisher, 2017*	*2. Jocelyn E. Krebs, Elliott S. Goldstein, Stephen T. Kilpatrick, Lewin's Genes XII, Jones & Bartlett Publishers, 2017*

Learning Assessment								
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*10%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*25%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	*10%*	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Dr. V. Ramprasad, CEO, MedGenome, Bengaluru. ramprasadv@medgenome.com	*1. Dr. Latha Rangan, Indian Institute of Technology Guwahati. lrangan@iitg.ac.in*	*1. Dr. M. Parani, SRMIST*

Course Code	21GEC503J	Course Name	MOLECULAR CLONING	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Genetic Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*summarize DNA manipulating enzymes*
CLR-2:	*illustrate use of various cloning and expression vectors*
CLR-3:	*explain the process of gene cloning strategies*
CLR-4:	*create knowledge on DNA library and screening*
CLR-5:	*construct expression vector for recombinant protein purification*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	**2**	**3**
CO-1:	*describe restriction enzymes and polymerases*	*3*	*3*	*2*
CO-2:	*use plasmids and vectors for gene cloning*	*3*	*3*	*2*
CO-3:	*compare various cloning strategies*	*3*	*3*	*2*
CO-4:	*explain DNA libraries and their uses*	*3*	*3*	*2*
CO-5:	*explain recombinant protein purification methods*	*3*	*3*	*2*

Module -1 - DNA Manipulating Enzymes	***15 Hour***
DNA manipulating enzymes- Restriction enzymes, types, DNA modifying enzymes, Terminal transferases, Alkaline phosphatases, Polynucleotide kinase, Methylases; DNA dependent DNA polymerases, DNA dependent RNA polymerases, RNA dependent DNA polymerases, Exo and endonucleases, DNA ligases and RNA ligases. ***Practice:*** *1. Plasmid DNA isolation for cloning* *2. PCR amplification of the insert* *3. Agarose gel electrophoresis of vector and insert*	
Module -2 - Vectors for Cloning	***15 Hour***
E. coli vectors: pBR322, pUC18/19, BAC, cosmids, Lambda and M13 phage vectors and expression vectors. Yeast vectors. Plant binary vectors for transformation. Animal vectors for transfection ***Practice:*** *1. Restriction digestion of Vector and Insert DNAs* *2. Gel purification of Vector and Insert DNA* *3. Qualitative and Quantitative analysis of purified DNA*	
Module -3 - Gene Cloning Strategies	***15 Hour***

Cloning using restriction enzymes: Cohesive end cloning and blunt end cloning. Cloning using linkers and adaptors. TA cloning and TOPO cloning. Restriction free cloning and ligation independent cloning. ***Practice:*** *1. Vector-Insert ligation* *2. Competent cell preparation*
Module -4 - DNA Library ***15 Hour***
Genomic DNA Library: Genomic DNA fragmentation, size fractionation, choice of vectors and size of library. cDNA Library: RNA isolation, mRNA purification, cDNA synthesis and cloning. Screening strategies of DNA libraries: Functional screening, probe-based screening and immunoscreening. ***Practice:*** *1. Transformation of ligated sample and selection* *2. Colony PCR for recombinant selection*
Module -5 - Gene Cloning and Expression ***15 Hour***
Expression vectors: Characteristics of expression vectors, cloning with fusion tags: His tags, GST tags, CBD and MBD tags. Expression and purification of recombinant protein. Codon bias and optimization. ***Practice:*** *1. Recombinant protein expression* *2. SDS-PAGE analysis of recombinant protein*

Learning Resources	1. *Principles of Gene Manipulation and Genomics, 7th Edition, S.B. Primrose and R.M. Twyman, Black well publishing, 2006*	2. *Current Protocols in Molecular Biology, Frederick M. Ausubel, Roger Brent, Robert E. Kingston, David D. Moore, J.G. Seidman, John A. Smith,Kevin Struhl (eds.), John Wiley & Sons, Inc*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (45%)		Life-Long Learning CLA-2 (15%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	15%	-	-	15%	15%	-
Level 2	Understand	25%	-	-	20%	25%	-
Level 3	Apply	30%	-	-	25%	30%	-
Level 4	Analyze	30%	-	-	25%	30%	-
Level 5	Evaluate	-	-	-	10%	-	-
Level 6	Create	-	-	-	5%	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Dr. Ramanathan Vai* *Head, Genomics at Metahelix Lifesciences, Bengaluru*	1. *Dr. N. Ayyadurai* *Senior Scientist, CLRI, Chennai*	1. *Dr. S. Iyappan, SRMIST*
2. *Dr. Shankar. S* *Principal Scientist, Adenovirus Therapeutics, Ltd*	2. *Dr.Vikas Jain* *Associate Professor, IISER, Bhopal*	2. *Dr. Rex Arunraj D, SRMIST*

Course Code	21GEC504J	Course Name	GENOMICS: METHODS AND ANALYSIS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Genetic Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*summarize the principles and resources for genomic data analysis*
CLR-2:	*interpret the different approaches for sequence quality assessment*
CLR-3:	*analyse the quality of the assembled transcriptome and the normalization*
CLR-4:	*predict the genes of significance based on differential gene expression*
CLR-5:	*simulate genomic and exomic data for variants prediction*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*explain concepts and databases for sequence analysis*	*2*	*-*	*-*
CO-2:	*demonstrate the different methods to perform data QC and file formats*	*2*	*-*	*-*
CO-3:	*differentiate between de novo and reference assembly approaches in transcriptomics*	*3*	*2*	*3*
CO-4:	*estimate the change in the expression pattern among genes*	*3*	*2*	*2*
CO-5:	*integrate methods and tools for WES and WGS analysis*	*2*	*2*	*2*

Module -1 - Concepts and Resources	***15 Hour***
Databases: Nucleotide and Protein Sequence Databases, NCBI Sequence Read Archive, TCGA, KEGG, RNA Central, Uniprot and InterPro; Sequence Analysis: Basics of Pairwise, Global and Local Alignment, BLAST and its types, Identity, Similarity, Homology, Orthologs, Paralogs, Xenologs; Multiple Sequence Alignment: Motifs, Domains, Family and Superfamily – Phylogeny tree construction and validation. ***Practice:*** *1. Data retrieval, pairwise sequence alignment and BLAST, 2. Multiple sequence alignment and Phylogenetic tree construction*	
Module-2 - Sequencing Data QC	***15 Hour***
Introduction to Linux and Galaxy; File Formats: FASTA, FASTQ, BCL, SAM and BAM; Characteristics of a NGS library – adapters, indexes; Single-end and Paired-end sequencing, Phred Score Calculation and its interpretation, Adapter trimming, FastQC and MultiQC. Visualization tools. ***Practice:*** *1. Linux commands and Galaxy, 2. File formats conversion, 3. SRA data mining and Assessment of sequence data quality*	
Module -3 - Transcriptomic Data Analysis	***15 Hour***
Introduction- RNASeq, Assembly: Reference and De novo, N50, N90, Bowtie2; Contigs, Transcripts and Isoforms; Completeness of De novo assembly: BUSCO, Bowtie, Indexes for Reference mapping, HISAT2, Normalization: RPKM, FPKM, TPM; Pipelines for RNA-Seq ***Practice:*** *1. De novo assembly and assessment of the transcriptome, 2. Reference assembly, 3. Feature counts and Normalization*	
Module -4 - Differential Gene Expression and Annotation	***15 Hour***
Introduction- Differential Gene Expression: Foldchange, logFC, Heatmap, Time Course analysis of DEGs, DESeq2, EdgeR; Functional Annotation: BLAST, Blast2GO, Gene Ontology, Geneset Enrichment Analysis, Principal Component Analysis, Gene-Gene network, Fusion Genes; Case studies.	

Practice: *1. Differential expression of genes, 2. Functional Annotation and Gene Ontology, 3. Cytoscape*
Module -5 - Whole Genome Sequencing and Whole Exome Sequencing ***15 Hour***
Introduction - WGS and WES, Targeted and Amplicon Sequencing, Coverage and Depth of Sequencing, Indels, Variant Calling – SNV, SNP, variant call format (VCF); Alignment, Copy number variation, Genome resequencing, COSMIC, OMIM, GATK, AnnoVar, Personalized Medicine; Pipelines for WES and WGS. Case studies.
Practice: *1. Identification of SNP using GATK, 2. Annotation of SNPs using COSMIC*

Learning Resources	1. *David W. Mount. Bioinformatics: Sequence and Genome Analysis, 2nd Edition, Cold Spring Harbor Laboratory Press, USA. 2004* *2. Hamid D Ismail. Bioinformatics A Practical Guide to Next Generation Sequencing Data Analysis, CRC Press. 2023.* *3. Ju Han Kim. Genome Data Analysis: Learning Materials in Biosciences, Springer Nature Singapore Pte Ltd. 2019.*	*4. Filippo Geraci, Indrajit Saha, Monica Bianchini. RNA-Seq Analysis: Methods, Applications and Challenges, Frontiers Media SA, 2020.* *5. Peter N. Robinson, Rosario Michael Piro & Marten Jager. Computational Exome and Genome Analysis, 1st Edition, Chapman and Hall/CRC, 2017* *6. https://en.wikibooks.org/wiki/Next_Generation_Sequencing_(NGS)/Print_version*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*30%*	*-*	*-*	*10%*	*20%*	
Level 2	*Understand*	*30%*	*-*	*-*	*10%*	*20%*	
Level 3	*Apply*	*20%*	*-*	*-*	*10%*	*20%*	
Level 4	*Analyze*	*20%*	*-*	*-*	*20%*	*20%*	
Level 5	*Evaluate*	*-*	*-*	*-*	*25%*	*20%*	
Level 6	*Create*	*-*	*-*	*-*	*25%*		
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Dr. Arpita Ghosh, Eurofins Genomic India Pvt. Ltd, Bengaluru, arpita.Ghosh@xoin.eurofinsasia.com	*1. Prof. V. Umashankar, ICMR-NIE Chennai, umashankar.v@icmr.gov.in*	*1. Dr. Habeeb. S. K. M, SRMIST*
2. Dr. Sanjay Singh, Eurofins Genomic India Pvt. Ltd, Bengaluru, sanjay.singh@xoin.eurofinsasia.com	*2. Prof. Saharuddin Bin Mohammad, University of Malaya, Kuala Lumpur, saharuddin@um.edu.my*	*2. Dr. T. Anand, SRMIST*

Course Code	21GEC505J	Course Name	REGULATION OF GENE EXPRESSION	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Genetic Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*summarize various factors influencing gene expression.*
CLR-2:	*illustrate transcriptional level control mechanisms in gene expression.*
CLR-3:	*explain post-translational regulation of gene expression*
CLR-4:	*analyze epigenetic mechanisms regulating gene expression.*
CLR-5:	*develop skills in quantifying gene expression and modifications*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*identify various regulatory elements influencing gene expression.*	3	2	3
CO-2:	*develop skills in quantifying gene expression.*	3	2	-
CO-3:	*demonstrate proficiency in utilizing antisense RNA.*	-	3	2
CO-4:	*analyze the effects of protein modifications.*	2	3	-
CO-5:	*apply principles of epigenetic regulation to control gene expression.*	3	-	2

Module -1 - Control of Gene Expression	***15 Hour***
Fine structure of gene; Structural elements controlling gene expression- promoters, enhancers, and silencers; General and Inducible transcription factors; Transcriptional regulation in prokaryotes- Lactose operon, tryptophan operon, arabinose operon and galactose operon; Translational regulation in prokaryotes. ***Practice:*** *1. Isolation of RNA* *2. Qualitative and Quantitative analysis of RNA using Agarose gel electrophoresis and Nanodrop spectrophotometer*	
Module -2 - Transcriptional and Post-Transcriptional Control of Gene Expression	***15 Hour***
Riboswitches and types; Control of gene expression using riboswitches; Regulation of gene expression by non-coding RNAs; X chromosome inactivation-Dosage compensation; Bacteriophage lambda genome; Control of lytic and lysogenic life cycle of lambda phage; Control of yeast HO gene using two repressors; Combinatorial control of yeast mating type genes. ***Practice:*** *1. DNase treatment and RNA purification* *2. Primer designing and first-strand cDNA synthesis*	
Module -3 - Translational and Post-Translational Control of Gene Expression	***15 Hour***
Protein folding; Molecular chaperons-Heat shock factors; Post-translational modifications of proteins-prenylation, palmitoylation, myristoylation, glycosylation, phosphorylation, ubiquitination, SUMOylation; mechanism in protein packaging.	

Practice: *1. Semiquantitative-Reverse Transcription PCR* *2. Quantitative gene expression analysis using qRT-PCR*
Module -4 - Epigenetic Control of Gene Expression ***15 Hour***
Histone modifications; Effect of histone modification on gene expression; Histone acetylation, methylation; Histone code hypothesis; Chromatin remodellers in eukaryotes; Chip-Seq; Regulators of homeotic genes- PcG and TrxG proteins; Role of polycomb group of proteins; Genomic imprinting- DNA methylation, Patterns of DNA methylation; Effects of DNA methylation on transcription; Imprinting control regions. ***Practice:*** *1. Methylation-specific PCR* *2. DNA cytosine methylation analysis by bisulfite sequencing*
Module -5 - Gene expression Analysis Methods ***15 Hour***
Analysis of regulatory elements using reporter genes; Protein-DNA/protein interaction-Yeast one-hybrid assay, EMSA, Yeast two-hybrid assay; post-transcriptional modification- Real-Time PCR, small RNA transcriptomics, mRNA stability assay; post-translational modifications of proteins-Western blotting, immunofluorescence assay; Epigenetic modification-Chromatin immunoprecipitation assay, Bisulfite sequencing. ***Practice:*** *1. IPTG induction protein expression and analysis* *2. Electrophoretic Mobility Shift Assay (EMSA)*

Learning Resources	*1. Molecular Biology of the gene by Watson J D, Bake T A, Bell SP, Gann A, Lewine M, Losick R 2014* *2. Epigenetic Gene Expression and Regulation by Huang S, Litt M D, and Blackey C A, 2015* *3. Molecular Cloning – A Laboratory Manual by Michael Green and Joseph Sambrook, CSHL Press, 4th edition, 2014*	*4. Mechanisms of Gene Regulation: How Science Works by Carsten Carlberg, Ferdinand Molnár, Springer Internation Publishing, 2020* *5. Laboratory Manual*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	-	*15%*	*15%*	-
Level 2	*Understand*	*25%*	-	-	*20%*	*25%*	-
Level 3	*Apply*	*30%*	-	-	*25%*	*30%*	-
Level 4	*Analyze*	*30%*	-	-	*25%*	*30%*	-
Level 5	*Evaluate*	-	-	-	*10%*	-	-
Level 6	*Create*	-	-	-	*5%*	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	*Experts from Higher Technical Institutions*	*Internal Experts*
1. *Dr. Ramanathan Vai Head, Genomics at Metahelix Lifesciences, Bengaluru*	*1. Dr. P.V. Shivaprasad, Group leader, NCBS Bengaluru*	*1. Dr. G. Ganesan, SRMIST*
2. Dr. P. Sadasivam Scientist, Du Pont Industrial biosciences, Hyderabad	*2. Dr. Sivaprakash Ramalingam, Scientist, IGIB, New Delhi*	*2. Dr. S. Iyyappan , SRMIST*

ACADEMIC CURRICULA

Genetic Engineering

Professional Elective Courses

Regulations 2021

SRM INSTITUTE OF SCIENCE & TECHNOLOGY
(Deemed to be University u/s 3 of UGC Act, 1956)

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

Course Code	21GEE501T	Course Name	HUMAN PHYSIOLOGY	Course Category	E	PROFESSIONAL ELCTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Genetic Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*generate knowledge in architecture of biological membrane and cellular processes involved in physiology*
CLR-2:	*provide an understanding about the basic functions of cardiovascular and respiratory systems*
CLR-3:	*enable the students to understand the digestion of macromolecules*
CLR-4:	*create an understanding about the neuromuscular systems that controls and maintains homeostasis*
CLR-5:	*initiate the students to understand the role of reproductive organs in gametogenesis*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*recall the structural organization of cell membrane and transport of molecules across the membrane*	3	2	-
CO-2:	*describe the cardiac events that helps in effective functioning of heart and exchange of gases between the lungs and tissues*	3	3	-
CO-3:	*explain the gastrointestinal secretions and their role in digestion and absorption*	-	-	3
CO-4:	*summarize the nerve impulse conduction and muscular contraction*	2	2	-
CO-5:	*integrate the process of gametogenesis and the role of hormones involved in the reproductive system.*	2	2	-

Module -1 - Cellular Physiology	***9 Hour***
Structural organization of cell, Transport function of cell membrane- Cross membrane movement of small and large molecules; Membrane shuttles - Endocytosis and Exocytosis.	
Module -2 - Cardiovascular and Respiratory System	***9 Hour***
Cardiovascular system –Working mechanism of heart, Electrocardiogram, Blood pressure, Cardiovascular pathways, Cardiac output and Cardiac cycle events. Cellular respiration-, Partial pressure of gaseous molecules, Effect of pO2 on Hb saturation, Gaseous transport – Exchange of O_2 and CO_2 between alveolar sac and tissues.	
Module -3 - Digestive System and Gastrointestinal Disorders	***9 Hour***
Overview of digestive system - Major and minor accessory organs of digestive system. Role of gastrointestinal enzymes in digestion and absorption of carbohydrates, proteins and fats. Physiology of gastrointestinal disorders	
Module -4 - Neuronal Biology and Muscular System	***9 Hour***
Neuronal structure, types of neurons, glial cells; Synapses – Chemical and electrical synapse; Mechanism of nerve impulse transmission with G protein coupled receptor; Neurotransmitters - Types of neurotransmitters, its synthesis and secretions. Muscular system – Role of contractile proteins in muscular contraction and relaxation Sources of ATP in muscle metabolism.	
Module -5 - Excretory System and Reproductive Biology	***9 Hour***
Overview of Urinary system, role of nephrons in urine formation; Countercurrent multiplier system in excretion; Role of Renin Angiotensin -Aldosterone regulation of kidney function. Reproductive system- Spermatogenesis, Oogenesis, Menstrual cycle, Maternal changes during pregnancy and lactation.	

Learning Resources	*1. Sembulingam P., Sembulingam K,"Essentials of Medical Physiology" , Jaypee Publications, 6th Edition. 2010.* *2. Jain A.K. "Textbook of Physiology", Avichal Publishing Company, 4th Edition, 2009.* *3. Guyton A.C. and Hall J.E., "Medical Physiology", Saunders Publications, 11thEdition, 2005* *4. Muthayya, N.M., "Human Physiology", 4th edition, Jaypee Publications, 2010.*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*30%*	-	*25%*	-	*30%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*25%*	-	*25%*	-	*25%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-		-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	*Experts from Higher Technical Institutions*	*Internal Experts*
1. Dr. V. Ganesan, Managing Director, Acme Progen Biotech (India) Pvt. Ltd, Salem *Astarich16@gmail.com*	*1. Dr. Jayanthi* *Assistant Professor, Dept of Environmental Sciences, Periyar University, Salem*	*1. Dr. J. Megala, SRMIST*
2. Dr. S. Ramamoorthy, CEO,Palamur Biosciences PVT Ltd, Hyderabad *ram.murthy@palamurbio.com.*	*2. Dr. S. Ananthi* *Scientist, Dept.of Preventive Oncology, Cancer Institue, Chennai*	*2. Dr. Sivaramakrishnan, , SRMIST*

Course Code	21GEE502T	Course Name	MOLECULAR IMMUNOLOGY	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Genetic Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*obtain knowledge of the principles of immune responses*
CLR-2:	*analyze the molecular mechanisms of immune response*
CLR-3:	*discuss about antigen and antibody*
CLR-4:	*illustrate various immunodeficiency diseases and vaccine development*
CLR-5:	*state an overview of emerging topics in immunology*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*recall about basic concepts of immunology*	-	2	-
CO-2:	*describe antibody structure and diversity*	-	2	-
CO-3:	*analyse recent developments in antigen-antibody interactions*	3	-	2
CO-4:	*discuss concepts in immunopathology and immunotherapy*	3	2	2
CO-5:	*apply emerging concepts in immunology*	3	2	2

Module -1 - Overview to Immunology	***9 Hour***
Basic concepts and principles of immunology; Cells and organs of the immune system; Adaptive immunity; Major histocompatibility complex (MHC); Antigen presentation system and Innate Immune Responses – PRRs – TLRs – RLRs and NLRs	
Module -2 - Molecular Mechanisms of Immune Responses	***9 Hour***
B cell development and activation; T cell development and activation; T cell receptor structure and function; T cell subsets and differentiation; Cell-mediated cytotoxicity and apoptosis; Chemokines and adhesion molecules in cell migration and homing to lymphoid organs.	
Module -3 - Antigens and Antibodies	***9 Hour***
Antigens- chemical and molecular nature; Haptens; Adjuvants; Antibodies- structure and functions of antibodies; Immunoglobulin gene rearrangement and diversity; Genetic control of antibody production; Isotype, Allotypes; Idiotypes; Antigen-antibody reactions and their significance in diagnosis; Immunotoxic chimeric antibodies and abzymes.	
Module -4 - Immunopathology and Immunotherapy	***9 Hour***
Monoclonal and polyclonal antibody production- principles and applications; Hypersensitivity and allergy; Autoimmunity and autoimmune diseases; Immunodeficiency and immunodeficiency diseases; Transplantation and graft rejection; Tumor immunology and cancer immunotherapy; Infectious diseases and vaccine development.	
Module -5 - Emerging Topics in Molecular Immunology	***9 Hour***
Immunogenomics and immunoproteomics; Immunoinformatics and computational immunology; Epigenetics and chromatin remodeling in immune cells; Microbiome and mucosal immunology; Nanovaccines and nanotheranostics in immunology.	

Learning Resources	*1. Abul K. Abbas Andrew H. Lichtman & Shiv Pillai, "Cellular and Molecular Immunology" 10th Edition. 2021* *2. Judith A. Owen, Jenni Punt and Sharon Stranford, "Kuby Immunology", W.H. Freeman and Company, 7th Edition, 2014.* *3. Sudha Gangal and Shubhangi Sontakke, "Textbook of basic and clinical immunology," Universities Press, 2013.*	*4. Bruce Alberts. Molecular Biology of the Cell, 5th Edition. 2017* *5. Roitt's Essential Immunology. 13th ed. P. Delves, et al., ed., Blackwell Publishing, 2017.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*25%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	*Experts from Higher Technical Institutions*	*Internal Experts*
1. Dr. C. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	*1. Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in*	*1. Dr. M. Ramya, SRMIST*
2. Dr. Karthik Periyasamy, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com	*2. Prof. R. B. Narayanan, SVCE, Chennai, rbn@svce.ac.in*	*2. Dr. V. Sivaramakrishnan, SRMIST*

Course Code	21GEE503J	Course Name	CANCER GENETICS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Genetic Engineering*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*obtain knowledge on biology and genetics of cancer*
CLR-2:	*comprehend the molecular signalling mechanisms involved in cancer*
CLR-3:	*study the types of cancer therapy*
CLR-4:	*evaluate the mechanisms of resistance*
CLR-5:	*identify novel drugs and targets for cancer treatment*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*define various factors involved in cancer progression and metastasis*	3	2	2
CO-2:	*analyze the mechanism of the spread of cancer*	3	3	2
CO-3:	*demonstrate the role of genetic and epigenetic factors in cancer*	3	2	2
CO-4:	*compile signaling pathways activated during carcinogenesis*	3	3	2
CO-5:	*propose the challenges and limitations in cancer therapies*	3	3	2

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Module - 1 - Classification and Causes of Cancer	***12 Hour***
Introduction to Cancer - Epidemiology of cancer; Global and Indian Scenario of Cancer; Types of Cancer; Causes of Cancer – Physical agents, Chemical agents, Genetic factors, Lifestyle influence, Bacterial, protozoan and viral causes of cancer; Cancer Prevention Strategies ***Practice:*** *1. MTT assay* *2. Colony Formation Assay*	
Module - 2 - Hallmarks of Cancer	***12 Hour***
Oncogenes and Tumor Suppressor genes; Cell cycle and Cancer; Programmed cell death, Metastasis – Steps and Genes involved in metastasis; Tumor recurrence, immune evasion; drug/radio -resistance; Cancer stem cells; tumor angiogenesis and Anti-angiogenic chemotherapeutics ***Practice:*** *1. Migration Assay* *2. CAM assay*	
Module - 3 - Aging and Epigenetics in Cancer	***12 Hour***
Genetic alterations in cancer- Mutation-p53, kRas, Translocation-Bcr/Abl, DNA repair mechanisms- MLH and MMR in cancer, Epigenetics- DNA methylation in promoter regions of tumor suppressor gene - p53, Histone modifications in cancer, Noncoding RNAs in Cancer-OncomiRs and Tumor suppressor miRNAs, Cellular senescence, aging and cancer. ***Practice:*** *1. Cell Viability – Trypan blue/ Fluorescein diacetate assay* *2. COMET assay*	
Module – 4 - Cancer Cell Signaling Pathways	***12Hour***
Basic elements and concepts of signaling, G-Protein Coupled Receptors in Cancer, Hormone signaling in Cancer-Estrogen receptor, Growth factor signaling - EGFR and cancer, Inflammation and cancer-Colitis associated cancer, Cancer stem cell self renewal signaling pathways-Hedgehog, Wnt and Notch signaling.	

Practice: *1. Anchorage independent assay* *2.Colonospheroid assay*	
Module - 5 - Cancer Therapy	***12 Hour***
Types of Cancer treatment – Radiation therapy; Chemotherapy-, Immunotherapy, Gene Therapy-Suicide Gene Therapy and oncolytic virus; Hormone Therapy-Aromatase inhibitors, Targeted Therapy, Cancer Stem Cell Therapy-Vismodegib ***Practice****: 1. PI/Annexin V – Flow cytometry* *2. Immunocytochemistry-cMYC*	

Learning Resources	1. *Bunz F. "Principles of Cancer Genetics", Springer Science, Second Edition (2016).* 2. *Weinberg R. "The Biology of Cancer", Garland, Second Edition (2013).*	3. *Ramalingam S, "Cancer Genes" Bentham Books, (2023)*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	-	*15%*	*15%*	-
Level 2	*Understand*	*25%*	-	-	*20%*	*25%*	-
Level 3	*Apply*	*20%*	-	-	*25%*	*20%*	-
Level 4	*Analyze*	*20%*	-	-	*25%*	*20%*	-
Level 5	*Evaluate*	*20%*	-	-	*10%*	*20%*	-
Level 6	*Create*	-	-	-	*5%*	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Dr. Durairaj Director & Head - Biotechnology at Orchid Pharma Ltd	*1. Dr. Rajasingh Johnson* *Associate Professor, University of Tennessee, USA*	*1. Dr. R. Satish, SRMIST*
2. Dr. Satheesh K. Sainathan *Study Director, Biomarker and Phenotypic services at Eurofins Discovery at Eurofins Discovery, Chesterfield, Missouri, USA*	*2. Dr. A. Muralidharan* *Assistant Professor, University of Tulane, USA*	*2. Dr. N.S. Raja, SRMIST*

Course Code	21GEE504J	Course Name	PLANT GENETIC ENGINEERING	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Genetic Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the methods of plant tissue culture*
CLR-2:	*mass propagation of plants through tissue culture methods*
CLR-3:	*reproduce the production of transgenic plants through various methods*
CLR-4:	*demonstrate the applications of genetically modified crops in various fields*
CLR-5:	*recall the legal issues concerned with cultivation and commercialization of transgenic plants*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*classify the different plant tissue culture methods*	-	-	-
CO-2:	*recall the strategies and tools used for creating transgenic crops*	3	-	-
CO-3:	*perform site directed genome editing in plants*	3	2	3
CO-4:	*apply different methods for creating genetically modified crops*	3	2	3
CO-5:	*create and commercialize genetically modified crops*	3	2	3

Module -1 - Plant Tissue Culture Methods and Applications	***12 Hours***
History; Tissue culture lab organization; Types of media and preparation; Sterilization methods; Plant hormones; Direct and indirect organogenesis; Micropropagation; Anther culture; Embryo culture; Somatic embryogenesis; Protoplast isolation and fusion; Callus and Suspension cell culture; Somaclonal variation. ***Practice:*** *1. Preparation of tissue culture media* *2. Aseptic germination of seeds* *3. Callus culture and meristem culture*	
Module -2 - Methods of Plant Transformation	***12 Hours***
Biology of Agrobacterium tumefaciens; Binary vectors; Agrobacterium mediated plant transformation; Selection and molecular characterization of transgenic crops; Particle bombardment; Promoters and its types; Selection and screening markers; Marker free transgenics. ***Practice:*** *1. Biolistic gene gun* *2. Transformation of binary vector into Agrobacterium tumefaciens*	
Module -3 - Site Directed Genome Editing in Plants	***12 Hours***
Mechanisms of gene editing -Zinc finger nucleases, TALENS; CRISPR-Cas9; orthologs of Cas9, Vectors of CRISPR construct, Components of SgRNA, Designing and cloning of SgRNA for plant transformation; Protoplast transformation for quick CRISPR confirmation, Confirmation of mutagenesis by Sanger sequencing. ***Practice:*** *1. Screening of recombinant colonies by colony PCR* *2. Agrobacterium mediated plant transformation*	
Module -4-: Transgenic Plants and Gene Edited Plants	***12 Hours***
Transgenic plants- Bt cotton, Round-up ready soybean, Blue rose, Golden rice, Pharmaceutical drugs and vaccines in plants; Gene edited plants- Semi-dwarf (sd1) mutant rice, Zea mays with reduced phytic acid content, Mushroom with reduced oxidation; Gene containment.	

Practice: *1. GUS Assay* *2. sgRNA design for CRISPR-Cas9 mediated gene editing*
Module -5 - Regulation of GM Crops in India ***12 Hours***
Biosafety and Safety assessment of GE plants in India and the world, Competent authorities and committees in India; Quarantine involved in import and export of GE crops, Recombinant DNA safety guidelines, Institutional biosafety committee guidelines ***Practice:*** *1. In-planta transformation (infiltration in tobacco leaves)* *2. Microscopic examination of GUS in transgenic cells*

Learning Resources	*1. Razdan. M.K., "Introduction to plant tissue culture" second edition, Science Publishers, 2003.* *2. Slater. A., Scott. N.W., Fowler. M.R., "Plant biotechnology-the genetic manipulation of plants", Third edition, Oxford University Press, 2008.* *3. Gelvin. S., Agrobacterium-mediated plant transformation: the biology behind the "gene-jockeying" tool. Microbiol. Mol. Biol. Rev., 67, 16–37, 2003.*	*4. Voytas. D.F., Gao. C., Precision genome engineering and Agriculture: opportunities and regulatory challenges. Plos One. 12, e1001877, 2014.* *5. Laboratory Manual*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	-	*5%*	*15%*	-
Level 2	*Understand*	*20%*	-	-	*10%*	*25%*	-
Level 3	*Apply*	*20%*	-	-	*25%*	*30%*	-
Level 4	*Analyze*	*15%*	-	-	*25%*	*30%*	-
Level 5	*Evaluate*	*15%*	-	-	*20%*	-	-
Level 6	*Create*	*15%*	-	-	*15%*	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	*Experts from Higher Technical Institutions*	*Internal Experts*
Dr. P. Sadasivam *Scientist, Du Pont Industrial biosciences, Hyderabad*	*Dr. Sivaprakash Ramalingam* *Scientist, IGIB, New Delhi*	*Dr. B. Usha, SRMIST*
Dr. M. Harikrishnan *Scientist, Pondicherry Biotech Pvt. Ltd, Pondicherry.*	*Prof. Raveendran* *Professor, TNAU, TamilNadu*	*Dr. M. Parani, SRMIST*

Course Code	21GEE505T	Course Name	MOLECULAR PATHOGENESIS OF INFECTIOUS DISEASES	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Genetic Engineering*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand important concepts in molecular pathology*
CLR-2:	*obtain knowledge on host defense mechanisms against pathogens*
CLR-3:	*learn the pathogenesis of infectious diseases*
CLR-4:	*discuss the different methods for disease diagnosis*
CLR-5:	*learn about evasion strategies of pathogens*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*explain the process of establishment of infection*		*2*	*2*
CO-2:	*describe how host responds to infection*	*3*	*3*	*2*
CO-3:	*analyse the expression of virulence factors*	*2*	*3*	*2*
CO-4:	*investigate the mechanisms of virulence gene expression*	*3*	*3*	*2*
CO-5:	*develop tools and techniques for diagnosis of diseases*	*3*	*3*	*2*

Module 1 - Infectious Agents and Disease Development	***9 Hour***
Emerging infectious diseases and outbreaks, categories of infectious agents, Koch postulates and molecular aspects, pathogens and mode of entry, host pathogen interaction and disease development, virulence factors and types, host defense against infection	
Module 2 - Mechanisms of Genetic Modification	***9 Hour***
Virulence factors in pathogens, Virulence gene mutations and types, modes of virulence gene transfer, antigenic and phase variation, pathogenicity islands and properties, genome rearrangements and pathogen evolution	
Module 3 - Virulence Factor Identification	***9 Hour***
Tissue culture models, plaque assay, cell to cell spread assay, Molecular approaches – gene cloning and PCR, measuring virulence using reporter assay, profiling virulence gene expression using transcriptomics and proteomics	
Module 4 - Mechanisms of Virulence Gene Regulation	***9 Hour***
Modes of gene regulation pathogens, Transcriptional activators and repressors, two component regulatory networks, quorum sensing mechanisms in Gram-positive and Gram-negative bacteria, environmental control on virulence gene expression, virulence gene expression for toxin production and biofilm formation	
Module 5 - Molecular Diagnostic Approaches for Infectious Diseases	***9 Hour***
Nucleic acid-based typing, aptamer-based detection, PCR-based diagnostic approaches, biomarker discovery using transcriptomics and proteomics approaches, Point -of-care testing, infectious disease surveillance approaches and biosecurity	

Learning Resources	1. *Brena Wilson, Abigail Syers, Malcom Winkler – Bacterial pathogenesis – a molecular approach, ASM Press, 2019*	2. *Anderson DG, Sarah S, Deborah Allen – Nesters Microbiology – A human Perspective, McGraw Hill, 2022*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*25%*	-	*25%*	-	*25%*	-
Level 2	*Understand*	*25%*	-	*25%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*20%*	-	*30%*	-
Level 4	*Analyze*	*20%*	-	*15%*	-	*20%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	*Experts from Higher Technical Institutions*	*Internal Experts*
1. Dr. B. Winston Umakanth, Director, Quality Control, Inventprise, USA	*1. Dr. Nivedita Gupta, Scientist F & Head, ICMR - NICED, Kolkata*	*1. Dr. K.N.Rajnish, SRMIST*
2. Dr. Sivakumar Selvaraj, Medall Diagnostics, Chennai	*2. Dr. Sibnarayanan Dutta,, Scientist, DRDO, Tezpur, Assam*	*2. Dr. S. Shobana, SRMIST*

Course Code	21GEE506T	Course Name	GENETIC ENGINEERING FOR INDUSTRIAL APPLICATIONS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Genetic Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*know the basic genetic modification tools to improve the productivity*
CLR-2:	*understand the various process used for primary metabolite production*
CLR-3:	*recognize the several methods involved in the formation of secondary metabolites.*
CLR-4:	*explore the application of genetic engineering in bioenergy and bioremediation*
CLR-5:	*develop interest on biopharmaceuticals through genetic engineering*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*identify the fundamental genetic modification techniques for enhancing productivity.*	3	-	-
CO-2:	*describe the diverse procedures employed in primary metabolite synthesis.*	2	2	-
CO-3:	*distinguish the different methodologies utilized in the production of secondary metabolites.*	-	2	3
CO-4:	*investigate the utilization of genetic engineering in bioenergy and bioremediation.*	2	-	2
CO-5:	*design genetic engineering method to produce biopharmaceuticals*	2	2	3

Module -1 Genetic Modification to Enhance the Production	***9 Hour***
Modification of strains: Random and site-directed mutagenesis, Genome shuffling, Gene integration, and gene knockout methods, Transposons mediated mutagenesis, CRISPR technology; Selection of genetically modified organism: Selectable and counter selectable markers, Allelic exchange and counter selection, Marker free selection.	
Module -2 Production of Primary Metabolites	***9 Hour***
Enhancing the primary Metabolites production through GMOs: Volatile fatty acids, organic acids, amino acids, vitamins, biopolymer and enzyme	
Module -3 Production of Secondary Metabolites	***9 Hour***
Production processes for various classes of secondary metabolites: Biopigments, Metabolic engineering of plants for the production of flavonoids, carotenoids; Bioengineering of Microalgae for the production of antibiotics	
Module -4 - Biofuel and Bioremediation	***9 Hour***
Biofuel intermediate-C4 and C6 intermediate for biofuel production, Fourth-generation biofuels: Bioethanol and biobutanol production through GMO; Biohydrogen production; Genetically engineered microorganisms for environmental remediation: Biodegradation of oil spills, xenobiotics degradation	
Module -5 - Biopharmaceutical	***9 Hour***
Heterologous expression of therapeutic protein, Production of therapeutic protein production: Insulin, Monoclonal Antibodies (mAbs), Interferons, Vaccines, Human growth hormones, Challenges in recombinant therapeutic protein production.	

Learning Resources	1. *Stephanopoulos G.N and Aristidou A.A. "Metabolic Engineering – Principles and Methodologies", Jens Nielsen Academic Press, First Edition (1998).* 2. *Dien S.V. "Metabolic Engineering for Bioprocess Commercialization", Springer, First Edition (2016).*	3. *Wim Soetaert and Eric J Vandamme "Industrial Biotechnology" , Wiley-VCH (2010)* 4. *Christoph Wittmann, James C.Liao, Industrial Biotechnology: Products and process, Wiley (2016)*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	10		*15%*	-
Level 2	*Understand*	*25%*	-	10		*25%*	-
Level 3	*Apply*	*30%*	-	30		*30%*	-
Level 4	*Analyze*	*30%*	-	30		*30%*	-
Level 5	*Evaluate*	-	-	20		-	-
Level 6	*Create*	-	-			-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. Shankar. S, Principal Scientist, Adnivirus therapeutics, Ltd*	*1.Dr. Debasish Das, IIT Guwahati*	*1.Dr. P. Rathinasabapathi SRMIST*
2. *Dr.DuraiRaj, Orchid Pharma*	*2. Dr. S. Ramalingam, ,Anna University, hennai rama@bioprocess.edu*	*2 Dr. N Selvarajan, SRMIST,*

Course Code	21GEE507T	Course Name	HUMAN GENETICS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Genetic Engineering*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*obtain knowledge on classical genetics and genotypes.*
CLR-2:	*comprehend the concepts of inheritance and associated complications in human*
CLR-3:	*study the regulation of gene expression in humans*
CLR-4:	*evaluate the human chromosomal abnormalities*
CLR-5:	*identify the human disease gene for screening using different methods*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*understanding classical and modern genetics*	*3*	*-*	*-*
CO-2:	*analyse the organization of the nuclear and mitochondrial genomes*	*-*	*3*	*-*
CO-3:	*define the role of human chromosome aberrations in disease burden*	*-*	*1*	*1*
CO-4:	*demonstrate the association of genomic variation in complex phenotypes*	*-*	*1*	*2*
CO-5:	*plan the genetic diagnosis, and assess the problems and limitations associated with diagnosis*	*3*	*2*	

Module -1 - Classical and Modern Genetics	***9 Hour***
Mendelian monogenic inheritance, Pedigree analysis, Autosomal linked inheritance, Sex-linked inheritance, Non-Mendelian inheritance, incomplete dominance, Co-dominance, Uniparental disomy, Penetrance, non-penetrance, Expressivity, Mitochondrial inheritance, Late-onset diseases, Anticipation, Imprinting, Heterogeneity, Consanguinity, Phenocopy, pleiotropy, Mosaicism, Quantitative traits of polygenic inheritance, Gene and Genotype frequencies	
Module -2 - Genome Organization	***9 Hour***
Human chromosomes - structure and organization; Mitochondrial genome- structure and organization- Limited autonomy; Genes - Protein coding, RNA genes, Micrornas, Overlapping genes; Gene arrangements - Genes-within-genes Non-coding DNA, Satellite DNA, Transposons; control of gene expression - Locus heterogeneity, Clinical heterogeneity Epigenetics	
Module -3 - Chromosomal Abnormalities and Detection Methods	***9 Hour***
Numerical chromosome abnormalities, Autosomal abnormalities, Sex chromosomal abnormalities, Sex chromosomal abnormalities, X-inactivation, Mixoploidy, Mosaicism, Chimerism, Polyploidy, Diandric and Digynic, Human reproductive disorders, Comparative genomic hybridization, Microarray, Karyotyping, FISH technique, Chromosome painting, Introduction to the international system of human cytogenetic nomenclature (ISCN)	
Module -4 - Understanding Genetic Variations	***9 Hour***
Human Genome Project; Human Genome Variation Society (HGVN) - nomenclature of human mutations; Pathogenic variations in the human genome, Functional classification of mutations, Segregation analysis, Linkage analysis, Linkage disequilibrium, Association studies GWAS	
Module - 5 - Genetic Testing and Applications	***9 Hour***
Genomics approaches, Whole genome approaches - Applications and limitations of Whole genome, Whole exome, targeted, clinical exomes, Applications and limitations, Transcriptome strategies, Candidate gene testing, Pre and post-natal Diagnosis, Pharmacogenomics, Personalized medicine, and Genetic counseling	

Learning Resources	1.	*Tom Strachan, Andrew Read " Human Molecular Genetics".5th Edition2019*	3.	*Arsham M.S and Barch M.J. "The AGT Cytogenetics Laboratory Manual" Wiley- Blackwell", New Jersey, USA, Fourth Edition (2017).*
	2.	*Gardner A and Davies T. "Human Genetics" Viva Books, Second Edition (2012).*		

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*25%*	-	*25%*	-	*25%*	-
Level 4	*Analyze*	*25%*	-	*25%*	-	*25%*	-
Level 5	*Evaluate*	*15%*	-	*10%*	-	*15%*	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Dr. Kalpana Gowrishankar, KKCTH, Chennai, gskalpana@yahoo.com	*1. Prof. Solomon F.D. Paul ,SRIHER, paul@sriramachandra.edu.in*	*1. Dr. KN. ArulJothi , SRMIST*
2. Dr. Fiona D'Souza, Anderson Diagnostics Labs, Chennai, fiona@andersondiagnostics.com	*2. Dr. Aravindhan Vivekanandhan, Dr ALM PG IBMS, University of Madras, cvaravindhan@gmail.com*	*2. Dr. B. Usha,SRMIST*

Course Code	21GEE508T	Course Name	FUNCTIONAL GENOMICS IN THE MODERN ERA	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Genetic Engineering*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the various approaches to functional genomic studies*
CLR-2:	*provide knowledge on gene expression tools*
CLR-3:	*summarize the features of NGS platforms*
CLR-4:	*recall the tools to investigate functional proteins*
CLR-5:	*predict co-expression networks and interactomes*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*Illustrate the principles of forward and reverse genetics*	3		
CO-2:	*experiment with the tools of gene expression studies*			3
CO-3:	*apply NGS platforms for high-throughput sequencing*	2		2
CO-4:	*investigate and characterize proteins*			2
CO-5:	*draw co-expression networks and interactomes*	2		

Module -1 - Approaches to Functional Genomics	***9 Hour***
Forward genetics - Methods in Forward genetics - Mutational Breeding - Linkage and Association Mapping - Insertion Mutagenesis, Reverse Genetics - Methods in Reverse genetics – RNAi – Antisense - Over-expression - Site directed mutagenesis – TILLING - Knock-outs - Genetic screens	
Module -2 - Analysis of Gene Expression	***9 Hour***
Differential display PCR, Microarray- analysis of differential gene expression, Serial analysis of gene expression, Northern hybridization, Subtractive hybridization, small non-coding RNA analytical tools, non-coding RNA in gene regulation.	
Module -3 - High-throughput Expression Analysis Platforms	***9 Hour***
Next generation sequencing – Illumina – ion torrent, whole genome sequencing, transcriptome sequencing, exome sequencing, targeted sequencing. small RNA sequencing, Metagenome analysis, Steps in differential expression of genes analysis.	
Module -4 – Proteomics	***6 Hour***
Approaches to proteomics – top-down and bottom-up approach, differential proteomics – gel based – non-gel based - reverse phase protein array, protein-protein interaction – yeast two hybrid system	
Module -5 - Co-expression Networks	***9 Hour***
Methods of constructing co-expression networks, network analysis. Protein interactomes, approaches to map individual protein interactions, large scale mapping interactomes – Machine learning based approaches for gene regulatory networks and protein interactomes	

Learning Resources	*1. Pevsner. J., "Bioinformatics and Functional Genomics", 3rd edition, Wiley-Blackwell. 2015.* *2. Mount. D, "Bioinformatics: Sequence and Genome Analysis", 2nd Edition, Cold Spring Harbor Laboratory Press, New York. 2004.*	*3. Primrose. S.B., Twayman. R.M., "Principles of Gene Manipulation and Genomics" 7th edition, Blackwell publishing. 2006.*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Dr. Florida Tilton, Managing Director, Biozone Research Technologies	*1. Dr. Subramanian Sankaranarayanan, Associate Professor, IIT Gandhinagar*	*1. Dr. D. Rex Arunraj, SRMIST*
Dr. Aneesh nair, Head-Centre for Genomic Medicine, NIMS Hospital, Trivandrum	*2. Prof. Gopalakrishnan Professor, IARI, New Delhi*	*2. Dr. Sathish R, SRMIST*

Course Code	21GEE601T	Course Name	MODERN BIOTECHNOLOGY OF CROP IMPROVEMENT	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Genetic Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the genetic approaches for crop improvement*
CLR-2:	*utilise genomics for crop improvement*
CLR-3:	*deduce the gene editing approach for crop improvement*
CLR-4:	*understand the approaches for biotic and abiotic tolerance*
CLR-5:	*focus on the modern approaches for crop yield and biofortification*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*understand the modern genetic approaches for crop improvement*	-	2	-
CO-2:	*correlate the genomics assisted biotechnology tools for crop improvement*	3	2	3
CO-3:	*perform gene editing in plants for crop improvement*	3	2	3
CO-4:	*reproduce different methods for developing biotic and abiotic tolerance crops*	3	2	3
CO-5:	*prioritize modern biotechnological approaches for crop yield and biofortification*	3	2	3

Module -1 - Modern Genetic Approaches for Crop Improvement	***9 Hour***
Classical breeding; Modern crop breeding- Marker assisted breeding -Marker assisted selection by QTL Mapping, GWAS and genomic selection; Reverse genetics approach; Forward genetics approach; Mutational Breeding	
Module -2 - Genomics Assisted Biotechnology for Crop Improvement	***9 Hour***
Genomics: Genomics assisted backcrossing; Gene expression analysis approaches-Transcriptomics-Methods and applications, RNA-Seq; Phenomics-Plant Phenotyping for crop improvement -High throughput plant phenotyping (HTPP)-HTPP types	
Module -3 - Gene Editing for Crop Improvement	***9 Hour***
Transgenesis and genome editing by CRISPR/Cas9 system; DNA-free editing and nanotechnology; CRISPR/Cas9 mediated gene editing for crop improvement-increasing crop yield, crop quality improvement focused on the physical appearance, edible quality, fruit texture and nutritional value	
Module -4 - Modern Approaches for Abiotic and Biotic Tolerance	***9 Hour***
Abiotic tolerance- climate resilient crops; drought tolerance, heat tolerance; Biotic tolerance-herbicide, bacterial, fungal and viral tolerance-Methods and approaches.	
Module -5 - Modern Approaches for Crop Yield and Biofortification	***9 Hour***
Nitrogen use efficiency; Water use efficiency; Biofortification in cereal and pulse crops-approaches and challenges; Low phytate crops	

Learning Resources	1. *Hakeem. K.R., Ahmad. P., Ozturk. M., "Crop Improvement New Approaches and Modern Techniques", Springer, Boston, 2013.* 2. *Kumar. P., Thakur. A. K., "Crop Improvement: Biotechnological approaches", First edition, CRC Press, Boca Raton, 2021.* 3. *Slater. A., Scott. N.W., Fowler. M.R., "Plant biotechnology-the genetic manipulation of plants", Third edition, Oxford University Press, 2008.*	4. *Wang. J.Y., Doudna. J.A., CRISPR technology: A decade of genome editing is only the beginning. Science., 379 (6629), 2023.* 5. *Benavente, E.; Giménez, E. Modern Approaches for the Genetic Improvement of Rice, Wheat and Maize for Abiotic Constraints-Related Traits: A Comparative Overview. Agronomy., 11, 376, 2021.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Dr. P. Sadasivam *Scientist, Du Pont Industrial biosciences, Hyderabad*	*1. Dr. Sivaprakash Ramalingam* *Scientist, IGIB, NewDelhi*	*1. Dr. Rex Arunraj, SRMIST*
2. Dr. Florida Tilton *MD, Biozone research technologies Pvt ltd, Chennai.*	*2. Prof. Raveendran* *Professor, TNAU, TamilNadu*	*2. Dr. A.Swapna Geetanjali, SRMIST*

Course Code	21GEE602T	Course Name	NEUROGENETICS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Genetic Engineering*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*describe the biology of nervous system*
CLR-2:	*explain the process of neurulation and brain development*
CLR-3:	*list neurotransmitter types and synaptic transmission processes*
CLR-4:	*discuss the biology of sensory systems*
CLR-5:	*summarize the genetics of neurodegenerative disorders*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*visualize the biology of neurons and glia*	-	2	-
CO-2:	*appraise neurulation and brain formation mechanisms*	-	2	-
CO-3:	*analyse the biology of neurotransmission*	3	-	-
CO-4:	*compare the molecular mechanisms behind sensory systems*	3	2	2
CO-5:	*integrate the genetic basis of various neuronal disorders*	3	2	2

Module -1 - Biology of Nervous System	***9 Hour***
Anatomy of nervous system; Functions of nervous system; CNS; Brain and behaviour; PNS; Spinal cord; Neuron; Soma, neuronal membrane, axon and dendrites; Glial cells; Neural circuitry; Electrical properties of neuron; Action potential	
Module -2:- Neurulation and Brain Formation	***9 Hour***
Neural plate; Neurulation; Role of Shh and BMP signaling in neural tube patterning; Forebrain regionalisation; Functions of midbrain and hindbrain; Cerebral cortex, Cortical neurons; Hippocampus, Amygdala; Limbic lobe; Emotion and memory	
Module -3 - Biology of Neurotransmission	***9 Hour***
Synaptic transmission; Electrical synapses; Chemical synapses; Role of neurotransmitters; Postsynaptic receptors; Role of ion channels; Excitatory synaptic transmission; Inhibitory synaptic transmission; Motor neurons; Acetylcholine receptor channels; Key criteria for neurotransmitters; Types of neurotransmitters	
Module -4 - Sensory Systems	***9 Hour***
Somatosensory system; Dorsal root ganglia; Primary sensory neurons; Mechanoreceptors; Touch response; Proprioceptors; Nociceptors; Thermal receptors; Olfactory receptors; Visual perception; Visual cortex; Addictive drugs; Short-term and long-term memory	
Module -5 - Biology of Neurodegenerative Diseases	***9 Hour***
Cognitive abnormalities in autism; Fragile X syndrome; Alzheimer's disease; Down syndrome; Epilepsy; Genetic basis of Huntington's disease; Genetic basis of Parkinson's disease; Unipolar depression; bipolar disorder; Anxiety; Working memory; Ageing brain and cognitive decline	

Learning Resources	*1. Principles of Neural Science (2012): Kandel, E.R. et al. (Eds.), Fifth Edition, McGraw Hill Education, 1760pp.*	*2. Neuroscience: Exploring the brain (2015): Bear, M.F., Connors, B. and M. Paradiso, Fourth Edition, Lippincott Williams and Wilkins Inc., 1008 pp.*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Dr. C. N. Ramchand, Ph.D., Saksin Life sciences Pvt Ltd, Chennai	*1. Dr. K. Subramaniam, Ph.D., Professor, IIT Madras, Chennai*	*1. Dr. S. Kirankumar, SRMIST*
2. Dr. Karthik Periyasamy, Ph.D., Aurobindo Pharma Limited, Hyderabad	*2. Dr. R. Venkatesh, M.B.B.S., M.S., M.Ch., Professor, Coimbatore Medical College, Coimbatore*	*2. Dr. Devi A, SRMIST*

Course Code	21GEE603T	Course Name	STEM CELL BIOLOGY	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Genetic Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*generate knowledge about stem cells and their characteristics*
CLR-2:	*provide knowledge on embryonic stem cells and stem cell niche*
CLR-3:	*create an interest about adult stem cells and their properties*
CLR-4:	*initiate interest on the role of signaling pathways and epigenetics in stem cell fate*
CLR-5:	*understand the applications of stem cells in tissue engineering and treatment of human diseases*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*recall knowledge about stem cells and their characteristics*	-	2	-
CO-2:	*discuss concepts in embryonic stem cells and stem cell niche*	2	2	-
CO-3:	*understand about adult stem cells and their properties*	2	2	-
CO-4:	*analyze the role of signaling pathways and epigenetics in stem cell fate*	2	-	2
CO-5:	*apply knowledge on stem cells in tissue engineering and treatment of human diseases*	2	2	3

Module -1 - Basics of Stem Cells	***9 Hour***
Origin of Stem Cells; Early development and embryogenesis; Stem Cell Properties; Symmetric and Asymmetric division; Classification of Stem Cells – Totipotent, pluripotent, multipotent; Types of Stem Cells - Embryonic Stem Cells, Adult Stem Cells, iPSCs, Cancer Stem Cells; Similarities and differences between embryonic and adult stem cells; Stem Cells and Regeneration	
Module -2 - Embryonic Stem Cells	***9 Hour***
Ethical issues involved in hESCs; Mouse embryo derived cells (mESCs) - Embryonic Carcinoma Cells, Embryonic Stem Cells, Embryonic Germ Cells, Trophoblast Stem Cells, Nuclear transfer embryonic stem cells; Comparison of various mESCs; Primate ESCs - Similarities and differences between primate and mouse ESCs; Naïve ESCs, Primed ESCs; Lab tests for identification of ESCs; Isolation techniques for human ESCs; Stem Cell Niches - Drosophila testis and ovary, Human intestinal epithelium, Hematopoietic cells	
Module -3 - Adult Stem Cells	***9 Hour***
Properties of adult stem cells (ASCs); Sources of ASCs; Lab tests for ASCs; Mesenchymal stem cells, hematopoietic stem cells, neural stem cells, germinal stem cells -Steven's experiment; Fusion and Trans differentiation; Cancer Stem Cells; Reprogramming of iPSCs-methods of producing of iPSCs; Somatic cell nuclear transfer; Molecular mechanisms in cloning; Stem cells and aging	
Module -4 - Stem Cell Signaling and Regulation	***9 Hour***
ESCs pluripotency and signaling - JAK-STAT pathway; Hematopoietic signaling pathways – Positive and Negative Regulators; Epigenetic control in pluripotent stem cells, Epigenetic regulation in progenitor and adult stem cells	
Module -5 - Applications of Stem Cells	***9 Hour***
Tissue Engineering and Biomaterial Scaffolds for Stem Cells; Stem Cell Therapies - Parkinson's disease, Burns, Spinal cord injury, Heart diseases, Diabetes, Auto Immune Diseases; Stem Cells in Cancer Therapy; Recent developments in stem cell research	

Learning Resources	1. *Sell S. "Stem Cells Handbook", Humana Press, Second Edition (2004).* 2. *Stem Cell Information, "National Institutes of Health", Stem Cell Primer (2009).* 3. *Lanza R and Atala A. "Essentials of Stem Cell Biology", Academic Press, Third Edition (2014).* 4. *https://www.stembook.org/chapters.* 5. *Bendall S.C, Stewart M.H and Bhatia M (2008) Human Embryonic Stem Cells: Lessons from Stem Cell Niches in Vivo, Regenerative Medicine, 3: 365-376.* 6. *Jopling C, Boue S, Carlos J and Belmonte I (2011) Dedifferentiation, Transdifferentiation and Reprogramming: Three Routes to Regeneration, Nature Reviews. Molecular Cell Biology, 12: 79-89.* 7. *Zech N (2005) Plasticity of Stem Cells: Cell-Fusion versus Trans Differentiation, Journal of Reproduktionsmed Endokrinol, 2: 239-245.*	8. *Ma D.K, Bonaguidi M.A and Ming G.L (2009) So. Adult Neural Stem Cells in the Mammalian Central Nervous System, Cell Research, 19: 672-682.* 9. *Takahashi K and Yamanaka S (2006) Induction of Pluripotent Stem Cells From Mouse Embryonic and Adult Fibroblast Cultures by Defined Factors, Cell, 126: 663-76.* 10. *Huang G, Ye S, Zhou X, Liu D and Ying Q.L (2015) Molecular Basis of Embryonic Stem Cell Self-Renewal: From Signaling Pathways to Pluripotency.* 11. *Zhang CL, Huang T, Wu BL, He WX, Liu D. Stem cells in cancer therapy: Opportunities and challenges. Oncotarget. 2017;8(43):75756-75766. doi:10.18632/oncotarget.20798* 12. *Ahmed ASI, Sheng MH, Wasnik S, Baylink DJ, Lau K-HW. Effect of aging on stem cells. World J Exp Med. 2017;7(1):1. doi:10.5493/wjem.v7.i1.1*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*20%*	-	*20%*	-	*20%*	-
Level 4	*Analyze*	*25%*	-	*20%*	-	*25%*	-
Level 5	*Evaluate*	*20%*	-	*20%*	-	*20%*	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	*Experts from Higher Technical Institutions*	*Internal Experts*
Dr. Indumathi Mariappan *Research Scientist, Center for Ocular Regeneration (CORE)* *Prof. Brien Holden Eye Research Center (BHERC), L.V. Prasad Eye Institute* *indumathi@lvpei.org*	*Dr Halagowdar Devaraj, Univ of Madras, hdrajum@yahoo.com*	*Dr. Devi A, SRMIST*
Dr. Bhavana Muralidharan *Principal Investigator, Institute for Stem Cell Biology and Regenerative Medicine (InStem), Bengaluru* *bhavanam@instem.res.in*	*Dr Sudha Warrier, Principal, SRIHER, Chennai* *sudha.warrier@gmail.com*	*Dr. Satish. R, SRMIST*

Course Code	21GEE604T	Course Name	GENETICS OF DISEASES AND DISORDERS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Genetic Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand about genetic factors behind diseases*
CLR-2:	*gain knowledge on autosomal and allosomal disorders*
CLR-3:	*summarize about chromosomal and multifactorial disorders*
CLR-4:	*explain about mitochondrial and metabolic disorders*
CLR-5:	*understand about congenital and connective tissue disorders*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*describe about the genetic factors responsible for different type of heritable diseases*	-	2	-
CO-2:	*recall about the genetics and treatment options of diseases related to autosomal and allosomal disorders*	3	2	-
CO-3:	*explain about the genetics and treatment options for chromosomal and multifactorial disorders.*	-	-	3
CO-4:	*discuss about the genetics and treatment options for mitochondrial and metabolic disorders*	2	-	2
CO-5:	*assess about the genetics and treatment options for congenital and connective tissue disorders*	2	2	3

Module -1 - Introduction to Genetic Disorders	***9 Hour***
Introduction to genetic versus non-genetic diseases; Importance of the genetics of heritable diseases; Dominance, recessive and co-dominance; Autosomal and sex-linked, multifactorial and polygenic (complex) disorders	
Module -2 - Autosomal and Allosomal Genetic Disorders	***9 Hour***
Autosomal Dominant Disorders-Huntington's disease and Marfan Syndrome; Autosomal Recessive Disorders – Cystic Fibrosis and Sickle Cell Anemia; X-Linked Disorders- Duchenne Muscular Dystrophy, Rett Syndrome, Hemophilia; Y-linked Disorders- Infertility	
Module -3 - Chromosomal and Multifactorial Disorders	***9 Hour***
Turner's syndrome, Down syndrome, Klinefelter's syndrome, Prader-Willi syndrome, Angelman syndrome, Williams syndrome, Edward's syndrome, Patau syndrome, Cri-du-chat syndrome. XYY Syndrome, X-Trisomy; Multifactorial Disorders- Type 2 diabetes, Heart disease, Cancer, and Psychiatric disorders like schizophrenia and bipolar disorder	
Module -4 - Mitochondrial and Metabolic Disorders	***9 Hour***
Mitochondrial diseases - Leber's hereditary optic neuropathy, mitochondrial myopathy, and mitochondrial encephalopathy, lactic acidosis, and stroke-like episodes (MELAS syndrome); Metabolic Disorders - Phenylketonuria (PKU), maple syrup urine disease (MSUD), Gaucher disease, and lysosomal storage disorders	
Module -5 - Congenital Anomalies and Connective Tissue Disorders	***9 Hour***
Structural Congenital Anomalies - Cleft lip and Palate, neural tube defects (e.g., spina bifida);, Functional Congenital Anomalies - Adrenal Hyperplasia, Congenital hearing loss; Environmental Teratogens-Fetal hydantoin syndrome ; Connective Tissue Disorders - Ehlers-Danlos syndrome, Osteogenesis Imperfecta, and Cutis laxa	

Learning Resources	1. *Genes and Diseases, NCBI Bookselfhttp://www.ncbi.nlm.nih.gov/books/bookres.fcgi/gnd/tocstatic.html* 2. *Tom S., and Andrew P. R., "Human Molecular Genetics", 2nd Edition NewYork ; Willy: Liss, 1999*	3. *Pagon R.A. et al.,"GeneReviews™ [Internet]".Seattle (WA): University of Washington, Seattle; 1993- 2016. Available from:http://www.ncbi.nlm.nih.gov/books/NBK1116/* 4. *Puiu, M. (Ed.). (2013). Genetic Disorders. InTech. doi: 10.5772/46039*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*10%*	-	*10%*	-	*10%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*25%*	-	*20%*	-	*25%*	-
Level 4	*Analyze*	*25%*	-	*25%*	-	*25%*	-
Level 5	*Evaluate*	*15%*	-	*20%*	-	*15%*	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Dr. S. Ezhilarasi,Paediatric Haematoncologist Metha Multispeciality Hospital, Chennai	*1. Dr. B. Anandan, University of Madras, anandan@unom.ac.in*	*1. Dr. Devi A, SRMIST*
2. Dr. Shruti Bajaj , MD Pediatrics, Fellowship in Clinical Genetics (MUHS, KEMHospital , Mumbai	*2. Dr K Thangaraj, CCMB, Hyderabad thangs@ccmb.res.in*	*2. Dr. Kirankumar S, SRMIST*

Course Code	21GEE605J	Course Name	DEVELOPMENTAL GENETICS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Genetic Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*describe the animal embryogenesis concepts*
CLR-2:	*summarize the importance of cell specification and cell-cell interactions*
CLR-3:	*explain the fruit fly and zebrafish development processes*
CLR-4:	*discuss the processes in neurulation, somitogenesis, kidney development and gut formation*
CLR-5:	*list the mechanisms in animal tissue regeneration*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	**2**	**3**
CO-1:	*differentiate between various cell signaling mechanisms*	-	2	-
CO-2:	*classify the key processes in fruit fly and zebrafish embryogenesis*	3	-	-
CO-3:	*analyse the molecular basis of neurulation and somitogenesis*	3	2	3
CO-4:	*compare the genetic basis of kidney and digestive tract development*	3	3	3
CO-5:	*integrate the different types of regeneration*	3	3	3

Module -1 - Basic Concepts in Animal Development	***12 Hour***
History; Epigenesis; Karl von Baer's principles; Embryonic homologies; Cell specification and types; Cell determination; Cell-Cell interaction; Cadherins and cell adhesion; Induction and Competence; Germ layers; Paracrine factors; Notch signaling and cell fate identity; Role of FGF signaling in Drosophila trachea formation; insect metamorphosis ***Practice:*** *1. Drosophila culturing techniques* *2. Stages of Drosophila larval development* *3. Observation and analysis of Drosophila white eye mutant*	
Module -2 - Drosophila Development	***12 Hour***
Morphogen gradients; Drosophila – life cycle; fertilisation, cleavage and gastrulation; Role of maternal factors; Anterior-posterior axis formation in Drosophila; Dorso-ventral axis specification; Segmentation genes: Gap genes, Pair-rule genes, Segment polarity genes; Homeotic genes ***Practice:*** *1. Observation and analysis of Drosophila vestigial wings mutant* *2. Observation and analysis of Drosophila Bar eye mutant* *3. Observation and analysis of Drosophila ebony body mutant*	
Module -3 - Zebrafish Development and Formation of Ectodermal Structures	***12 Hour***
Zebrafish – fertilization, cleavage & gastrulation; Body axes specification; Vertebrate neurulation; Formation of neural tube; Patterning in the neural tube; Tissues and cells of the CNS; Neurogenesis; Development of epidermis ***Practice:*** *1. Dissection of brain from Drosophila larvae* *2. Culture, maintenance and breeding methods for zebrafish*	
Module -4 : Specification and Development of Mesodermal Structures	***12 Hour***

Paraxial mesoderm specification; Somitogenesis; The clock and wavefront model; Role of Hox genes in axial identity; Intermediate mesoderm specification; Kidney tissue development; Formation of kidney; Lateral plate mesoderm; Specification of heart tissue; Development of heart ***Practice:*** *1. Anaesthetizing protocol for larval and adult zebrafish* *2. Stages of zebrafish embryonic and larval stages*
Module -5: Overview on endodermal organ Development and Tissue Regeneration ***12 Hour***
Specification of gut tissue; Development of liver, pancreas and gall bladder; Origin of respiratory tube; Development of respiratory tube; Epimorphic regeneration in Salamander; Morphallactic regeneration in hydra; Regeneration in mammalian liver ***Practice:*** *1. Staining of bone and cartilage tissue in zebrafish* *2.Measurement of heartbeat in zebrafish larvae*

Learning Resources	1. *Developmental Biology (2016): Scott F. Gilbert and Michael J.F. Barresi, Eleventh Edition, Oxford University Press, Inc.* 2. *Essential Developmental Biology (2012): J.M.W. Slack, Third Edition, Wiley-Blackwell Publishers* 3. *Principles of Development (2015): Lewis Wolpert, Cheryll Tickle and Alfonso Arias, Fifth Edition, Oxford Publishers, Inc.*	4. *The zebrafish book: A guide for the laboratory use of zebrafish (2007): Westerfiled, M., Fifth Edition, University of Oregon Press.* 5. *Drosophila: A laboratory handbook (1989): Ashburner, M., First Edition, Cold Spring Harbor Laboratory Press.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	-	*15%*	*15%*	-
Level 2	*Understand*	*25%*	-	-	*20%*	*25%*	-
Level 3	*Apply*	*30%*	-	-	*25%*	*30%*	-
Level 4	*Analyze*	15%	-	-	*25%*	10%	-
Level 5	*Evaluate*	15%	-	-	*10%*	10%	-
Level 6	*Create*	-	-	-	*5%*	10%	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	*Experts from Higher Technical Institutions*	*Internal Experts*
1. Dr. Krutika Rajkumar, Ph.D., Life Cell International, Chennai	*1. Dr. K. Subramaniam, Ph.D., Professor, IIT Madras, Chennai*	*1. Dr. S. Kirankumar, SRMIST*
2. Dr. James Bhaskar, Ph.D., ITC, Bengaluru	*2. Dr. Richa Arya, Ph.D., Assistant Professor, BHU, Varanasi*	*2. Dr. Devi A, SRMIST*

Course Code	21GEE606T	Course Name	GENETIC COUNSELLING	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Genetic Engineering*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*define the principles of genetic counselling*
CLR-2:	*assess psychological aspects of patients in genetic counselling*
CLR-3:	*explain about strategies involved in genetic counselling*
CLR-4:	*demonstrate the genetic counselling process using case studies*
CLR-5:	*understand the ethical and legal implications of genetic counselling*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*recall knowledge about human genetics and inheritance*	3	-	2
CO-2:	*integrate knowledge of psychological aspects of patients and genetic counsellors*	-	-	2
CO-3:	*discover the strategies involved in genetic counselling*	2	-	-
CO-4:	*evaluate various cases of genetic diseases*	2	-	3
CO-5:	*create knowledge on ethical legal implications surrounding genetic counselling*	-	2	2

Unit-1 - introduction and Essential Components of Genetic Counselling	***9 Hour***
Historical overview, definition, models of genetic counselling, components of genetic counselling interaction, providers of genetic counselling, professional and educational landmarks in Genetic counselling, Interpretation of genetic case - pedigree analysis, consent form, family history, risk assessment, verbal and non-verbal communication, psychological aspects of patient- case documentation	
Unit-2 - Psychological aspects of Genetic Counselling	***9 Hour***
The psychological processes underlying genetic counseling - understanding the individual difference in genetic counseling using attachment theory; The role and skills of the counselor and ideas from psychotherapy; the nature of the disorder influencing the consultation; psychological effects on the counselor, the interview and non-directiveness in genetic counseling	
Unit-3 - Strategies of Genetic Counseling	***9 Hour***
Strategies for genetic counselling- characteristics and systems of family, comparison of family therapy – medical therapy, structuring the genetic counseling session, Patient Factors: Resistance, Coping, Affect, and Styles	
Unit-4 - Case studies in Genetic Counseling	***9 Hour***
Genetic counseling for specific diseases- Case study for genetic counseling: Huntington's disease; Beta Thalassemia, Cystic fibrosis, Fragile X syndrome, Duchenne muscular dystrophy, Down syndrome, Leukemia, Breast cancer, male and female infertility, Autism	
Unit-5 - Genetic testing and Ethical and Legal Implications in Genetic Counseling	***9 Hour***
Criteria for Genetic testing; Tests for genetic disorders - physical, chemical and genetic tests; risks and limitations of genetic testing; Regulatory affairs of genetic testing; Ethics and legal issues of genetic testing - Genetics and Patent Law	

Learning Resources	*1. Wendy R. Uhlmann, Jane L. Schuette, Beverly Yashar, "A Guide to Genetic Counselling", 2nd Edition, Wiley-Blackwell, 2009.* *2. Bonnie S. LeRoy, Patricia M. Veach, Dianne M. Bartels "Genetic Counselling Practice: Advanced Concepts and Skills". Wiley-Blackwell, 2010* *3. Christine Evans and Barbara Bowles Biesecker, "Genetic Counselling A Psychological Conversation", Cambridge University press, 2006*	*4. Patricia McCarthy Veach, Bonnie S. LeRoy, Dianne M. Bartels "Facilitating the Genetic Counselling Process: A Practice Manual", Springer, 2003* *5. Peter S. Harper "Practical Genetic Counselling" 7th Edition. Taylor & Francis group, 2011* *6. Janice I. Berliner, Ethical Dilemmas in Genetics and Genetic Counselling, Oxford press, 2015*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	*-*	*15%*	*-*	*15%*	*-*
Level 2	*Understand*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 3	*Apply*	*25%*	*-*	*25%*	*-*	*25%*	*-*
Level 4	*Analyze*	*25%*	*-*	*25%*	*-*	*25%*	*-*
Level 5	*Evaluate*	*15%*	*-*	*10%*	*-*	*15%*	*-*
Level 6	*Create*	*-*	*-*	*5%*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	*Experts from Higher Technical Institutions*	*Internal Experts*
1. Dr. Janani Dakshina Moorthy, GeneAura Pvt Ltd, Chennai, janani@geneaura.com	*1. Dr. Madhavilatha, Scientis, Medgenome labs, Bangalore, madhavi@medgenome.com*	*1. Dr. N. Aruljothi SRMIST*
2. Dr. Finoa D'souza, Anderson Diagnostics, Chennai, fiano@andersondiagnostics.com	*2. Dr. Uma Maheswari MBBS. DGO, Tagore Medical College, Chennai Leeuma6@gmail.com*	*2. Dr. R. Satish, SRMIST*

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(Deemed to be University u/s 3 of UGC Act, 1956)

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