ACADEMIC CURRICULA

UNDERGRADUATE/ INTEGRATED POST GRADUATE DEGREE PROGRAMMES

(With exit option of Diploma)

(Choice Based Flexible Credit System)

Regulations 2021

Volume – 9
(Syllabi for Biomedical Engineering Programme 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

ACADEMIC CURRICULA

Engineering Science Course

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	21PYS202T	Course Name	MEDICAL PHYSICS	Course Category	S	ENGINEERING SCIENCE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*gain knowledge on the basics of radiation physics*
CLR-2:	*understand the working principle of particle accelerators*
CLR-3:	*gain knowledge on the interaction of radiation at cellular and tissue level*
CLR-4:	*understand photo biological effect and its applications*
CLR-5:	*gain knowledge on working principle of imaging systems*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*understand the interaction of radiation with matter with emphasis on energy transfer and dose deposition*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*understand the construction and working of tele cobalt unit, Linear accelerator etc*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*decide the type of radiation, dose, fractionation*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-4:	*analyze the uses of different lasers for various diagnostic and therapeutic applications*	*3*	-	*3*	-	-	-	-	-	-	-	-	-	-	-	-
CO-5:	*identify the major medical imaging methods for clinical and biomedical research*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-	-	-

Unit-1 – Interaction of Radiation with Matter and Dosimetry ***9 Hour***

Structure of matter - atom - nucleus -atomic mass and energy units- Distribution of orbital electrons - atomic energy levels -nuclear forces- Nuclear energy levels- particle radiation -Electromagnetic radiation- Binding energy - General properties of alpha, beta and gamma rays- Laws of equilibrium – modes of radioactive decay – nuclear isomerism- Nuclear reactions - natural and artificial radioactivity- Interaction of electromagnetic radiation with matter-Thomson scattering- Rayleigh scattering, Compton scattering (Klein-Nishina differential cross section)- Photoelectric absorption-Pair production – Interaction of light (electrons and positrons) and heavy charged particles with matter- Mass-energy attenuation and absorption coefficient- mass-collision – Bragg peak- Introduction -exposure-Roentgen - photon fluence and energy fluence- KERMA-Kerma and absorbed dose- CEMA -Absorbed dose -stopping power - relationship between the dosimetric quantities- Principles of Radiation detection – properties of dosimeters- Theory of gas filled detectors – Ion chamber dosimetry systems- Free air ion chamber – parallel plate chamber- GM counter – condenser type chambers and thimble chambers working and different applications- Film dosimetery- Luminescence dosimetry – semiconductor dosimetry- Gel dosimetry – radiographic and radio chromic films – scintillation detections.

Unit-2 – Particle and Linear Accelerators ***9 Hour***

Particle accelerators for medical applications- Resonant transformer- Cascade generator- Van De Graff Generator- Pelletron- Cyclotron- Betatron- Synchrocyclotron- Electron synchrotron- Protron synchrotron Components of modern linear accelerator- Standing and travelling wave guides- Magnetrons and Klystrons- Bending Magnet- Target-Flattening filter- Collimators Need for high quality portal imaging- Fluoroscopic, diode, crystal- Diagnostic imaging on a linear accelerator - portal dose images- Portal Dosimetry- Telecobalt Vs Linacs

Unit-3 – Genetic Effects of Radiation ***9 Hour***

Target theory-Single hit and multi hit target theory- Other theories of cell inactivation- Concepts of micro dosimetry- Direct and indirect action- Radicals and molecular products- Cellular effects of radiations- in activations- Division delay- DNA damage- Depression of macromolecular synthesis- Giant cells- Chromosomal damage- Point mutations- Threshold and linear dose- Effect relationship- Factors affecting frequency of radiation induced mutations recessive and dominant mutations- Gene controlled hereditary diseases- Human data on animals and lower species- Doubling dose and its influence of genetic equilibrium

Unit-4 – Lasers and Imaging Systems	***9 Hour***
*Laser tissue interaction- Photophysical process- Photobiological process- Absorption by biological systems- Different types of interactions - thermal - photochemical (one photon and multiphoton) - electro mechanical photo ablative process- Optical properties of tissues (normal and tumor)- Experimental methods to determine the reflectance, transmittance, absorption and emission properties of tissues- Laser systems in medicine and biology - Nd-YAG, Ar ion, CO2- Excimer - Gold vapour laser - beam delivery system and control- Evaporation and excitation techniques - sterilization - hemostasis - laryngeal surgery - cancer surgery- Cardiac surgery- lasers in Opthalmology – Dermatology and Dentistry – cosmetic surgery-Bremsstralung-characteristic line spectrum- factors affecting the x-ray spectrum- Attenuation of heterogeneous and homogenous x-rays- Attenuation coefficients- Attenuation mechanisms- Radiographic image quality-factors affecting image quality- Focal spot-Heel Effect –Filters –Grids -Intensifying Screens- X-ray film- Diagnostic applications of X-rays-Skeletal system-soft tissues-the Chest — mobile and dental X-ray machine-mammography- CT**:** Basic principle, – Generation of CT – Helical CT – Single slice and Multi slice CT scan System– Image reconstruction – CT artifacts- Magnetic Resonance Imaging**-**Basic principles- T1, T2 proton density weighted image- Pulse sequences - Basic and advance, Pulse sequences- MR instrumentation — Image formation– Localisation of the signal - Factors influencing signal intensity- contrast and resolution - Types of magnets –super conductors- RF Transmitters – RF receivers – Gradiant coils – RF shielding –safety aspects in MRI-Ultrasonic waves - Beam characteristics –- attenuation of ultrasound – Specific acoustic impedance - reflection at body interfaces-Coupling medium- Interaction ultrasound with tissues -A scan B scan and M mode-real time scanners Image clarity - Resolution –axial and lateral resolution*	
Unit-5 – Radiation Hazards Evaluation	***9 Hour***
Radiation dose to individuals from natural radioactivity in the environment and man-made sources- Basic concepts of radiation protection standards- Historical background _ ICRP and its recommendations- The system of radiological protection – Justification of practices- Optimization of protection and individual dose limits- Radiation and tissue weighting factors, equivalent dose, effective dose- Committed equivalent dose, committed effective dose – concepts of collective dose- Potential exposures, dose and dose constrains- System of protection for intervention – categories of exposures- Occupational, public and medical exposures- Permissible levels for neutron flux- Factors governing internal exposure- Radionuclide concentrations in air and water – ALI, DAC and contamination levels- Effects of time, distance, shielding - shielding materials- shielding calculations- Different barrier thickness calculations- Definition of working conditions - personnel and area monitoring rules and instruments- Radio toxicity of different radionuclides and classifications of laboratories- Control of contamination- Bioassay and air monitoring- Chemical protection- Radiation accidents- Disaster monitoring	

Learning Resources		
	1. *Radiation oncology physics: A Handbook for teachers and students. IAEA publications 2005.* 2. *F.M.Khan, The Physics of Radiation Therapy, Third Edition, Lippincott Williams and Wilkins,U.S.A.,2003* 3. *S. S. Martellucci and A. N. Chester, Laser Photobiology and Photomedicine, Plenum Press, New York, 1985.*	4. *E. J. Hall, Radiobiology for Radiologists, J. B. Lippincott Co., Philadelphia, 2000.* 5. *Christensen',s Physics of Diagnostic Radiology by Thomas S Curry, IV Edition, Lippincott Williams & Wilkins, 1990.* 6. *Medical Physics: Imaging, Jean A. Pope, Heinemann Publishers, 2012* 7. *R. F. Mold, Radiation Protection in Hospitals, Adam Hilger Ltd., Bristol, 1985.*

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. *Dr. M Krishna Surendra, Saint Gobain Research, krishana.muvvala@saint-gobain.com*	1. *Prof. V Subramanian, IIT Madras, manianvs@iitm.ac.in*	1. *Dr. A. Naga Rajesh, SRMIST*
2. *Dr. M Satish, CSIR-CECRI, msathish@cecri.re.in*	2. *Prof. C. Venkateswaran, University of Madras, cvenkateswaran.unom.ac.in*	2. *Dr.Devanand, SRMIST*

ACADEMIC CURRICULA

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	21BMC202T	Course Name	BIOMEDICAL SIGNALS AND SYSTEMS	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:	*classify the continuous time signals and systems and discrete-time signals and systems*
CLR-2:	*illustrate the concepts of Continuous Time Signals and System*
CLR-3:	*compute the Convolution and Correlation in bio signals*
CLR-4:	*execute z-transform and discrete Fourier transform*
CLR-5:	*analyze the discrete time IIR and FIR systems by using suitable structures and apply in biomedical applications*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*sketch the Discrete time and continuous time signals and systems*	*2*	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-2:	*evaluate the Continuous Time Signals and System*	*2*	*2*	-	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-3:	*illustrate the concepts of convolution and correlation in bio signals*	*2*	*1*	-	-	-	-	-	-	-	-	-	-	-	-	*2*
CO-4:	*analyze the transforms of Discrete Time Signals and Systems*	-	-	*2*	*1*	-	-	-	-	-	-	-	-	-	-	*2*
CO-5:	*implement suitable filter structures and analyze the signal in Biomedical applications*	*2*	-	-	*2*	-	-	-	-	-	-	-	-	-	-	*2*

Unit-1 - Basics of Discrete Time and Continuous Time Signals and Systems ***9 Hour***

Representation of discrete time signals- continuous time signals- standard discrete time signals,- standard continuous time signals- Classification of signals: Continuous time(CT)- Tutorials- Classification of Discrete time (DT) signals- Tutorials- Mathematical operations on CTS- DTS- Classification of systems: static and dynamic systems- time invariant and time variant- linear and nonlinear systems- causal and non-causal systems,- stable and unstable systems

Unit-2 - Analysis of Continuous Time Signals and System ***9 Hour***

Fourier transform analysis- Properties- Laplace transform analysis—properties- Poles and zeros - Analysis of differential equation- impulse response-- Transfer function- Analysis of differential equation-frequency response Bio signal measurements

Unit-3 - : Convolution and Correlation of Discrete Time Signals ***9 Hour***

linear convolution- Circular convolution- linear convolution via circular convolution- Sectioned convolution-overlap add method- Overlap save method- Inverse system- deconvolution- Correlation- autocorrelation- cross correlation- Correlation of Bio signals- ECG,EMG

Unit-4 - Transforms of Discrete Time Signals and Systems ***9 Hour***

Z transform- properties- region of convergence- representation of poles and zeros in z transform- Inverse z transform- residue method-Partial fraction method-Discrete time Fourier transform-properties-Relation between Z transform and DTFT Introduction to discrete Fourier transform-DFT-properties

Unit-5 - Realization and Bio Signal Applications ***9 Hour***

Introduction to discrete time Infinite impulse response (IIR)-finite impulse response (FIR) systems-Structure for realization of IIR systems-direct form-I direct form-II -Cascade form-parallel form of IIR system-Structure for realization of FIR systems-direct form -cascade and linear phase realization of FIR systems--Neural Firing rate analysis-Nerve action potentials Linearized model and system equations for immune response

Learning Resources	1. *Alan V Oppenheim, Ronald W. Schafer Signals & Systems, 2nd ed., Pearson Education, 2015* 2. *P.Ramakrishna Rao, Shankar Prakriya, Signals & Systems, 2nd ed., McGraw Hill Education, 2015* 3. *Simon Haykin, Barry Van Veen, Signals and Systems, 2nd ed., John Wiley & Sons Inc., 2007*	4. *Lathi B.P, Linear Systems & Signals, 2nd ed., Oxford Press, 2009* 5. *John G. Proakis, Manolakis, Digital Signal Processing, Principles, Algorithms and Applications, 4th ed., Pearson Education, 2007.*

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. Anbuselvan T, General Manager – Sales, Wipro GE Healthcare Pvt. Ltd., Tamil Nadu, Srilanka& Maldives*	1. *Dr. S. Poonguzhali, Professor, Centre for Medical Electronics, Anna University*	1. *Dr.U.Snekhalatha, SRMIST*

Course Code	21BMC203J	Course Name	ELECTRIC AND ELECTRONIC CIRCUITS	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:	analyze real-time circuits using mesh and nodal analysis and network reduction
CLR-2:	implement various Network theorems for analyzing electrical circuits
CLR-3:	apply the principles of network theorems in simplifying electrical circuits
CLR-4:	summarize the basis for understanding semiconductor material, how a PN junction is formed and its principle ofoperation
CLR-5:	explain the importance of diode in electronic circuits by presenting appropriate diode applications

Course Outcomes (CO):	At the end of this course, learners will be able to:	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	apply the concepts of mesh and nodal analysis in solving electric circuits	3	-	1	-	-	-	-	-	-	-	3	-	2	-	-
CO-2:	analyze the concepts of network theorems in simplifying electric circuits	3	2	-	-	-	-	-	-	-	-	3	-	2	-	-
CO-3:	indicate the concepts of network theorems for electric circuits	3	1	-	2	-	-	-	-	-	-	-	-	2	-	-
CO-4:	identify the operation, characteristics, parameters and specifications of semiconductor diodes	3	-	2	2	-	-	-	-	-	-	-	-	2	-	-
CO-5:	explain the bipolar transistor construction, operation, characteristics, and parameters, as well as Its application in amplification and switching	3	-	2	2	-	-	-	-	-	-	-	-	2	2	-

Unit-1 - Methods of Analysing Circuits — **15 Hour**

Introduction – Circuit Variables and Circuit Elements-Basic Circuits Laws : Kirchoff's Voltage Law (KVL)-Kirchoff's Current Law (KCL)-Practice problems-Mesh analysis- Practice problems -Nodal Analysis-Practice problems- Star to Delta conversion: Transformation formula, Diagram : Practice problems- Delta to Star conversion: Transformation formula, Diagram : Practice problems

Experiments: *Verification of KVL, Verification of KCL, Mesh Analysis*

Unit-2 - Network Theorems — **15 Hour**

s Theorem -Practice problems-Norton's Theorem-Practice problems-Maximum Power Transfer Theorem-Practice problems-Millman's theorem-Practice problems- Duals and Duality-Practice problems

Experiments: *Verification of Thevenin's theorem, Verification of Norton's theorem, Verification of Maximum Power Transfer Theorem*

Unit-3 - Network Theorems — **15 Hour**

ition Theorem-Practice problems-Substitution Theorem-Practice problems -Reciprocity theorem-Practice problems

Experiments: *Verification of Superposition Theorem, Verification of Reciprocity Theorem, Verification of Substitution Theorem*

Unit-4 - Semiconductor Diodes and Diode Circuits — **15 Hour**

Semiconductor theory: Definition and Fundamentals : Intrinsic & extrinsic semiconductors-Current flow in semiconductors-PN junction theory-Forward biased PN junction-Reverse biased PN junction-Relation between Current and Voltage- Zener diode theory-Forward biased, Zener diode junction-Reverse biased Zener diode junction-Relation between Current and Voltage-Problems-Half wave rectifier operation-Efficiency and ripple factor-Full wave rectifier operation-Efficiency and ripple factor-Bridge rectifier operation-Efficiency and ripple factor

Experiments: *PN Junction Diode Characteristics Problem Solving, Zener diode characteristic, Diode circuits*

Unit-5 - Bipolar Junction Transistors	***15 Hour***
Bipolar Junction Transistors (BJT): Construction types and Operation - Common (CE) configuration-CE configuration-Current-Voltage characteristics of CE BJT-configuration-Current-Voltage characteristics of CE BJT configuration-Common Base (CB) configuration-Current-Voltage characteristics of CB BJT-Configuration-Current-Voltage characteristics of CB BJT configuration-Current-Voltage characteristics of CB BJT configuration- Common collector (CC) configuration-Current-Voltage characteristics of CC BJT configuration-Working of BJT as an amplifier - Working of BJT as a switch	
Experiments: *CE configurations – Input and output characteristics, CC and CB configurations – Input and output characteristics, Miniproject*	

Learning Resources	1. *David A. Bell, Electronic Devices and Circuits, 5th ed., Oxford University Press, 2015* 2. *Jegatheesan R, Analysis of Electric Circuits, McGraw Hill, 2014.* 3 *Robert L. Boylestad, Louis Nashelsky, Electronic Devices and Circuit Theory, 11th ed., Pearson Education, 2013*	4. *William H. Hayt, Jack E. Kemmerly, Steven M. Durbin, Engineering circuit analysis, 8th ed., McGraw Hill,2012* 5. *Mahmood Nahvi & Joseph Edminister, "Schaum's Outline of Electric circuits", McGraw-Hill Education, 5thedition 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 (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. Anbuselvan T, General Manager – Sales, Wipro GE Healthcare Pvt. Ltd., Tamil Nadu, Srilanka & Maldives*	1. *Dr. S. Poonguzhali, Professor, Centre for Medical Electronics, Anna University*	1. *Dr. P. Muthu, SRMIST*

Course Code	21BMC204J	Course Name	DIGITAL LOGIC FOR MEDICAL SYSTEMS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							2	0	2	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:	explain and understand the numerical conventions in digital electronics
CLR-2:	understand the mathematical concepts of combinatorial logics
CLR-3:	design and execute synchronous sequential logic circuits
CLR-4:	design and execute asynchronous sequential logic circuits
CLR-5:	explain and develop programmable logic circuits

Course Outcomes (CO):	At the end of this course, learners will be able to:	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	present the fundamentals of digital circuits and simplification methods	2	2	1	-	-	-	-	-	-	-	-	2	2	-	-
CO-2:	practice the design of various combinational digital circuits using logic gates	2	1	-	-	-	-	-	-	-	-	-	1	1	-	-
CO-3:	bring out the analysis and design procedures for synchronous Sequential circuits	-	2	-	1	-	-	-	-	-	-	-	-	1	1	-
CO-4:	bring out the analysis and design procedures for asynchronous Sequential circuits	2	2	1	2	2	-	-	-	-	-	-	-	-	1	2
CO-5:	Implement various digital logic circuits using PLDs	-	2	-	2	-	-	-	-	-	-	-	-	-	1	2

Unit-1 - Basics of Digital Electronics — **12 Hour**

Number systems- representation - Signed and unsigned numbers, binary codes, arithmetic operation of binary numbers-addition, subtraction and multiplication, Conversion. Boolean algebra, theorems, sum of product and product of sum simplification, canonical forms-min term and max term, Simplification of Boolean expressions- Karnaugh map, completely and incompletely specified functions, Implementation of Boolean expressions using universal gates

Experiments: *Design of Adder, Design of Subtractor,*

Unit-2 - Combinational Systems — **12 Hour**

Binary arithmetic units- Adder- Design of Half adder- Design of Full adder- Subtractor- Design subtractor using logic gates- n-bit parallel adder & subtractor- look ahead carry generator- BCD Adder, Decoder- Encoder- Priority Encoder. Multiplexer- Demultiplexer- Code converters- Magnitude comparators- Applications- Parity generators (Odd parity)- Parity generators (Even parity). Case study: Digital trans-receiver / 8 bit Arithmetic and logic unit, Parity Generator/Checker, Seven Segment display decoder

Experiments: *Design of Multiplexer and Demultiplexer, Design of Encoders and Decoder*

Unit-3 - Synchronous Sequential Systems — **12 Hour**

Flip-flop and Latch: SR latch,- JK flip-flop, T flip-flop, D flip-flop- Master-slave RS flip-flop- Master-slave JK flip-flop- Registers & Counters- Shift registers (SISO, SIPO, PISO, PIPO)- Design and implement Synchronous Counters- Ripple Counters, Ring Counters, Universal shift register- Synchronous counters, Modulus-n Counter- Mealy and Moore model- Mealy and Moore model- Synchronous (Clocked) sequential circuits- Synchronous(Clocked) sequential circuits- Design of combinational circuits using PLD's- Design of combinational circuits using PLD's- RAM Memory decoding- ROM- Programmable Array Logic (PAL)- Programmable Array Logic (PAL)

Experiments: *Design and implementation of counters using flip-flop, Design and implementation of shift register*

Unit-4 - Asynchronous Sequential Systems	***12 Hour***
Stable and Unstable states, output specifications, cycles and races, state reduction, race free assignments, Hazards, Essential Hazards, Fundamental and Pulse mode sequential circuits, Design of Hazard free circuits. ***Experiments:*** *Verify characteristic table of flip-flops, Design of Code converter*	
Unit-5 - Programmable Logic Devices	***12 Hour***
Logic families- Propagation Delay, Fan - In and Fan - Out - Noise Margin - RTL ,TTL,ECL, CMOS - Comparison of Logic families - Implementation of combinational logic/sequential logic design using standard ICs, PROM,PLA and PAL, basic memory, static ROM,PROM,EPROM,EEPROM EAPROM ***Experiments:*** *Implement combinational logic functions using standard IC, Design of Magnitude Comparator*	

Learning Resources	1. *M. Morris Mano and Michael D. Ciletti, 'Digital Design', Pearson, 5th Edition, 2013.* 2. *Charles H. Roth, Jr, 'Fundamentals of Logic Design', Jaico Books, 4thEdition, 2002.* 3. *William I. Fletcher, "An Engineering Approach to Digital Design",Prentice- Hall of India, 1980.*	4. *Floyd T.L., "Digital Fundamentals", Charles E. Merril publishing company, 1982.* 5. *John. F. Wakerly, "Digital Design Principles and Practices", Pearson Education, 4 th Edition, 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 (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. Anbuselvan T,General Manager – Sales, Wipro GEHealthcare Pvt. Ltd., Tamil Nadu, Srilanka & Maldives*	1. *Dr. S. Poonguzhali, Professor, Centre for Medical Electronics, Anna University*	1. *Dr. D. Kanchana, SRMIST*

Course Code	21BMC205J	Course Name	INTEGRATED CIRCUIT DESIGN FOR BIOINSTRUMENTATION	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							2	0	2	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:	explain the operation and analysis of op-amp oscillators, single chip oscillators and frequency generators
CLR-2:	identify the active filter types, filter response characteristics, filter parameters and IC voltage regulators
CLR-3:	illustrate the concepts of data converter terminology, its performance parameters, and various circuit arrangements for A/D and D/A conversions
CLR-4:	familiarize the mathematical operations of combinational systems
CLR-5:	design simple combinational logics using basic gates, MSI circuits, flip-flops, registers, counters and their usage, and able to design and analyze sequential logic circuits and Finite State Machines

Course Outcomes (CO):	At the end of this course, learners will be able to:	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	elucidate and design the linear and non-linear applications of an opamp and special application ICs	2	2	1	-	-	-	-	-	-	-	-	2	2	-	-
CO-2:	classify and comprehend the working principle of data converters and active filters	2	1	-	-	-	-	-	-	-	-	-	1	1	-	-
CO-3:	illustrate the function of application specific ICs such as Voltage regulators and ADC and DAC	-	2	-	1	-	-	-	-	-	-	-	-	1	1	-
CO-4:	analyze, design and troubleshoot various combinational logic circuits	2	2	1	2	2	-	-	-	-	-	-	-	-	1	2
CO-5:	design and troubleshoot various clocked sequential logic circuits and waveform generators	-	-	2	2	2	-	-	-	-	-	-	-	-	1	2

Unit-1 - Basics of Operational Amplifiers **12 Hour**

Basic information about op-amps – Ideal Operational Amplifier – General operational amplifier stages -and internal circuit diagrams of IC 741, DC and AC performance characteristics, slew rate, Open and closed loop configurations –JFET Operational Amplifiers

Experiments: *Basic op-amp circuits, Integrators and Differentiators, Rectifiers*

Unit-2 - Applications of Operational Amplifiers **12 Hour**

Sign Changer, Scale Changer, Phase Shift Circuits, Voltage Follower, V-to-I and I-to-V converters, adder, subtractor, Instrumentation amplifier, Integrator, Differentiator, Logarithmic amplifier, Antilogarithmic amplifier, Comparators, Schmitt trigger, Precision rectifier, peak detector, clipper and clamper, Low-pass, high-pass and band-pass Butterworth filters

Experiments: *Comparators, Instrumentation amplifier, Wave shaping Circuits*

Unit-3 - Analog Multiplier and PLL **12 Hour**

Analog Multiplier using Emitter Coupled Transistor Pair – Gilbert Multiplier cell – Variable trans conductance technique, analog multiplier ICs and their applications, Operation of the basic PLL, Closed loop analysis, Voltage controlled oscillator, Monolithic PLL IC 565, application of PL for AM detection, FM detection, FSK modulation and demodulation and Frequency synthesizing and clock synchronization

Experiments: *Waveform generators: using op-amp., Waveform generators: using 555 Timer., Schmitt Trigger using op-amp*

Unit-4 - Analog to Digital and Digital to Analog Converters **12 Hour**

Analog and Digital Data Conversions, D/A converter – specifications – weighted resistor type, R-2 Ladder type, Voltage Mode and Current-Mode R – 2R Ladder types – switches for D/A converters high speed sample-and-hold circuits, A/D Converters – specifications – Flash type – Successive Approximation type – Single Slope type – Dual Slope type – A/D Converter using Voltage-to-Time Conversion – Over-sampling A/D Converters, Sigma – Delta converters

Experiments: *Phase shift and Wien bridge oscillators using op-amp, A stable and monostable multivibrators using NE555 Timer, Design of LPF, HPF, BPF and Band Reject Filters*

Unit-5 - Waveform Generators and Special Function ICS	***12 Hour***
Sine-wave generators, Multivibrators and Triangular wave generator, Saw-tooth wave generator,ICL8038 function generator, Timer IC 555, IC Voltage regulators – Three terminal fixed and adjustable voltage regulators – IC 723 general purpose regulator – Monolithic switching regulator, Low Drop – Out(LDO) Regulators – Switched capacitor filter IC MF10, Frequency to Voltage and Voltage to Frequency converters, Audio Power amplifier, Video Amplifier, Isolation Amplifier, Optocouplers and fibre optic IC	
Experiments: *IC Voltage Regulators. R -2R ladder DAC. Flash Type ADC*	

Learning Resources		
	1. *Morris Mano M, Michael D. Ciletti, Digital Design with an Introduction to theVerilog HDL, 5th ed., Pearson Education, 2014* 2. *Charles H Roth (Jr), Larry L. Kinney, Fundamentals of Logic Design, 5th ed., Cengage LearningIndia Edition, 2010* 3. *Thomas L. Floyd, Digital Fundamentals, 10th ed., Pearson Education, 2013*	4. *Roy Choudhury, Shail Jain, Linear Integrated Circuits, 4th ed., New Age International Publishers, 2014* 5. *Robert F. Coughlin, Frederick F. Driscoll, Operational-Amplifiers and Linear Integrated Circuits, 6th ed.,Prentice Hall, 2001* 6. *IO Franco, Design with operational amplifier and analog integrated circuits, McGraw Hill, 1997*

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. Anbuselvan T, General Manager – Sales, Wipro GE Healthcare Pvt. Ltd., Tamil Nadu, Srilanka& Maldives*	1. *Dr. S. Poonguzhali, Professor, Centre for Medical Electronics, Anna University*	1. *Ms.G.Anitha, SRMIST*

Course Code	21BMC206J	Course Name	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:	*enumerate the basic function of physiological systems and bio-potential electrodes for picking up biological signals*
CLR-2:	*describe various biological signals acquired from physiological systems using various instruments*
CLR-3:	*identify the various blood pressure and blood flow measurement techniques*
CLR-4:	*explain the various techniques used for measurements in the respiratory system*
CLR-5:	*classify the various instruments used for therapeutic and patient safety*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*describe the function of physiological systems and basic man instrument system and bio-potential electrodes*	*2*	*-*	*-*	*1*	*-*	*1*	*-*	*-*	*-*	*-*	*-*	*-*	*1*	*-*	*-*
CO-2:	*identify the various biological signals and its abnormalities*	*2*	*1*	*-*	*1*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*1*	*-*	*-*
CO-3:	*classify the various blood pressure and blood flow measurement techniques*	*2*	*-*	*-*	*1*	*2*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*2*	*-*	*-*
CO-4:	*demonstrate the various techniques used for measurement of respiratory system parameters*	*2*	*-*	*-*	*1*	*2*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*1*	*-*
CO-5:	*illustrate the various instruments used for the emergency therapeutic application and patient safety*	*2*	*1*	*-*	*1*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*2*	*-*	*1*

Unit-1 - Introduction to Bioinstrumentation System ***15 Hour***

Physiological systems of the human body-Biometrics-Introduction to the Man-Instrument system-Components of Man-Instrument system-Problem encountered in measuring in a living system-Intelligent medical instrumentation system-Resting and action potential-Propagation of Action potential-Nernst equation, Goldman equation, Hodgkin- Huxley model-Sources of Bioelectric potentials-Bio interface, potential measurement: electrode electrolyte interface -polarizable and non-polarizable electrodes, - Equivalent circuits – recording problems The electrode skin interface and motion artifact.

Experiments: *Study of block diagram of man instrument system, Study of sources of Bio potentials, Study of bio potential electrodes -Surface and Micro electrodes, Needle electrodes, pH electrodes, pO2, pCO2, Transcutaneous electrodes, Ion sensitive field effect Transistor*

Unit-2 – Bio Signal Acquisition from Physiological System ***15 Hour***

Cardiovascular system: Basic anatomy and physiology of heart-Electrophysiology of the Heart-Electrocardiography waveform and its characteristics-ECG lead configurations-12 lead ECG machine circuit--Various Arrhythmias occurring in ECG signal – Holter recording-Introduction to basic Anatomy and function of brain-Bioelectric potential from the brain-10-20 system of placement of electrode-EEG Machine block diagram description Computerized analysis of EEG-Magnetoencephalography-Electromyography(EMG):Basics of EMG-Recording of EMG-Electrooculography(EOG):Origin and measurement-Electroretinography(ERG): Origin and measurement-Phonocardiography(PCG):Origin of heart sound, Measurement of PCG – Sources of signal artifact and their implications -Biofeedback Instrumentation

Experiments: *Real time ECG monitoring, Real time EEG monitoring, Real time EMG monitoring*

Unit-3 - Blood Pressure and Blood Flow Measurement ***15 Hour***

Measurement of blood pressure: indirect Methods- Measurement of blood pressure: Direct methods- Blood flow measuring techniques: electromagnetic blood-flow meter, Ultrasonic blood flow meter-NMR blood flow meter, Laser Doppler blood flow meter-Cardiac output measuring techniques: dye dilution method-Thermal dilution method-Cardiac output from aortic pressure waveform-Impedance technique-Ultrasound method-Bioreactance method, Co2 rebreathing method. Heart rate measurement-Invitro-oximetry, invivo-oximetry-Ear oximeter-Pulse oximeter-Skin reflectance oximeter, Intravascular oximeter.

Experiments: *Measurement of blood flow, Measurement of cardiac output, Study of oximeters*

Unit-4 - Measurements in the Respiratory System	***15 Hour***
Introduction of respiratory system-Gas exchange and distribution-Measurement of Respiratory volumes and capacities-Spirometry-Pneumotachometers: different types- Respiratory gas analyzers: Infrared gas analyzer- Oxygen analyzers-Thermal conductivity analyser-Nitrogen gas analyzer--Measurement of respiration rate: displacement method,-Thermistor method,-Impedance pneumography-Co2 method-Apnea detector-Bedside andCentral Monitoring system	
Experiments: *Pulmonary analysis using spirometer, Study of pneumotachometers: Measurement of respiration rate*	
Unit-5 - Biomedical Instrument for Therapeutic and Patient Safety	***15 Hour***
Need for cardiac pacemaker-External pacemaker-Implantable pacemaker-Recent developments in Implantable pacemaker-Pacing system analyzer--DC Defibrillator-Types of implantable Defibrillators-Pacer-Cardioverter- defibrillator-Defibrillator analysers-Left ventricular assist device-Electric shock hazards-Microshock and Macroshock-Threshold of perception and Leakage current-Safety codes for electromedical equipment-Electrical safety analyzer-Testing of biomedical equipments	
Experiments: *Study of pacemakers, Study of defibrillators, Study of safety codes, Model exam-Lab*	

Learning Resources	1. *R.S.Khandpur, 'Handbook of Biomedical instrumentation', Tata McGraw Hill Publishing Co Ltd., 3rd edition, 2014.* 2. *John G.Webster, "Medical Instrumentation application and design", Wiley India Pvt Ltd, India, 4th edition, 2015* 3. *Joseph J Carr and John M Brown, "Introduction to biomedical equipment technology", Pearson Education, New Delhi, 4th edition, 2004.*	4. *Leslie Cromwell, Fred J.Weibell, Erich A. Pfeiffer, "Bio-Medical Instrumentation and measurements", Pearson Education, PHI Learning Private limited, India, 2nd edition, 2007.* 5. *Hodgkin, A. L.; Huxley, A. F. (1952),"A quantitative description of membrane current and its application to conduction and excitation in nerve", The Journal of Physiology 117 (4): 500–544.*

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. Anbuselvan T, General Manager – Sales, Wipro GE Healthcare Pvt. Ltd., Tamil Nadu, Srilanka& Maldives*	1. *Dr. S. Poonguzhali, Professor, Centre for Medical Electronics, Anna University*	1. *Dr.A.K.Jayanthy, SRMIST*

Course Code	21BMC207J	Course Name	BIOMATERIALS AND TISSUE INTERACTION	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							2	0	2	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:	*attain the knowledge on basics properties of biomaterials*
CLR-2:	*study the phenomena various metals used in implant applications*
CLR-3:	*acquire knowledge importance of ceramics and polymer used biomedical diagnostics*
CLR-4:	*familiarize with biological system, prosthetic and medical implants*
CLR-5:	*obtain the concept of different types biomaterials applied in-vitro and in-vivo biomedical implant application*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*write the basic principle and properties of biomaterials*	*1*	-	-	-	-	-	-	*1*	-	-	-	-	-	*1*	*2*
CO-2:	*analyze various types of metals used in implant application*	*1*	-	-	-	-	-	-	*2*	-	-	-	-	-	-	*1*
CO-3:	*explain the process of importance of ceramics and polymer used biomedical diagnostics*	*1*	-	-	-	-	-	-	*2*	-	-	-	-	-	-	-
CO-4:	*select appropriate class of polymers using knowledge of, prosthetic and medical implants*	*1*	-	-	-	-	-	-	*2*	-	-	-	-	*2*	*2*	-
CO-5:	*demonstrate the concepts of different types of biomaterials applied in-vitro and in-vivo biomedical implant application*	*1*	-	-	-	-	-	-	*1*	-	-	-	-	*2*	-	-

Unit-1 - Introduction to Biomaterials and its Properties ***12 Hour***

Introduction to Biomaterials-Performance of biomaterials-Characterization of biomaterials-Mechanical properties-Stress–Strain Behavior-Mechanical Failure- failure-Dynamic failure.-Friction and wear failure-viscoelastic properties-Thermal Properties Surface properties: Contact angle-Ceramics and Glasses and Polymers and-Elastomers-Adhesion, Problem for surface properties-Electrical properties-Piezoelectricity, Density of various materials-Porosity of various materials-Diffusion properties-

Experiments: *Study of metallurgical Microscope, Specimen preparation for identification of metals/alloys-B1 Hand Polishing B2 Etching, Determination of coating thickness using Image analyzer*

Unit-2 - Metallic and Ceramics Implants Materials ***12 Hour***

Metallic implant materials-Stainless steel, Co alloy properties and application-Ti based alloys properties and application-Dental metals: Dental Amalgam, Corrosion of metals and ceramics, Gold-Shape memory alloys:- Application of Nickel titanium materials-Other metallic materials and properties-,Applications Other metallic materials and properties-,Applications-New generation of bimetallic materials: Properties and application-Corrosion metallic implants: Electrochemical Aspects Structure and properties of ceramic materials-Impact of fabrication on microstructure and properties :Alumina and its properties-Zirconia and its properties-Calcium phosphate and its properties-Glass ceramics. Yttria ceramics and its properties-Other ceramics-Hydroxyapatite ceramics and its properties-Manufacture of Implants in ceramics

Experiments: *Preparation and characterization of Hydroxyapatite, Preparation and characterization of titanium oxide, Study the corrosion behavior of coated and uncoated substrate*

Unit-3 - Polymeric Implant Materials ***12 Hour***

Polymer Materials: Synthetic polymer-Polymers in biomedical use-Polyethylene and polypropylene-Perfluorinated polymers-Acrylic polymers and Hydrogel-Polyurethane-Polyamides-Biodegradable synthetic polymer Silicone rubber-Plasma polymerization and Polymer sterilization-Composite materials: Structure-Mechanics of composite and application of composite materials -Porous Implants materials-Fibrous and Particulate Composites in Orthopedic Implants-Design criteria for bio composites-Inflammation and wound healing-Normal wound healing-Body response to implants, Biocompatibility

Experiments: *Physical Characterization of Coated/Uncoated Surfaces Contact Angle measurement polycaprolactone (PCL), Physical Characterization of Coated/Uncoated Surfaces Contact Angle measurement poly lactic acid (PHBV, Preparation of simulated body fluid solution.*

Unit-4 - Soft and Hard Tissue Replacements	***12 Hour***
Sutures, skin, Tapes, and Adhesives-Maxillofacial implants-Cardiovascular Grafts and Stents.-Heart Valve Implants.-Hard Tissue replacement: Wires, Pins, and Screws-)-Lower Extremity Implants: Hip Joint Replacements Knee Joint Replacements-Introduction to Kidney implant-Artificial Lung implant-Liver implant,-Artificial Pancreas-Optical implants Contact lenses-Ear implant Blood flow in artificial devices-Artificial Nose-Regeneration andPotential Future Uses for Stem Cells-Ethical consideration. ***Experiments:*** *Chemical Characterization of modified/unmodified surfaces (PVA), Chemical Characterization of modified/unmodified any biodegradable polymers, In-vitro Study in any metallic medical implants.*	
Unit-5 - Biomaterials in Tissue Interaction	***12 Hour***
Scaffolds for tissue engineering-Classes of potential scaffold materials-The criteria for an ideal scaffold-Polymer scaffolds-Polymer scaffolds applications-Bioactive ceramic scaffolds--Bioactive ceramic scaffolds and its applications-Substrate Scaffold Materials-A guide to basic cell culture and applications in biomaterials and tissue engineering-sterilization of scaffolds, Sterilization methods-Cell culture protocols-Basic techniques for assessment of cell viability-maintenance of cells in vitro, cryopreservation-Regeneration stimulated electrically-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. ***Experiments:*** *Preparation and characterization of hydrogels using polymers, Preparation and characterization of Zirconia Ceramics, Model Exam*	

Learning Resources	1. *Joon park, R.S Lakes, "Biomaterials An Introduction "Springer, 2007* 2. *Sujata V. Bhat "Biomaterials" springer 2002*	3. *Larry L. Hench and Julian R. Jones, Biomaterials, artificial organs and tissue engineering, CRC Press 2010* 4. *P Ducheyne (Editor), Comprehensive Biomaterials, 1st Edition, Elsevier, 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*	*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. Anbuselvan T, General Manager – Sales, Wipro GE Healthcare Pvt. Ltd., Tamil Nadu, Srilanka& Maldives*	1. *Dr. S. Poonguzhali, Professor, Centre for Medical Electronics, Anna University*	1. *Dr S.Gnanavel, SRMIST*

Course Code	21BMC301J	Course Name	BIOMEDICAL SIGNAL 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	*Biomedical Engineering*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*explain the basic of signal processing techniques*
CLR-2:	*apply the concept of IIR filter design*
CLR-3:	*implement of concepts of FIR filter design and its application*
CLR-4:	*describe the various signal processing algorithms in ECG*
CLR-5:	*illustrate the concept of Heart rate variability and speech signal analysis*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*describe the DIT-FFT and DIF-FFT algorithm*	*2*	*2*	*-*	*2*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*1*	*-*	*-*
CO-2:	*implement the IIF filter design in real time bio signals*	*2*	*-*	*2*	*2*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*2*
CO-3:	*design the FIR filter using windowing techniques*	*2*	*-*	*2*	*-*	*2*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*2*	*-*	*1*
CO-4:	*execute the various signal processing algorithms in analysis of ECG*	*-*	*2*	*1*	*-*	*2*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
CO-5:	*apply the advanced techniques in various bio signal applications*	*2*	*2*	*1*	*2*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*2*	*-*	*1*

Unit-1 - Basics of Signal Processing — ***15 Hour***

Sampling-Aliasing-FFT-Decimation in time radix-2 algorithm -Implementation of DIT- FFT algorithm-FFT-Decimation in Frequency radix-2 algorithm- -Implementation of DIF- FFT –algorithm -Different types of bioelectric signals-Characteristics- Bio impedance signals- -Bio acoustic signals- -Bio mechanical signal.

Experiments: *Basic signal operations, DFT and FFT computations, Representation of –Biosignals*

Unit-2 - IIR Filter Design — ***15 Hour***

IIR Filter- Impulse invariant method-Bilinear transformation method -Butterworth filter- Chebyshev filter-Magnitude response -Design of butterworth filter using bilinear-transformation technique- -Design of butterworth filter using impulse invariant method-Design of Chebyshev filter using bilinear transformation technique -Design of Chebyshev filter using impulse invariant method- -Frequency warping-Prewarping effect-Frequency transformation-digital domain

Experiments: *Design of digital Butterworth IIR filter, Design of digital Low pass Chebyshev IIR filter, Design of digital high pass Chebyshev IIR-Filter*

Unit-3 - FIR Filter Design and Its Application — ***15 Hour***

FIR filter -Characteristics-Frequency method sampling method-Type I and Type II-FIR filter design using windowing techniques- Rectangular window- Hamming window- Hanning window - Blackman window- -Time domainfilters -Moving averaging filters Algorithm-Synchronized averaging filters

Experiments: *FIR Filter using hamming windowing techniques, FIR Filter using Hanning windowing techniques, FIR Filter using blackman windowing-Techniques*

Unit-4 - Analysis of ECG — ***15 Hour***

P-Wave detection-Estimation of R-R Interval-QRS complex detection-Template subtraction method-Template correlation method-Pan Tompkins algorithm for QRS detection-block diagram Algorithm and waveforms–Physiological origin-Generation of HRV- Time domain methods of HRV-Frequency domain Methods- -Non-linear analysis of HRV-Pit falls in understanding HRV-Adaptive filter –Introduction Adaptive noise canceller –block diagram-LMS adaptive filter algorithm

Experiments: *Analysis of ECG, Heart rate variability, Adaptive filtering techniques*

Unit-5 - Advanced Techniques in Biosignal Processing	***15 Hour***
Speech signal analysis-Cepstrum-Analysis of complex cepstrum-Homomorphic filtering of speech signals- Synchronized averaging of PCG envelopes Envelogram-Signal averaged ECG-Normal and Ectopic ECG beats classification-Analysis of Exercise ECG-Adaptive segmentation of EEG signals –SEM method-ACF distance method-Adaptive segmentation -Spectral Analysis-Power spectral density	
Experiments: *Analysis of speech signals, Classification of Normal and abnormal ECG, Spectral analysis of signals*	

Learning Resources	1. *Ramesh Babu," Digital signal processing" Laxmi Publications, 2005.* 2. *Rangaraj.M.Rangayyan, "Biomedical signal processing ' ,Wiley-IEEE press,2nd ed 2015*	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 (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. Anbuselvan T, General Manager – Sales, Wipro GE Healthcare Pvt. Ltd., Tamil Nadu, Srilanka& Maldives*	1. *Dr. S. Poonguzhali, Professor, Centre for Medical Electronics, Anna University*	1. *Dr.U.Snekhalatha, SRMIST*

Course Code	21BMC302J	Course Name	MICROCONTROLLERS AND ITS APPLICATION IN MEDICINE	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:	*explain the fundamental concepts of 8086 microprocessors*
CLR-2:	*interpret the basic concepts of 8051 microcontroller*
CLR-3:	*illustrate the concepts of interfacing devices*
CLR-4:	*describe the instruction set of Microcontroller*
CLR-5:	*implement the ARM microcontroller in Biomedical applications*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*describe the fundamental concepts of 8086 microprocessors*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*implement the concepts of 8051 microcontroller*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*analyze the features of interfacing devices*	*2*	-	*2*	-	*2*	-	-	-	-	-	-	-	*2*	-	*1*
CO-4:	*apply the concepts of RISC Processor and understand ARM processor programming*	*2*	-	-	-	*2*	-	-	-	-	-	-	-	-	-	-
CO-5:	*implement the ARM microcontroller for Biomedical applications*	*2*	-	-	-	-	-	-	-	-	-	-	-	*2*	-	*1*

Unit-1 - 8086 Processor — ***15 Hour***

Evolution of Microprocessor -signal description of 8086 -Architecture -Addressing modes -Minimum mode operation-Maximum mode operation -Instruction set : Data transfer- Arithmetic, Logical-Instruction set : String Manipulating Instructions-Instruction set : Control Transfer Instructions-8086 Interrupt

Experiments: *16 Bit addition, Block transfer of data type, Sum of n numbers, Sorting even and odd numbers in an array*

Unit-2 - 8051 Microcontroller — ***15 Hour***

Introduction to Microcontroller-Difference between Microprocessor and Microprocessor-signal description of 8051- -architecture-Addressing modes -Register set of 8051-Instruction set : Data transfer-Instruction set : Arithmetic, Logical-Instruction set : String Manipulating Instructions, control transfer-Special Function Registers -8086 Interrupt-Memory interfacing

Experiments: *8-bit addition using 8051 microcontrollers, 8-bit subtraction using 8051 microcontroller, One and two complement of a number, Fibonacci series*

Unit-3 - Interfacing Devices — ***15 Hour***

Introduction to 8251: Architecture-8251: Processing Mode-Interfacing to external memory -Timer interfacing -Basic techniques for reading & writing from I/O port pins-Basic techniques for reading & writing from I/O port pins-Interfacing 8051 to ADC -Stepper motor-Keyboard Interfacing -Liquid crystal display (LCD)

Experiments: *Generate Saw tooth Waveform, Generate Triangular waveform, Generate Sine Waveform, Generate Square Waveform, Stepper motor interface*

Unit-4 - ARM Microcontroller — ***15 Hour***

Reduced Instruction Set Computer (RISC) Design Physiology-Difference between RISC and Complex Instruction Set Computer (Processor-Major Design rules-Major Design rules-ARM Design Physiology- ARM core data flow model-Processor Modes-Registers ARM Instruction set -Exceptions-Exceptions-Thumb Instruction set

Experiments: *Assembly language program to compute sum of n consecutive numbers and to find the-factorial of the result, Assembly language program to compute factorial of a number and to compute the parity of the result, Assembly language program to determine the bigger number of two given number*

Unit-5 - Applications in Medicine	***15 Hour***
Mobile phone based bio signal recording -Design of pulse oximeter circuit using ARM microcontroller-Design of EOG based home appliances using PIC microcontroller-Analysis of EEG signal using microcontroller-- Design of heart rate monitoring circuit using ARM microcontroller ***Experiments:*** *Mini Project*	

Learning Resources	1. *A.K.Ray, K.M.Bhurchandi, "Advanced Microprocessor and Peripherals", Tata McGraw Hill, 3rd edition, 2013* 2. *Douglas V. Hall, "Microprocessor and Interfacing:Programming and Hardware",Glencoe, 2ndedition, 2006.*	3. *Andrew N.Sloss,DonimicSymes, Chris Wright, "ARM System Developer's Guide",Elsevier, 1st edition, 2007.* 4. *Muhammad Ali Mazidi and JanicaGilliMazidi, 'The 8051 microcontroller and embedded systems', Pearson Education, 5th Indian reprint, 2003.*

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. Anbuselvan T, General Manager – Sales, Wipro GE Healthcare Pvt. Ltd., Tamil Nadu, Srilanka& Maldives*	1. *Dr. S. Poonguzhali, Professor, Centre for Medical Electronics, Anna University*	1. *Dr.Vani Damodaran, SRMIST*

Course Code	21BMC303T	Course Name	PRINCIPLES OF MEDICAL IMAGING	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:	*narrate the physics of X –ray production and image intensifier system*
CLR-2:	*demonstrate the working of different components of Computed tomography and its different generations*
CLR-3:	*describe the working principle of PET and SPECT imaging*
CLR-4:	*explain the basic physics behind MRI imaging and reconstruction algorithms for MRI Images*
CLR-5:	*illustrate the working principles of different types of scanners – A, B & M mode and Duplex ultrasound scanners*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*describe the production of X ray and the working principle of X –ray machine*	*1*	-	-	*1*	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*differentiate the generations of CT*	*2*	-	-	-	*1*	-	-	-	-	-	-	-	-	-	-
CO-3:	*illustrate the working principle of PET and SPECT scanner*	*1*	*1*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-4:	*explain the working principle of MRI and its different components*	*2*	*1*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-5:	*analyze the working of Different ultrasound scanners for diagnostic purpose*	*1*	*1*	-	*1*	-	-	-	-	-	-	-	-	*1*	*2*	-

Unit-1 - X-Ray Imaging and Digital Radiography ***9 Hour***

Nature of X-rays-Properties of X –rays-Production of X-rays-Stationary X –ray anode tube-Rotating anode tube-X –ray machine-High frequency generator-Collimators and grids-Automatic exposure control – photocell method-Ionization method-Visualization of X-rays – X- ray film-Fluorescent screen-X –ray image intensifier tube X –ray image intensifier system-Dental X-ray Machines-Portable and Mobile X-ray Units-Digital Radiography- Flat panel detectors

Unit-2 - Computed Tomography ***9 Hour***

Computed Tomography-basic principle-Contrast scale – CT number-CT – system components-Scanning system-Different generation of CT-X – ray source-X –ray detectors and types-Data acquisition system-Processing unit-Iterative reconstruction-Back projection reconstruction-Filtered back projection-Block diagram of the image computer-Viewing system-Storing and documentation-Gantry geometry-Patient dose in CT scanners

Unit-3 - Nuclear Imaging ***9 Hour***

Radioisotopes in medical diagnosis-Physics of Radioactivity-Radiation Detectors – Ionization chamber-Scintillation detector-Semiconductor detectors-Solid state detectors-Pulse Height-analyzer Uptake Monitoring Equipment-Radio-isotope Rectilinear Scanner-The Gamma Camera-Emission computed tomography-Single-photon Emission Computed Tomography – Principle-SPECT system – simplified diagram and description-Positron Emission Tomography – Principle-PET – Gantry and detector module-Data acquisition system for PET scanner

Unit-4 - Magnetic Resonance Imaging ***9 Hour***

Principles of NMR-Free induction decay-T1 and T2 relaxation-Fourier transformation of FID-Bloch equation-Image Reconstruction Techniques-Sequential point method, Sequential line method Sequential plane method- Discrimination based on relaxation rates-Saturation recovery-Inversion recovery-Spin echo imaging technique-Generic pulse sequence used in MRI-Basic NMR Components-NMR Detection system, NMR gradient controlsystem-Biological Effects of NMR Imaging Advantages of NMR Imaging System-fMRI basic physics, Image acquisition procedure

Unit-5 - Ultrasound Imaging	***9 Hour***
Diagnostic Ultrasound-Physics of Ultrasonic Waves-Generation and detection of ultrasound-Medical Ultrasound-Basic Pulse-echo Apparatus-A scanner and applications-B scanner and –applications-Echocardiography (M- mode)-Block diagram of echocardiograph circuit-Doppler scanner - Real time ultrasonic imaging systems Multi-element Linear Array Scanners-Linear array scanner-Phased array system-Area array system-Duplex scanner- Intravascular imaging- Principles of Elastography technique.	

Learning Resources	1. *R.S.Khandpur., 'Handbook of Biomedical instrumentation', Tata McGraw Hill Publishing CoLtd., 3rd edition, 2014.* 2. *Jerrold T. Bushberg, John M. Boone., "The essential physics of medical imaging", LippincottWilliams & Wilkins, 3rd edition, 2011.* 3. *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.*	3. *Nadine Barrie Smith, Andrew Webb, "Introduction to medical imaging: Physics, Engineering and clinical applications", Cambridge University Press, 1st edition, 2010.* 4. *K. Kirk Shung, Michael Smith, Benjamin M.W. Tsui., "Principles of medical imaging", Academic Press, 1st 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%*	*-*	*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. Anbuselvan T, General Manager – Sales, Wipro GE Healthcare Pvt. Ltd., Tamil Nadu, Srilanka& Maldives*	1. *Dr. S. Poonguzhali, Professor, Centre for Medical Electronics, Anna University*	1. *Dr. S. P. Angeline Kirubha, SRMIST*

Course Code	21BMC304J	Course Name	MEDICAL IMAGE PROCESSING	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							2	0	2	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:	*explain the basic image operations and image transforms*
CLR-2:	*apply various image enhancement techniques in medical images*
CLR-3:	*illustrate the concepts of Image restoration and reconstruction techniques*
CLR-4:	*analyze the various types of image segmentation algorithms*
CLR-5:	*describe various Image compression and fusion methods*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*describe the elements of visual perception and various types of image transforms*	*2*	*1*	-	-	*2*	-	-	-	-	-	-	-	-	-	*1*
CO-2:	*implement the image enhancement techniques for improving the quality of images*	*2*	*1*	-	*2*	-	-	-	-	-	-	-	-	*1*	-	-
CO-3:	*analyze the various image restoration and reconstruction methods used for medical images*	*3*	-	*2*	-	*2*	-	-	-	-	-	-	-	*2*	-	*1*
CO-4:	*apply the different image segmentation algorithms for various medical applications*	*3*	-	*1*	-	*2*	-	-	-	-	-	-	-	-	-	-
CO-5:	*differentiate and analyze the various image compression and fusion techniques*	*2*	*1*	*2*	*2*	*2*	-	-	-	-	-	-	-	*2*	-	*1*

Unit-1 - Fundamental Image Operations and Transforms ***12 Hour***

Fundamentals steps in Digital Image processing - Elements of Visual Perception- structure of human eye and image formation - Brightness range adaptation and discrimination - Image sensing and acquisition-using a single sensor - Basic concepts in Image sampling and quantization - Spatial and intensity resolution - Some basic relationships between pixels- Image Arithmetic operations - Logical operations - Image transforms - DCT - Hadamard transform- Haar transform and its properties

Experiments:

- *Basic operations on images*
- *Image Arithmetic and logical operations*
- *Image transforms in frequency domain*

Unit-2 - Image Enhancement Methods ***12 Hour***

Basic Intensity transformation functions - Histogram equalization - Histogram specification - Smoothening linear filters - Sharpening spatial filters - First order Derivative filters - Second order derivative filters - Unsharp masking and high boost filtering - Color image processing- Color models - Conversion of RGB to HSI model - Conversion of HSI to RGB Model

Experiments:

- *Intensity transformation and histogram equalization*
- *Filtering using averaging filter unsharp masking and high boost filtering*
- *Color image processing*

Unit-3 - Image Restoration and Reconstruction Techniques	***12 Hour***
Image restoration-Mean filters - Order-statistic and Adaptive filters - Image degradation model properties - Inverse filtering - Minimum mean square error (wiener) filtering -- Image reconstruction from projections- Radon transform- derivation –Properties - Inverse radon transform- Filter back projection - Digital implementation of filter back projection - Fourier reconstruction of MRI images ***Experiments:*** • *Image reconstruction using radon transform* • *Fourier reconstruction of MRI images*	
Unit-4 - Image Segmentation Techniques	***12 Hour***
Basic edge detection - Marr-Hildreth edge detector - Canny edge detector - Thresholding- Foundation - Basic global thresholding - Optimum global thresholding using otsu's method – Algorithm - Region based segmentation-- Segmentation using morphological watersheds- Clustering based segmentation techniques –Algorithms - Basic Active Contour Model - Formulation ***Experiments:*** • *Advanced Edge detection techniques* • *Image segmentation by watershed algorithm*	
Unit-5 - Image Compression and Image Fusion Methods	***12 Hour***
Image compression- Huffman coding technique –Procedure - Arithmetic coding technique - Run length coding technique- Image fusion- Pixel based image fusion techniques - Wavelet transform based image fusion - Image registration-Introduction - Types of image registration ***Experiments:*** • *Image fusion* • *Image registration*	

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 ed 1997.*	3. *Joseph V.Hajnal, Derek L.G.Hill, David J Hawkes, "Medical image registration",Biomedical Engineering series, CRC press,2001.*

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. Anbuselvan T, General Manager – Sales, Wipro GE Healthcare Pvt. Ltd., Tamil Nadu, Srilanka& Maldives*	1. *Dr. S. Poonguzhali, Professor, Centre for Medical Electronics, Anna University*	1. *Dr.U.Snekhalatha,SRMIST*

Course Code	21BMC305T	Course Name	BIOCONTROL SYSTEMS	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:	*explain about mathematical modeling of mechanical and electrical systems*
CLR-2:	*analyze the transient and steady state error and its analysis*
CLR-3:	*identify and analyze stability of a system in time domain using root locus technique*
CLR-4:	*explain the different frequency domain analytical techniques*
CLR-5:	*illustrate the controllers used in control systems*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*calculate the Transfer function of a system by mathematical modeling, block diagram reduction and signal flow graph techniques*	2	2	-	2	-	-	-	-	-	-	-	-	2	-	-
CO-2:	*classify the standard test inputs, time domain specifications and evaluate steady state error*	2	2	-	2	-	-	-	-	-	-	-	-	2	-	-
CO-3:	*sketch a root locus curve and analyze the system stability using Routh array*	2	2	-	2	-	-	-	-	-	-	-	-	2		-
CO-4:	*analyze the frequency domain specifications*	2	2	-	2	-	-	-	-	-	-	-	-	-	2	-
CO-5:	*explain use of various controllers used in control systems*	2	2	-	2	-	-	-	-	-	-	-	-	-	-	2

Unit-1 - Mathematical Modeling — ***9 Hour***

Control system terminology-classification of control systems, SISO and MIMO control systems - Feedback and its effects on overall gain, stability, noise and sensitivity - Open loop and closed loop control systems with physiological system examples - Advantages and disadvantages of OLCS and CLCS systems - Transfer function of a system and basics of Laplace transform - Transfer function of translational mechanical systems - Transfer function of rotational mechanical systems - Transfer function of electrical systems - Analogous systems -Block diagram reduction technique - Signal flow graph - Conversion of block diagram to signal flow graph need for modeling physiological systems

Unit-2 - Time Response Analysis — ***9 Hour***

Standard test signals- step, ramp, parabolic and impulse - Derivation of expression for standard test signals - Type and order of a system - Transfer function of First order system for Step and ramp input signal - Transfer function of First order system for Impulse and parabolic input signals - General transfer function of second order system - Identification of damping factor and classification based on it - Step response of critically damped second order system - Step response of under damped second order system - Step response of over damped second order system - Step response of undamped second order system - Transfer function-Time constant form and pole zero form - Time domain specifications - Evaluation of time domain specifications - Transient and steady state error analysis - Static and dynamic Error coefficients - Static error constants and evaluation of steady state error - Dynamic error constants and evaluation of steady state error

Unit-3 - Stability Analysis — ***9 Hour***

Poles and zeros of a system - Pole zero plot and concept of s plane - Characteristic equation - Concept of stability from pole zero location - Need for Stability analysis and available techniques - Necessary and sufficient Conditions for stability – Definition of dominant poles and relative stability - Routh Hurwitz Technique - Significance of Routh Hurwitz Technique - Computation of Routh array - Routh array of stable systems - Unstable systems - Root locus technique - Rules for construction of root locus - Root locus plot of typical systems - Effect of adding poles and zeros to a system

Unit-4 - Frequency Response Analysis	***9 Hour***
Frequency domain analysis - Frequency domain specifications - Estimation of frequency domain specifications - Correlation between time and frequency domain - Bode plot approach and stability analysis - Rules for sketching bode plot - Bode plot of typical systems - Nyquist stability criterion – Nyquist plot - Sketching of polar plot - Polar plot and its significance – Use of Nichol's chart to compute response frequency and bandwidth	
Unit-5 - State Space Variable Analysis and Biomedical Applications	***9 Hour***
Introduction to state space - General state space representation - Applying the state space representation - - Converting a transfer function to state space - Converting from state space to a transfer function - Controllers- P, PI and PID controllers - Physiological control system analysis - A simple example - Linear model of physiological system-Distributed parameter Vs Lumped parameter models - Lung mechanics model with proportional control - Controllers in blood glucose regulation and artificial ventilation	

Learning Resources	1. *Nagrath.J and Gopal, "Control System Engineering", 5th Edition, New Age, 2007.* 2. *Benjamin C Kuo, "Automatic Control System", 9th edition, John Wiley & Sons, 2010.*	3. *Gopal.M, "Control System Principles and Design", 2nd Edition, TMH, 2002.* 4. *Michael C K Khoo, "Physiological Control Systems: Analysis, Simulation and Estimation", John Wiley& Sons, 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*	*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. Anbuselvan T, General Manager – Sales, Wipro GE Healthcare Pvt. Ltd., Tamil Nadu, Srilanka& Maldives*	1. *Dr. S. Poonguzhali, Professor, Centre for Medical Electronics, Anna University*	1. *Dr.A.K.Jayanthy,SRMIST*

Course Code	21BMC401J	Course Name	BIOMECHANICS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							2	0	2	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 concepts of kinematics and kinetics of human motion*
CLR-2:	*express the basic mechanics of skeletal and muscular movements*
CLR-3:	*apply the basic mechanics in various movements and loads on shoulder, elbow and wrist*
CLR-4:	*analyze the movements and loads applied on hip, knee, ankle and foot*
CLR-5:	*implement the analysis of gait and study the movement characteristics of spine*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*describe the principles and concepts of biomechanics in the field of kinematics and kinetics of human motion*	*2*	*1*	-	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-2:	*identify the mechanical properties of bone and muscle tissues*	*2*	*1*	-	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-3:	*analyze the functional and movement characteristics of upper extremity bones and joints*	*2*	-	-	*2*	-	-	-	-	-	-	-	-	*2*	-	-
CO-4:	*apply the various effect of loads on lower extremity bones and joints*	*2*	-	-	*2*	-	-	-	-	-	-	-	-	-	*2*	-
CO-5:	*implement the knowledge in biomechanics of spine and human locomotion*	-	-	-	*2*	*1*	-	-	-	-	-	-	-	-	*1*	*2*

Unit-1 - Kinematic and Kinetic Concepts of Human Motion — ***12 Hour***

Forms of Motion-Standard Reference Terminology-Joint Movement Terminology -Qualitative analysis of human movement-Basic concepts related to kinetics and kinematics-Mechanical loads on the human body -Effectsof loading-Tools for Measuring Kinetic and kinematic quantities.

Experiments: *Analysis of mechanical stress and strain, Projectile motion analysis, Measurement of bone mineral density*

Unit-2 - Characteristics of Bone — ***12 Hour***

Mechanical properties of body tissues-Structural Analysis -Biomechanical Characteristics of Bone-Bone tissue function- Composition of bone tissue-Bone Modeling and Remodeling-Mechanical properties of bone-Maxwell and Voight model.

Experiments: *Study of Mechanical properties of bone, Preprocessing and post processing analysis, Deflection analysis*

Unit-3 - Functional Anatomy of Upper Extremity — ***12 Hour***

Shoulder complex- Functional Characteristics of the Joints of the Shoulder-Loads on the shoulder-Elbow and Radio ulnar joints- Functional Characteristics of the Joints of the Elbow-Loads on the elbow-Functional Characteristics of the joints Of the Wrist and Hand -Common injuries of upper extremity.

Experiments: *Study of upper extremity joints, Segmentation of radius and ulna, 3D modeling of radius and ulna*

Unit-4 - Functional Anatomy of Lower Extremity — ***12 Hour***

Structure of Hip joint-Loads on the Hip- Structure of Knee joint- Movement Characteristics of the Knee- Loads on the knee-Structure of Ankle and Foot-Combined movements of Ankle and Foot-Common injuries of lower extremity.

Experiments: *Study of lower extremity joints, Segmentation and modeling of femur bone, Segmentation and modeling of fibula and tibia*

Unit-5 - Biomechanics of Spine and Gait	***12 Hour***
Structural and movement characteristics of spine- Movements of spine--Posture and spinal stabilization- Loads on spine-Common injuries of spine- Gait analysis-Measurement of gait parameters.	
Experiments: *Segmentation and modeling of lumbar spine, Analysis of gait, Mini project*	

Learning Resources		
	1. *Joseph Hamill & Kathleen M. Knutzen, "Biomechanical Basis of Human Movement", Lippincott Williams & Wilkins, a Wolters Kluwer business, 3rd Edition, 2009*	3. *Peter M. McGinnis, "Biomechanics of sports and exercise", Human kinetics, 3rd Edition, 2013*
	2. *Susan J Hall, "Basic Biomechanics", Tata Mcgraw hill, 6th Edition, 2012.*	4. *Fung Y C, Biomechanics: "Mechanical Properties of Living Tissues", Springer, 2nd Edition, 1993.*

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. Anbuselvan T, General Manager – Sales, Wipro GE Healthcare Pvt. Ltd., Tamil Nadu, Srilanka& Maldives*	1. *Dr. S. Poonguzhali, Professor, Centre for Medical Electronics, Anna University*	1. *Dr. Ashokkumar D, SRMIST*

Course Code	21BMC402J	Course Name	BIOMEDICAL EQUIPMENTS FOR CLINICAL APPLICATIONS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							2	0	2	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:	*explain the fundamentals of diagnostic and therapeutic equipment's*
CLR-2:	*summarize the functioning of different types of physiotherapy and electrotherapy equipment's*
CLR-3:	*illustrate the concepts of the instruments dealing with bone*
CLR-4:	*construct the respiratory care equipment's*
CLR-5:	*describe the diagnosis procedure of hearing problems and Hearing aids and working principle of therapeutic equipment's*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*outline the importance of therapeutic and diagnostic devices and medical device*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*analyze the types of pacemakers*	*2*	-	-	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-3:	*apply the principle of ultrasound in diagnostic and therapeutic application*	-	*2*	-	-	-	-	-	-	*2*	-	-	-	*2*		-
CO-4:	*explain the importance of respiratory care equipment's*	*2*	-	*3*	-	-	-	-	-	-	-	-	*2*	-	*2*	-
CO-5:	*design the hearing aid Equipment and Interpret concept of surgical diathermy*	*2*	-	*3*	-	-	-	-	-	*2*	-	-	*2*	-	-	-

Unit-1 - Coronary Care Equipment's ***12 Hour***

Cardiac pacemakers: different modes of operation - external pacemaker - implantable pacemakers - pacemaker standard codes - Defibrillator: AC defibrillator - DC defibrillator - Implantable defibrillator types - automated externaldefibrillator (AED) - Pacer- cardioverter defibrillator - defibrillator analysers - Heart lung machine (HLM) - Functional details of oxygenators - types of oxygenators

Experiments: *Study – Working principle of defibrillator, Study – Working principle of pacemaker, Study – Working principle of HLM*

Unit-2 - Physiotherapy, Electrotherapy and Phototherapy Equipment's ***12 Hour***

Short wave diathermy - Advantages of Microwave diathermy over shortwave diathermy - Microwave diathermy - Ultrasound application in medical diagnostic - Working details of Ultrasonic therapy unit - Electro diagnostic apparatus - Electro therapeutic apparatus - Interferential current therapy - Transcutaneous electrical nerve stimulation (TENS) - bladder stimulator - Spinal cord stimulator - deep brain stimulation - Photo therapy unit

Experiments: *Ultrasound diathermy – working principle, Shortwave diathermy – working principle, Measurement of nerve conduction velocity*

Unit-3 - Instruments Dealing with Bones and Respiratory Care ***12 Hour***

Introduction to Respiratory care equipment's – humidifier – nebulizer – aspirators - Working of Ventilators - Ventilators types – capnography –Anesthesia machine - Baby incubator - BMD measurements: Single X-ray absorptiometry (SXA) - Dual X-ray absorptiometry (DXA) - Quantitative ultrasound bone densitometer - Comparison of DXA and Bone densitometer

Experiments: *BMD measurement – using peripheral DEXA, Study- Working of Ventilators, Mini Project- Baby Incubator*

Unit-4 - Sensory Diagnosis and Hearing Aid Equipment's ***12 Hour***

Mechanism of hearing - sound conduction system - basic audiometer - pure tone audiometer - Speech audiometer – Bekesy audiometer system - Evoked response audiometry system - Hearing aids - galvanic skin response – Tonometry - Measurement of basal skin response - galvanic skin response

Experiments: *Measurement of hearing ability – audiometer, Tonometry, Mini Project- Measurement of Skin resistance*

Unit-5 - Surgical and Therapeutic Equipment's	***12 Hour***
Surgical diathermy unit - Endoscopy basic components - Endoscopy different types – Laparoscope –gastro scope – bronchoscope - Cryogenic techniques - Cryogenic technique application - Operating microscope – arthroscopy - Modern lithotripter system - laser lithotripsy - Hospital visit ***Experiments:*** *Study – Working principle of Gasto scope, Study-Cryogenic Techniques*	

Learning Resources	1. *R.S.Khandpur, 'Handbook of Bio-Medical instrumentation', Tata McGraw Hill Publishing Co Ltd., 3rd edition, 2014.* 2. *Albert M.Cook and Webster.J.G, "Therapeutic Medical Devices", renticeHall Inc., New Jersey, 1st edition, 1982* 3. *Sydney Lou Bonnick, Lori Ann Lewis, "Bone Densitometry and Technologists", Springer, 3rd edition, 2013*	4. *Marc. Safran, Bobby. Chhabra. A., Mark. Miller.D., "Primer of Arthroscopy",Elsevier Health Sciences, 2nd edition, 2010* 5. *Leslie Cromwell, Fred J.Weibell, Erich .Pfeiffer, "Bio- Medical Instrumentation and Measurements",Pearson Education, PHI LearningPrivate limited, India, 2nd edition, 2007 "* 6. *John G.Webster, "Specifications of Medical Instrumentation Application andDesign",Wiley India Pvt Ltd, India, 4th edition, 2015.*

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. Anbuselvan T, General Manager – Sales, Wipro GE Healthcare Pvt. Ltd., Tamil Nadu, Srilanka& Maldives*	1. *Dr. S. Poonguzhali, Professor, Centre for Medical Electronics, Anna University*	1. *Dr. G.Anitha, SRMIST*

ACADEMIC CURRICULA

UNDERGRADUATE/ INTEGRATED POST GRADUATE DEGREE PROGRAMMES

(With exit option of Diploma)

(Choice Based Flexible Credit System)

Regulations 2021

Volume – 9B
(Syllabi for Biomedical Engineering (Machine Intelligence) Programme Courses)

SRM
INSTITUTE OF SCIENCE & TECHNOLOGY
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SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

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

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

ACADEMIC CURRICULA

Professional Elective Courses

Regulations 2021

SRM INSTITUTE OF SCIENCE & TECHNOLOGY
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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	21BME271T	Course Name	AI AND MACHINE LEARNING FOR HEALTH CARE	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:	*infer the basics of artificial intelligence*
CLR-2:	*explain the various types of informed search techniques*
CLR-3:	*compare the techniques in knowledge representation*
CLR-4:	*appraise the various types of machine learning approaches*
CLR-5:	*summarize the various techniques in machine learning*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*describe the basics of artificial intelligence*	*3*	*2*	-	-	*1*	-	-	-	-	-	-	-	-	-	-
CO-2:	*explain the different concepts in problem solving by applying search techniques*	*2*	*3*	*1*	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*summarize the techniques in knowledge representation*	*3*		*2*	-	*1*	-	-	-	-	-	-	-	-	-	-
CO-4:	*elaborate the basics of machine learning*	*3*	*2*	*1*	-	-	-	-	-	-	-	-	-	*2*	-	*1*
CO-5:	*list the various applications of machine learning*	*3*	*2*	*1*	-	-	-	-	-	-	-	-	-	*2*	-	*1*

Unit -1 : Introduction to Artificial Intelligence	***9 Hour***
Definition- Intelligent Agents-Structure of Agents-Types of Agents-Agents and environments-nature of environments-task environment-structure of agents-agent programs-Types of agents-Problem solving agents-formulating problems-toy problems-real world problems. Searching for solutions-Uninformed Search-Breadth First-Uniform cost search-Depth first-Depth limited-Iterative deepening depth first search-Bidirectional search	
Unit-2 - Informed Search Techniques	***9 Hour***
Greedy best first search-A search-memory bounded heuristic search-recursive best first search-Simplified MA*-Local search Algorithms-Hill Climbing-Simulated Annealing-Local beam search-Genetic algorithms. Constraint satisfaction problem-Map coloring problem. Knowledge and Reasoning-knowledge based agent-representation reasoning and logic-semantics and inference-Propositional logic-syntax-semantics-Validity and inference.*	
Unit-3 - Knowledge Representation	***9 Hour***
First order logic-syntax-semantics-symbols-terms,sentences-quantifiers,equlity-extensions-notational variations- Higher order logic, A-expression- Using first order logic-kinship domain-Axioms, definitions and theorems – Domain of sets-special notation for sets, lists and arithmetic-Logical agents for Wumpus world-simple reflex agent-limitations-Representing change in the world-situation calculus- Frame problem and its relatives- Deducing hidden properties if the world- Preferences among actions, toward a global agent- Knowledge engineering – introduction- Knowledge engineering and programing	
Unit-4 - Machine Learning	***9 Hour***
Learning-types of learning-Machine learning. Formal learning Model-learning via uniform convergence-convergent series-Linear Regression-Correlation-Regression Analysis-Supervised learning-learning model-unsupervised learning model-semi-supervised learning model-Reinforcement learning model-Association Rule mining – concept and terminology	
Unit-5 - Clustering and Applications	***9 Hour***
Clustering-k-means clustering-fuzzy clustering-Hierarchical clustering-cluster similarity-nearest neighborhood-distance measure-KNN algorithm-applications-Nature inspired learning-Bio-inspired models-Evolutionary Models-swarm models-applications, Machine learning for healthcare diagnostics , Disease detection system using machine learning, Clinical decision support systems and predictive analytics	

Learning Resources	1. *Stuart Jonathan Russell, Peter Norvig, Ernest Davis, "Artificial Intelligence: A Modern Approach, Prentice Hall series in artificial intelligence, Prentice Hall, 2010* 2. *Chandra S.S., Vinod, Hareendran S., Anand, "Machine Learning a Practitioner's Approach", 4th edition, Elsevier, 2006.*	3. *Vinod chandra S.S, Anand hareendran S. "Artificial intelligence and machine learning", PHI Learning; 1st edition, 2014.* 4. *Jyotir Moy Chatterjee, Vishal Jain, Machine Learning with Health Care Perspective: Machine Learning and Healthcare, Springer International Publishing,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%*	*-*	*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**
Mr. Anbuselvan T, General Manager – Sales, Wipro GE Healthcare Pvt. Ltd., Tamil Nadu, Srilanka & Maldive	*Dr. S. Poonguzhali, Professor, Centre for Medical Electronics, Anna University*	1. *Dr. T. Jayanthi, SRMIST*
		2. *Dr. Angeline Kirubha, SRMIST*

Course Code	21BME272T	Course Name	STATISTICS AND DATA SCIENCE	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 role of probability and statistics and its models in data analytics*
CLR-2:	*gain Knowledge probability distribution and basic of hypothesis testing*
CLR-3:	*learn the different data structures and their packages in Python*
CLR-4:	*utilize the Numpy library to analyze numbers, Pandas library to analyze data frames*
CLR-5:	*explore the visualization tools for different kinds of input data formats*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*Categorize various probably representation to understand the data and use probability concepts for real world data*	*3*	*3*	*2*	*3*	-	-	-	-	*1*	-	-	*1*	*1*	-	*1*
CO-2:	*Collect/make sample data and apply/ perform hypothesis test to infer the insight of resultant data*	*3*	*3*	*3*	*2*	-	-	-	-	*1*	-	-	*2*	*1*	-	*1*
CO-3:	*Distinguish the different data structures using the various packages*	*2*	*3*	*3*	*3*	-	-	-	-	*2*	-	-	*2*	*1*	-	*1*
CO-4:	*Implement the code for numbers using Numpy and Develop code for data frames using Pandas*	*3*	*3*	*2*	*2*	-	-	-	-	*2*	-	-	*2*	*1*	-	*1*
CO-5:	*Visualize different kinds of data using matplotlib and seaborn*	*3*	*3*	*3*	*3*	-	-	-	-	*3*	-	-	*2*	*1*	-	*1*

Unit -1 : Statistics – an Introduction ***9 Hour***

Role of statistics in Data science Different types of data. - Numerical Variable and Categorical Variable - Measure of Central Tendency Mean, Median - Measure of Dispersion Range, Quartiles, Standard Deviation, Variance - Distribution of Data Skewness and Kurtosis - Covariance and Correlation Difference between covariance and correlation and its significance - Introduction to Probability - Marginal probability Conditional probability - Bayes Theorem, Applications of Bayes Theorem - Problem solving Bayes theorem

T1: Descriptive statistics, Correlation Analysis in Python

T2: Probability & Bayes theorem applications in python

T3: Plotting and Analyzing distribution in python and Sampling in Python

Unit-2 - Random Variable and Distributions ***9 Hour***

Probability Distribution – Binomial, Poisson, Normal Distribution - Sampling and Estimation - Sampling Techniques – Simple random, Stratified, Systematic and Cluster sampling - Point estimate, confidence internal - Hypothesis Testing Basics Null & Alternative Hypothesis formulation - Types of hypothesis and Hypothesis testing process - Errors in hypothesis testing – Type I and Type II Power of test - Number of tails Choice of test statistic – Examples - Hypothesis Testing – Test of Mean - One sample Z Test - One sample t Test - Hypothesis Testing – Categorical vs Continuous –- More than 2 samples - Analysis of Variance - One way ANOVA - Two way ANOVA.

T4: Hypothesis testing and Case study in Python

T5: z-test and t-test in python

Unit-3 - Introduction to Data Science ***9 Hour***

Benefits and uses of Data science, Facets of data, The data science process-Introduction to Python Libraries: Numpy, creating array, attributes, Numpy Arrays objects: Creating Arrays, basic operations (Array Join, split, search, sort), Indexing, Slicing and iterating, copying arrays, Arrays shape manipulation, Identity array, eye function, Universal function, Linear algebra with Numpy, eigen values and eigen vectors with Numpy,Numpy Random: Data Distribution, Normal, Exponential, Binomial, Poisson, Uniform and Chi-Square distributions.

T7: Using Numpy implement Array Indexing and slicing *T8: Using Numpy implement Array basic operations* *T9: Using Numpy implement Linear algebra and Random package*
Unit-4 - Handling Data ***9 Hour***
Problem faced when handling large data-General techniques for handling large volume of data- General programming tips for dealing large data sets Introduction to Pandas, Data Structure in pandas – dataframe and series, Accessing and slicing of series and dataframes - Arithmetic and logical operations on dataframe, Accessing and slicing of series And dataframes - Arithmetic and logical operations on dataframe, 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, Handling missing data – Time series – date functionality, Time delta Vectorization concept implementation using pandas – I/O tools of Pandas, Indexing, multi indexing concepts - Application. Data handling – Categorical data, Integer data. Computational tools – Statistical functions, windowing operations, Chart and Table Visualization in Pandas. *T10: Building programs to access the csv files as a dataframe and analyze the dataframe.* *T11: Perform different arithmetic, logical, and filtering operations on dataframes* *T12: Perform group by, pivot and crosstab aggregation on the dataframes*
Unit-5 - Visualization ***9 Hour***
Advantages and usecases, working with Matplotlib to plot different visuals, working with Seaborn to plot different visuals, Univariate graphs for numeric and categorical data, Bivariate graphs for numeric and categorical data, Multivariate Graphs, Choosing appropriate graphical techniques, using graph to explore the data insights, Introduction to dashboards. *T13: Building programs to visualize the dataframe in matplotlib and seaborn* *T14: Building programs to visualize the univariate, bivariate and multivariate relation* *T15: Case study with all the appropriate graphs to visualize the relationship in the data*

Learning Resources	1. *Kathryn A Szabat David M. Levine, P. K. Viswanathan, David Stephan (2017). Business Statistics : A First Course, 7th Edition* 2. *Haslwanter, T. H. O. M. A. S. (2018). Introduction to Statistics with Python: with applications in the life sciences. Place of publication not identified: Springer.* 3. *Downey, A., & Green Tea Press. (2012). Think Bayes: Bayesian statistics made simple. Needham, Massachusetts: Green Tea Press* 4. *Montgomery, D.C. and Runger, G.C. (2011). Applied Statistics and Probability for Engineers, John Wiley & Sons, 5th Edition* 5. *Grus, J. (2019). Data Science from Scratch, 2nd Edition. O'Reilly Media, Inc.*	6. *Davy Cielen, Arno Meysman, Mohamed Ali – Introducing Data Science: Big Data, Machine Learning, and, more, using Python tools, ManningPublications,2016* 7. *McKinney, W. (2018). Python for data analysis: Data wrangling with pandas,NumPy, and IPython. O'Reilly Media, Inc.* 8. *Vanderplas, J. T. (2017). Python data science handbook: Essential tools for working with data. O'Reilly Media, Inc.* 9. *Magnus Lie Hetland, "Beginning Python: From Novice to Professional", Apress, Second Edition, 2005.* 10. *Shai Vaingast, "Beginning Python Visualization Crafting Visual Transformation* 11. *Scripts", Apress, 2nd edition, 2014.* 12. *7. Wes Mc Kinney, "Python for Data Analysis", O'Reilly Media, 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*	*40%*	-	*20%*	-	*40%*	-
Level 2	*Understand*	*40%*	-	*20%*	-	*40%*	-
Level 3	*Apply*	*10%*	-	*20%*	-	*10%*	-
Level 4	*Analyze*	*10%*	-	*20%*	-	*10%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*10%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
Mr. Anbuselvan T, General Manager – Sales, Wipro GE Healthcare Pvt. Ltd., Tamil Nadu, Srilanka & Maldive	*Dr. S. Poonguzhali, Professor, Centre for Medical Electronics, Anna University*	*1. Dr. A. Shobanadevi, SRMIST*
		2. Dr. M. Lakshmi, SRMIST

Course Code	21BME273T	Course Name	ARTIFICIAL NEURAL NETWORKS AND PATTERN RECOGNITION	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:	*analyze the pattern classification methods*
CLR-2:	*familiarize basic models of neural networks*
CLR-3:	*apply advanced neural network models*
CLR-4:	*describing the linear models for classification and regression*
CLR-5:	*identify the application in medical technologies*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*implement classification of patters and work with Bayes theorem*	*2*	*1*	*2*	-	-	-	-	-	-	-	-	-	*1*	-	*1*
CO-2:	*identify basic models of neural networks*	*1*	*2*	-	-	-	-	-	-	-	-	-	-	*1*	-	*1*
CO-3:	*work with advanced neural networks*	*1*	*2`*	-	-	-	-	-	-	-	-	-	-	*1*	-	*1*
CO-4:	*use linear models for classification and regression*	*2*	*1*	*1*	-	-	-	-	-	-	-	-	-	*1*	-	*1*
CO-5:	*apply neural networks and pattern recognition in biomedical application*	*2*	*2*	*2*	-	-	-	-	-	-	-	-	*2*	*1*	-	*1*

Unit -1 : Pattern Classification and Bayes Theorem	***9 Hour***
Introduction to Statistical Pattern Recognition - Overview of Pattern Classifiers - Bayesian decision making and Bayes Classifier - The Bayes Classifier for minimizing Risk -Estimating Bayes Error; Minimax and Neymann- Pearson Classifier – Parametric estimation- Implementing Bayes Classifier; Estimation of Class Conditional Densities-Nonparametric estimation, Parzen Windows, nearest neighbour methods	
Unit-2 - Artificial Neural Network model	***9 Hour***
Overview of Artificial Neural Networks-Multilayer Feedforward Neural networks with sigmoidal activation functions-Backpropagation Algorithm; Representational abilities of feedforward networks Feedforward networks for Classification and Regression; Backpropagation in Practice	
Unit-3 - Working Advanced Network Models	***9 Hour***
Self-organizing maps-Kohonen's SOM-pattern clustering-Learning vector quantization (LVQ)-Competitive models-min, max net - Radial Basis Function Networks; Gaussian RBF networks, - Learning Weights in RBF networks; K-means clustering algorithm	
Unit-4 - Linear Models for Classification and Regression	***9 Hour***
Linear Discriminant Functions; Perceptron Learning Algorithm and convergence proof - Linear Least Squares Regression; LMS algorithm - Adaline and LMS algorithm; General nonlinear least-squares regression-Linear Discriminant functions for multi-class case	
Unit-5 - Support Vector Machines and Feature Selection, Boosting	***9 Hour***
Support Vector Machines – Introduction SVM formulation with slack variables; nonlinear-SVM classifiers - Kernel Functions for nonlinear SVMs- Feature Selection and Dimensionality Reduction-Principal Component Analysis- Bootstrap, Bagging and Boosting- Classifier Ensembles; AdaBoost- Neural network- Biomedical applications -Cardiovascular, Breast tumor , EMG pattern recognition , lung cancer detection	

Learning Resources	1. *David Kriesel, "Neural Networks: Scalable and efficient NN framework, written in JAVA", 2005* 2. *Raul Rojas, "Neural Networks A systematic Introduction", Springer, Berlin Heidelberg, New York, 1996* 6. *Charu C. Aggarwal, "Neural Networks and deep learning", Springer International Publishing AG, part of Springer Nature, 2018*	4. *R.O.Duda,P.E.Hart and D.G.Stork," Pattern Classification, "John Wiley, 2002.* 5. *Christopher M. Bishop, "Pattern Recognition and Machine Learning", Springer Science+Business Media, LLC, 2006* 7. *C.M.Bishop, Neural Networks and Pattern Recognition, Oxford University Press (Indian 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**
Mr. Anbuselvan T, General Manager – Sales, Wipro GE Healthcare Pvt. Ltd., Tamil Nadu, Srilanka & Maldive	*Dr. S. Poonguzhali, Professor, Centre for Medical Electronics, Anna University*	*1. Dr. Varshini Karthik, SRMIST*
		2. Dr..A Bhargavi Haripriya, SRMIST

Course Code	21BME274T	Course Name	IoT AND SMART SENSORS	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:	*Explore the foundation of IoT and wearables in healthcare for innovative healthcare solutions*
CLR-2:	*Demonstrate IoT and wearable architecture for efficient and reliable system design*
CLR-3:	*Gain sensor expertise for accurate and meaningful data collection in IoT*
CLR-4:	*Master the product development process for turning ideas into functional devices*
CLR-5:	*Discover IoT and wearables' diverse real-world impact in biomedical industry*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*Demonstrate the framework and basic design of IoT and wearables in healthcare*	*2*	*-*	*-*	*-*	*1*	*-*	*-*	*-*	*-*	*-*	*-*	*1*	*1*	*-*	*1*
CO-2:	*Establish a sound understanding of architectural layers of IoT and wearables*	*2*	*-*	*1*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*1*	*-*	*1*
CO-3:	*Develop proficiency in sensor technology including selection criteria of sensors in IoT and wearables*	*3*	*1*	*2*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*1*	*-*	*1*
CO-4:	*Acquire skills in the product development process, including ideation, prototyping, and testing.*	*1*	*2*	*3*	*-*	*-*	*-*	*1*	*-*	*-*	*-*	*-*	*2*	*1*	*-*	*1*
CO-5:	*Explore various biomedical applications of IoT and wearables for healthcare, elderly care, fitness and well-being*	*1*	*-*	*2*	*-*	*-*	*1*	*-*	*1*	*-*	*-*	*-*	*3*	*1*	*-*	*1*

Unit -1 : Introduction to IoT and Wearables	***9 Hour***
IoT Fundamentals: Introduction to IoT, IoT Characteristics and Architectures, Enabling Technologies in IoT, IoT Frameworks and Standards, Challenges, Security, Privacy, and Energy Issues; Wearables: Role and Attributes of Wearables, Taxonomy of Wearables, Wearable Challenges and Regulations, Connectivity Options in Wearables	
Unit -2 : Architectures in IoT and Wearables	***9 Hour***
Overview of IoT Architectures, OSI Model and IoT Layers, Perception and Actuation Layer (Sensors and Actuators), Data Conditioning and Linking Layer, Network Transport and Application Layers; Wearable Device Architecture: Wearable Technology Architectures, Understanding Wearable Device Layers	
Unit -3 : Hardware Components	***9 Hour***
IoT and Wearable Sensors: Types of Sensors, MEMS Sensors, Common Sensors in IoT and Wearables, Signal Conditioning for Sensors; Microcontrollers and SoCs: Microcontrollers vs. Microprocessors, System-on- Chip (SoC) Platforms, Development Boards and Selection Criteria; Connectivity and Power: Wireless Connectivity Options, Battery Technology, Displays, Microphones, and Speakers	
Unit -4 : Product Development and Design	***9 Hour***
Product Development Process: Ideation and Research, Requirements and Specifications, Prototyping and Testing, Production; IoT and Wearable Product Requirements: Form Factor and Power Requirements, Energy Budget, Wireless Connectivity, Cost Considerations; Design Considerations: Durability, Reliability, and Usability, Aesthetics and Compatibility, Safety, Maintenance, and Security	
Unit -5 : Applications	***9 Hour***
IoT in Healthcare: Remote Patient Monitoring and Telemedicine, Wearable Health Devices (e.g., ECG monitors, Pulse oximeters); Fitness and Well-being: Wearables for Fitness Tracking and Personal Health, Smart Health Apps and Analytics, Sleep monitoring; Elderly care: Medical alert systems and Fall Detection, IoT-Based Assisted Living Solutions (e.g. for Alzheimer's and Dementia Patients); Advanced Biomedical Applications: Smart Prosthetics and Assistive Devices, Emerging Trends in Biomedical IoT; Case Studies: Case Study-I, Case Study -II.	

Learning Resources	1. *Edward Sazonov, "Wearable Sensors: Fundamentals, Implementation and Applications", 2nd edition, Elsevier, 2020.* 2. *Raad, Haider. Fundamentals of IoT and wearable technology design. John Wiley & Sons, 2020.*	3. *Morales-Narvaez and Can Dincer, Wearable Physical, Chemical and Biological Sensors : Fundamentals, Materials and Applications.Elsevier, 2022.* 4. *Onur Parlak, Alberto Salleo and Anthony Turner, "Wearable Bioelectronics", Elsevier, 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%*	-	*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**
Mr. Anbuselvan T, General Manager – Sales, Wipro GE Healthcare Pvt. Ltd., Tamil Nadu, Srilanka & Maldive	*Dr. S. Poonguzhali, Professor, Centre for Medical Electronics, Anna University*	*1. Dr. Nabarun Polley, SRMIST*
		2. Dr. N Ashwin Kumar, SRMIST

Course Code	21BME275T	Course Name	TELEHEALTH CARE INFORMATICS	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:	*know the evolution and concepts of telehealth technology*
CLR-2:	*learn the methods for handling patient information*
CLR-3:	*understand the technology associated with tele-health care system*
CLR-4:	*acquire knowledge on various applications of telehealth*
CLR-5:	*explore the possibilities of disruptive technologies associated with health care*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*understand the concepts of telehealth technology*	*1*	-	-	-	*2*	-	-	-	-	-	-	-	*1*	-	*1*
CO-2:	*manage and analyse health care information*	*1*	*1*	-	-	-	-	-	-	-	-	-	-	*1*	-	*1*
CO-3:	*demonstrate the functioning of a telehealth care system*	*2*	-	-	-	-	-	-	-	-	-	-	-	*1*	-	*1*
CO-4:	*know the various applications of telehealth*	*2*	-	-	-	*3*	-	-	-	-	-	-	-	*1*	-	*1*
CO-5:	*acquire knowledge on potential benefits of using disruptive technologies in health care*	*2*	-	-	-	*3*	-	-	-	-	-	-	-	*1*	-	*1*

Unit -1 : Genesis and development of Tele-Health Technology	***9 Hour***
Genesis and Evolution of telemedicine, Block diagram of telemedicine system, Telemedicine – types, Tele health, Tele care, Organs of telemedicine, National and International scenario, Ethical and legal aspects of Telemedicine System, benefits & limitations of telemedicine	
Unit -2 : Management of patient healthcare Information	***9 Hour***
EMR, HER, Applications of HER's in Tele-health, Data entry, Acquiring and utilizing non-textual data: images and sound, Alerts and triggers, health care data analytics, Analytics approaches	
Unit -3 : Technology considerations for Tele-health care	***9 Hour***
Infrastructure requirement, How to ensure effective communications, Video conferencing, Video-conferencing system for emergency care, Standards and certification	
Unit -4 : Tele-health Applications	***9 Hour***
Tele-surgery, Tele-cardiology, Tele-oncology, Tele-neurology, Tele-dentistry, Tele-pathology, Tele-dermatology, Tele-rehabilitation, Tele-Ophthalmology	
Unit -5 : Disruptive Technologies	***9 Hour***
Tele homecare, Tele robotics in health care and surgery, AI and IOT in health care, VR in health, Block chain, Big data	

Learning Resources	1. *Shashi Gogia, "Fundamentals of Telemedicine and Telehealth" Academic Press, 2019* 2. *H K Huang, "PACS and Imaging Informatics: Basic Principles and Applications Wiley", New Jersey, 2010.*	3. *Olga Ferrer Roca, Marcelo Sosa Iudicissa, "Handbook of Telemedicine", IOS Press, Netherland, 2002* 4. *Khandpur R S, "TELEMEDICINE – Technology and Applications", PHI Learning Pvt Ltd., New Delhi, 2017* 5. *Halit Eren (Editor), John G. Webster (Editor), "Telemedicine and Electronic Medicine" 1st Edition, CRC Press; December 1, 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%*	-	*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**
Mr. Anbuselvan T, General Manager – Sales, Wipro GE Healthcare Pvt. Ltd., Tamil Nadu, Srilanka & Maldive	*Dr. S. Poonguzhali, Professor, Centre for Medical Electronics, Anna University*	*1. Dr. D. Kathirvelu, SRMIST*
		2. Dr. D. Ashok Kumar,, SRMIST

Course Code	21BME276T	Course Name	NATURAL LANGUAGE PROCESSING FOR HEALTH CARE 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:	Explore the concepts of morphology, syntax, semantics and discourse of the language, and to recognize the significance of word level analysis.
CLR-2:	Familiarize the syntactic processing and probabilistic context-free grammars.
CLR-3:	Conceive the basics of the knowledge representation, inference, and discourse analysis.
CLR-4:	Recognize the significance of transformer-based models and develop language models.
CLR-5:	Apply the natural language processing applications in Health care and to learn how to apply basic algorithms in this field.

Course Outcomes (CO):	At the end of this course, learners will be able to:	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	Explain the text preprocessing techniques and word level analysis.	3	3	2	-	-	-	-	-	-	-	-	-	2	-	-
CO-2:	Illustrate approaches to syntax including the probabilistic context-free grammars	3	3	2	-	-	-	-	-	-	-	-	-	2	-	-
CO-3:	Analyse the approaches to semantics and discourse analysis in NLP.	3	3	2	-	-	-	-	-	-	-	-	-	2	-	-
CO-4:	Develop current models of transfer learning approaches.	3	-	-	3	3	-	-	-	-	-	-	-	2	-	-
CO-5:	Implement the Natural Language Processing applications in health care domain	-	-	2	3	3	-	-	-	-	-	-	-	-	-	-

Unit -1 : Overview and Word Level Analysis	**9 Hour**
Introduction to Natural Language Processing, Applications of NLP, Levels of NLP, Regular Expressions, Morphological Analysis, Tokenization, Stemming, Lemmatization, Feature extraction: Term Frequency (TF), Inverse Document Frequency (IDF), Modeling using TF-IDF, Parts of Speech Tagging, Named Entity Recognition, N-grams, Smoothing	
Unit -2 : Syntax Analysis	**9 Hour**
Context Free Grammars, Grammar Rules for English, Top-Down Parsing, Bottom-Up Parsing, Ambiguity, CKY Parsing, Dependency Parsing, Earley Parsing - Probabilistic Context-Free Grammars	
Unit -3 : Semantic and Discourse Analysis	**9 Hour**
Representing Meaning, Lexical Semantics, Word Senses, Relation between Senses, Word Sense Disambiguation, Word Embeddings, Word2Vec, CBOW, Skip-gram and GloVe, Discourse Segmentation, Text Coherence, Discourse Structure, Reference Resolution, Pronominal Anaphora Resolution, Coreference Resolution	
Unit -4 : Languages Models in Health Care	**9 Hour**
Recurrent Neural Networks (RNN), Long Short-Term Memory (LSTM), Attention mechanism, Transformer Based Models, Self-attention, multi-headed attention, BERT, Med BERT, BIO BERT Fine Tuning for downstream tasks, Disease classification.	
Unit -5 : Health Care NLP Applications	**9 Hour**
Introduction to Health Care Chatbot Applications, Question Answering, Summarization, Extractive Vs Abstractive Summarization, Machine Translation. Applications: Generating clinical reports, Clinical trial matching, Clinical decision support.	

Learning Resources	1. *Daniel Jurafsky and James H Martin, "Speech and Language Processing: An introduction to Natural Language Processing, Computational Linguistics and Speech Recognition", Prentice Hall, 2nd Edition, 2018.* 2. *C.Manning and H.Schutze, —Foundations of Statistical Natural Language Processing‖, MIT Press. Cambridge,MA:,1999* 3. *JamesAllen,Bejamin/cummings,—NaturalLanguageUnderstanding‖,2ndedition,1995* 4. *Cohen, Kevin Bretonnel, and Dina Demner-Fushman. Biomedical natural language processing. Vol. 11. John Benjamins Publishing Company, 2014.*	5. *Rothman, Denis. Transformers for Natural Language Processing: Build innovative deep neural network architectures for NLP with Python, PyTorch, TensorFlow, BERT, RoBERTa, and more. Packt Publishing Ltd, 2021.* 6. *http://mccormickml.com/2106/04/19/word2vec- tutorial-the-skip-gram-model/* 7. *https://nlp.stanford.edu/pubs/glove.pdf*

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*	-	-	-	-	*10%*	-
Level 6	*Create*	-	-	-	-	*10%*	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr. Anbuselvan T, General Manager – Sales, Wipro GE Healthcare Pvt. Ltd., Tamil Nadu, Srilanka & Maldive	*Dr. S. Poonguzhali, Professor, Centre for Medical Electronics, Anna University*	*1. Dr. R. Anita, SRMIST.*
		2. Dr.Subalalitha C.N , SRMIST
		3. Dr.Vani Damodaran, SRMIST

Course Code	21BME381T	Course Name	DEEP LEARNING TECHNIQUES 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:	manifest the basic DNN architecture and the need of hyper parameters tuning
CLR-2:	outline different Optimizers, Normalization, Data Augmentation and Attention mechanism
CLR-3:	delineate Different DNN Architectures- DNN, LeNet, AlexNet, VGGNet and Resnet Architectures
CLR-4:	portray Different types of recurrent and recursive networks
CLR-5:	converse recent trends in Deep learning architectures

Course Outcomes (CO):	At the end of this course, learners will be able to:	Program Outcomes (PO)												Program Specific Outcomes		
		1 Engineering Knowledge	2 Problem Analysis	3 Design/development of solutions	4 Conduct investigations of complex problems	5 Modern Tool Usage	6 The engineer and society	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	describe the basic DNN model, hyper parameters tuning and define the activation functions	1	-	2	1	1	-	-	-	2	-	-	1	-	-	1
CO-2:	narrate Different Optimization techniques and challenges in training Deep learning network	-	3	-	2	1	-	-	-	2	-	-	1	-	-	1
CO-3:	elucidate basic CNN Architecture and other LeNet, AlexNet, VGGNet & Resnet Architectures	-	2	-	2	1	-	-	-	2	-	-	1	-	-	1
CO-4:	illustrate the performance of Recurrent and Recursive Neural	-	2	-	2	1	-	-	-	2	-	-	1	-	-	1
CO-5:	discuss the recent trends in Deep learning such as U- Net, Faster RCNN, GAN and residual network	-	3	-	2	1	-	-	-	2	-	-	1	-	-	1

Unit -1 : Introduction to Deep Learning — **9 Hour**

The Neuron- Expressing Linear Perceptron's as Neurons-Linear models: SVMs, Single layer and multi-layer Perceptron- logistic regression- Linear Neurons' limitations- Simple DNN model- Activation Functions: Sigmoid, Tanh, and ReLU Neurons- Fully Connected layer-Softmax Output Layers- Deep learning libraries: Tensorflow, Keras, PyTorch- Training sets, Test Sets, Validation Sets- Hyper parameters tuning-Deep Feed-Forward Neural Network.

Unit -2 : Training Deep Neural Networks — **9 Hour**

Optimization Techniques-:Gradient Descent, The Delta Rule and Learning Rates, Batch Optimization, adaptive moment estimation (Adam), RMSProp - Backpropagation Algorithm- Stochastic and Minibatch Gradient Descent- Effective training in Deep Net: early stopping, Dropout, Batch Normalization, Instance Normalization, Group Normalization- Overfitting- Small dataset - Class imbalance Possible Solutions - Data augmentation- Redesign the loss function- Generate synthetic data- Attention Mechanism: Query, key, value - Attention function: Dot-product attention and Additive attention.

Unit -3 : Convolutional Neural Networks (CNN) — **9 Hour**

Basic CNN architecture - Convolutional layer- kernel size- stride- number of kernels- Padding options: valid padding, same padding, zero padding - Pooling layers: Max pooling, average pooling, global average pooling- Introduction to Imagenet- LeNet architecture-AlexNet architecture- VGGNet architecture-ResNet architecture

Unit -4 : Introduction to Recurrent and recursive Neural Networks (RNN) — **9 Hour**

Networks (RNNs) Basic- Understanding a Recurrent Neuron- Long Short_Term Memory(LSTM)- Gated recurrent Unit- Encoder and Decoder- Back propagation Through Time(BPTT)-Recursive Neural network- Difference between recursive and recurrent neural network

Unit -5 : Recent Trends in Deep Learning Architectures — **9 Hour**

Deep Learning Based Image Segmentation - Transposed convolution - Categorical cross entropy loss vs Dice loss -U-Net- Faster RCNN network & Application-Generative Adversarial Network-Residual Network-Skip Connection Network- Multi-Scale and Pyramid Network Based Models, Prediction Modelling techniques

Learning Resources	1. *Yuxi (Hayden) Liu, Saransh Mehta,"Hands-On Deep Learning Architectures with Python", 2019.* 2. *Charu C. Aggarwal ,"Neural Networks and Deep Learning", Springer 2018.* 3. *Ovidiu Calin" Deep Learning Architectures A mathematical approach ,Springer 2020.*	4. *Kevin P. Murphy, "Machine Learning: A Probabilistic Perspective", MIT Press, 2012.* 5. *Christopher and M. Bishop, "Pattern Recognition and Machine Learning", Springer Science Business Media, 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*	*20%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	*10%*	-	*10%*	-	*10%*	-
Level 6	*Create*	-	-	*10%*	-	*10%*	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
Mr. Anbuselvan T, General Manager – Sales, Wipro GE Healthcare Pvt. Ltd., Tamil Nadu, Srilanka & Maldive	*Dr. S. Poonguzhali, Professor, Centre for Medical Electronics, Anna University*	*1. Dr. S. P. Angeline Kirubha, SRMIST*
		2. Dr. Amrutha, SRMIST

Course Code	21BME382T	Course Name	COMPUTER VISION AND IMAGE PROCESSING	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:	*familiarize the concepts of computer vision and image formation models*
CLR-2:	*apply the texture descriptors and corner point detector in medical imaging applications*
CLR-3:	*illustrate the concepts of advanced image feature detection methods*
CLR-4:	*implement the image segmentation techniques in medical images*
CLR-5:	*analyze the medical image visualization and registration techniques using software tools*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1 Engineering Knowledge	2 Problem Analysis	3 Design/development of solutions	4 Conduct investigations of complex problems	5 Modern Tool Usage	6 The engineer and society	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*illustrate the concepts of Image formation model and Geometric camera models.*	*2*	-	-	-	-	-	-	-	-	-	-	-	*1*	-	*1*
CO-2:	*analyze the image descriptors and corner detector in medical images*	*2*	-	-	-	-	-	-	-	-	-	-	-	*1*	-	*1*
CO-3:	*implement the feature extraction techniques in medical imaging applications*	*2*	-	*2*	-	*1*	-	-	-	-	-	-	-	*1*	-	*1*
CO-4:	*apply advanced image segmentation techniques in computer vision perspective*	*2*	-	*2*	-	*2*	-	-	-	*1*	-	-	-	*1*	-	*1*
CO-5:	*demonstrate the medical image visualization techniques with suitable example*	*2*	-	*1*	-	*2*	-	-	-	*1*	-	-	-	*1*	-	*1*

Unit -1 : Introduction to Computer Vision and Image Formation	***9 Hour***
Introduction and Goals of Computer Vision, Image formation, Geometric Transformations – 2D,3D Transformations, 3D rotations, Geometric Camera Models- Single camera setup of image formation, Image formation in a stereo vision setup, Basics of stereo correspondence, Basics of digital camera	
Unit -2 : Image Descriptors	***9 Hour***
Texture descriptors – Texture representation methods, Local binary patterns, Object Boundary and Shape Representations- Chain code and shape number, Fourier descriptors, Boundary representation by B-spline curves, corner point detector- Harris corner detector, Hessian corner detector	
Unit -3 : Image Features	***9 Hour***
Histogram of oriented gradients , Scale Invariant Feature Transform (SIFT), Speeded up robust features (SURF), Features from accelerated segment test (FAST), Oriented Fast and Rotated brief feature detector, Feature maps in Convolutional Neural network, pooling layer-Max, global average	
Unit -4 : Applications of Computer Vision	***9 Hour***
Clustering for Image segmentation- Unsupervised clustering for image segmentation - K Means, Mean shift ,Hierarchical Agglomerative clustering (HAC), Fuzzy c-means clustering, Supervised clustering for image segmentation- Support vector machine (SVM), Random forest classifier, Graph partitioning method, Vision based hand Gesture recognition system	
Unit -5 : Medical Image Visualization and Registration	***9 Hour***
Fundamentals of Medical Image Visualization- Scalar image visualization, direct volume rendering, Vector image Visualization, Software tools for medical image visualization- 3D slicer, Image Registration- Rigid Transformation, Non rigid transformation, Image fusion, 3D modeling	

Learning Resources	1. *Bhuyan M.K. Computer Vision and Image processing: Fundamentals and applications, CRC Press 2020* 2. *Richard Szeliski, Computer Vision: Algorithms and applications, Springer 2nd Edition, 2021 .*	3. *Liang Zhou, Mengjie Fan, Charles Hansen, Chris R. Johnson, and Daniel Weiskopf. A Review of Three- Dimensional Medical Image Visualization. Health data Science Journal, Volume 2022, Article ID 9840519,*

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**
Mr. Anbuselvan T, General Manager – Sales, Wipro GE Healthcare Pvt. Ltd., Tamil Nadu, Srilanka & Maldive	*Dr. S. Poonguzhali, Professor, Centre for Medical Electronics, Anna University*	*1. Dr. U.Snekhalatha, SRMIST*
		2.Dr.Nijisha Shajil, SRMIST

Course Code	21BME383T	Course Name	ROBOTICS AND SMART 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	*Biomedical Engineering*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*develop the foundational knowledge about robotics and sensors, laying the groundwork for future exploration of robotics in healthcare*
CLR-2:	*grasp knowledge of the core components of robotic control systems in healthcare.*
CLR-3:	*develop the ability to design precise and efficient robots for diverse applications*
CLR-4:	*identify the advancement of smart technologies and their role in biomedical robotics*
CLR-5:	*understand the ethical, regulatory, and legal complexities that underpin the development of biomedical robotics.*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*explore the fundamentals of robotics, and the role of sensors in biomedical robotics*	*1*	-	-	-	-	-	-	-	-	-	-	-	*1*	-	*1*
CO-2:	*understand the required/essential components of any robotic system and designing aspect of its control system*	*1*	-	-	-	-	-	-	-	-	-	-	-	*1*	-	*1*
CO-3:	*equip students with solving kinematic and dynamic problems in robotics focused on human lower limb*	*2*	-	*2*	-	-	-	-	-	-	-	-	-	*1*	-	*1*
CO-4:	*explain the different smart technologies and its integration in robotics for rehabilitation*	*2*	-	*1*	-	-	-	-	-	-	-	-	-	*1*	-	*1*
CO-5:	*illustrate the different key components of advanced biomedical robotics structure along with the ethical, regulatory, and legal challenges associated with it.*	*2*	-	*2*	-	-	-	-	*1*	-	-	-	*1*	*1*	-	*1*

Unit -1 : Introduction to Robotics and Sensors	***9 Hour***
Automation and robotics, Robot anatomy, Basic structure of robots and its classification, standard terminologies related to robotics, Point to point and continuous path systems. Sensors and Instrumentation in robotics: Tactile sensors, proximity and range sensors, Force, and torque sensors. Application of sensors in robotics.	
Unit -2 : Fundamental Components of Robotic Control Systems	***9 Hour***
Components of robotic system; Hydraulic systems; DC servo motors; Basic control systems concepts; models and its components; Control system analysis; Robot activation and feedback components.	
Unit -3 : Kinematic and Dynamic Analysis of Robotic Systems	***9 Hour***
Robot joints, The direct kinematics problem, The inverse kinematics solution, Lagrange-Euler formation, Generalized D'Alembert equations of motion, Denavit-Hartenberg convention and its Applications.	
Unit -4 : Smart Technologies in Biomedical Robotics	***9 Hour***
Introduction to different smart technologies in robotics, IoT-Integrated Robotics in the Health Sector, Architecture and components of IoT-integrated robots, AI integrated robotic application: A smart mobility assistive robots. Humancentric smart assistive robotic interface: for lower limb and for upper limb.	
Unit -5 : Development of Biomedical Robotics and Ethical Issues	***9 Hour***
Surgical Robotics: Robotic-assisted surgery in ophthalmology; Remote Diagnosis and Teleoperated Robotic Surgery; Wearable Sensors and Devices for Health Monitoring; Robotics in biomedical: Regulatory, ethical, and legal considerations	

Learning Resources	1. *Nikku, S.B., Introduction to Robotics, Prentice Hall of India Private Limited (2002).* 2. *Schilling. R. J., Fundamentals of Robotics: Analysis and Control, Prentice Hall of India Private Limited (2006).* 3. *J. Craig, "Introduction to Robotics: Mechanics and Control," 3rd Edition, Pearson Prentice Hall (2005)* 4. *Gonzalex, R. C. and Fu, K. S., Robotics Control Sensing, Vision and Intelligence, McGraw Hill (2004).*	5. *Saha S.K., Introduction to Robotics, McGraw Hill, Second Edition (2014).* 6. *Izonin, I., Ribino, P., Ebrahimnejad, A., & Quinde, M. (2023). Smart technologies and its application for medical/healthcare services. Journal of Reliable Intelligent Environments, 9(1), 1-3.* 7. *Gupta, D., Sharma, M., Chaudhary, V., & Khanna, A. (Eds.). (2021). Robotic Technologies in Biomedical and Healthcare Engineering. CRC Press.* 8. *Yang, G. Z., Cambias, J., Cleary, K., Daimler, E., Drake, J., Dupont, P. E., ... & Taylor, R. H. (2017). Medical robotics—Regulatory, ethical, and legal considerations for increasing levels of autonomy. Science Robotics, 2(4), eaam8638.*

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**
Mr. Anbuselvan T, General Manager – Sales, Wipro GE Healthcare Pvt. Ltd., Tamil Nadu, Srilanka & Maldive	*Dr. S. Poonguzhali, Professor, Centre for Medical Electronics, Anna University*	*1. Dr.G.Anitha , SRMIST*
		2. Dr. Rohit Gupta, SRMIST

Course Code	21BME384T	Course Name	BRAIN COMPUTER 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:	*Describe the neuronal activity in motor cortex and related areas*
CLR-2:	*Discriminate the basic concepts of neural recording with chronically implanted microelectrodes*
CLR-3:	*Analyze the various applications of Brain Computer Interface (BCI)*
CLR-4:	*Identify the ethical issues in Brain computer interface research*
CLR-5:	*Analyze the future of Brain computer interface*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1 Engineering Knowledge	2 Problem Analysis	3 Design/development of solutions	4 Conduct investigations of complex problems	5 Modern Tool Usage	6 The engineer and society	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*Identify the different modes of acquiring EEG signal*	*1*	-	-	-	-	-	-	-	-	-	-	*1*	*1*	-	*1*
CO-2:	*Demonstrate chronic recording performance of intracortical microelectrode arrays*	*1*	-	-	-	-	-	-	-	-	-	-	*1*	*1*	-	*1*
CO-3:	*Analyze various BCI based supplemented games*	*2*	-	-	-	-	-	-	-	-	-	-	*2*	*1*	-	*1*
CO-4:	*Describe several BCI research to help people with disabilities*	*2*	-	-	-	-	-	-	*2*	-	-	-	*2*	*1*	-	*1*
CO-5:	*Demonstrate the different signal acquisition hardware*	*2*	-	-	-	-	-	-	-	-	-	-	*2*	*1*	-	*1*

Unit -1 : Brain Signals for Brain Computer Interfaces (BCIs)	***9 Hour***
Neuronal activity in motor cortex and related areas – Overview of brain anatomy – The time dimension – Encoding dimension – Complexity dimension – The source dimension – EEG recording – EEG Electrodes – Bipolarity of EEG recording – Electrode montage – Avoiding, recognizing, and eliminating non-brain signals (Artifacts)	
Unit -2 : BCI Design, Implementation and Operation	***9 Hour***
Overview of implantable microelectrodes for BCIs - Basic concepts of Neural recording with chronically implanted microelectrodes – How a recording microelectrodes registers signals – Factors that influence neural signals fidelity in chronic neural recordings – Factors that introduce noise in chronic recordings – Chronic recording performance of intracortical microelectrode arrays – Brain tissue responses to intrcortical microelectrode arrays	
Unit -3 : BCI Applications	***9 Hour***
Optimizing conventional performance – Attention – Workload – Emotion – Enhancing conventional performance – Object detection – Other possible BCI – based performance enhancements – Broadening of enriching life experience – Artistic expression – Games – BCI based games – BCI supplemented games	
Unit -4 : Ethical issues in BCI Research	***9 Hour***
BCI research to help people with disabilities – Beneficence – Doing good and not doing harm – The need for multidisciplinary expertise and collaboration – Ensuring quality of care – Ensuring accessibility of results – Invasive BCI Research - Moving from animals to humans - Studying BCI use by people with disabilities – Respect for person - Informed consent	
Unit -5 : The Future of BCIs	***9 Hour***
The most important problems – Signal Acquisition Hardware – Non-invasive BCIs – Implanted (Invasive) BCIs – Validation and Dissemination - Comparing different signals and methods – The value of a clinical focus – The problem of dissemination – Reliability – Adaption – Distribution of control – Signals from multiple areas and additional sensory inputs	

Learning Resources	1. *Panigrahi, Narayan,"Brain Computer Interface", 1st edition, Taylor and Francis Ltd, 2022.* 2. *idu Sahu, G R Sinha, "Brain and Behavior Computing", CRC Press, 2021.*	3. *Jonathan R. Wolpaw, Elizabeth Winter Wolpaw, "Brain-Computer Interface – Principles and Practice", 1st edition, Oxford University Press, 2012.* 4. *Damien Coyle, "Brain-Computer Interfaces-Lab experiments to real world applications", 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 (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**
Mr. Anbuselvan T, General Manager – Sales, Wipro GE Healthcare Pvt. Ltd., Tamil Nadu, Srilanka & Maldive	*Dr. S. Poonguzhali, Professor, Centre for Medical Electronics, Anna University*	1. *Dr. P. Muthu, SRMIST*
		2. *Dr.Gnanavelu,SRMIST*

Course Code	21BME481T	Course Name	BIOMIMETICS AND BIO-INSPIRED 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	*Biomedical Engineering*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*describe biomimetic of medical materials*
CLR-2:	*demonstrate biomimetic design of biosensors*
CLR-3:	*illustrate bioinspired wearable devices*
CLR-4:	*analyze the bioinspired design on bio signal analysis*
CLR-5:	*discover the clinical applications of bioinspired design*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*elaborate the various biomimetic materials*	*1*	-	-	-	-	-	-	-	-	-	-	-	*1*	-	*1*
CO-2:	*describe biomimetic design using biosensors*	*1*	-	-	-	*1*	-	-	-	-	-	-	-	*1*	-	*1*
CO-3:	*discover bioinspired wearable device*	*1*	-	*2*	-	*2*	-	-	-	-	-	-	-	*1*	-	*1*
CO-4:	*elaborate the various bio signal using bioinspired design*	*1*	-	*1*	-	*1*	-	-	-	-	-	-	-	*1*	-	*1*
CO-5:	*demonstrate the clinical applications of bioinspired design*	*1*	-	*1*	-	-	-	-	-	-	-	-	-	*1*	-	*1*

Unit -1 : Biomimetic Medical Materials ***9 Hour***

Nanomaterials as emerging biomimetic materials, biomimetic material in tissue engineering, biomimetic medical materials and stem cell, functional biomaterials,3D bio printing biomaterials, Applications of biomimetic biomaterials, 3D bio printing biomaterials of artificial pancreas.

Unit -2 : Biomimetic Design of Biosensors ***9 Hour***

Miniature sensor in biomimetic robots, MEMS –Based Flow Detector Mimicking Hair cells with cilium, collision Avoidance using whiskers, Emulating Bats Acoustic sensor, Acoustic and elastic wave sensors, Fire monitoring, Sense of smell and artificial nose, Sense of taste and artificial tongue

Unit -3 : Bioinspired Wearable Device ***9 Hour***

Wearable device for personalized mobile healthcare monitoring, wearable sensor for upper limb monitoring, and Wearable smart textile for telemedicine intervention of movement disorder -Powered Height Sensor With ZigBee Networks for Intelligent Systems, Bioinspired e-skin systems for wearable devices

Unit -4 : Bioinspired design on Bio Signal Analysis ***9 Hour***

Need For HMI-Understanding Disability, Principles of HMI, Vision based HMI design-Introduction, Affective Computing based HMI-Data Acquisition, Affective Computing based HMI-Data Classification ECG based HMI design, EOG based HMI design- Signal Acquisition, Signal Analysis, Signal Classification, Applications, EEG based HMI design

Unit -5 : Clinical Application of Bioinspired Design ***9 Hour***

Introduction to Bioelectric Interfaces, Myoelectric interface, Muscle regions and responsibilities, Bioinspired artificial muscle based on dielectric elastomers, Bioinspired Engineering of multifunctional devices, Nature inspired engineering, Biomedical engineering for drug delivery ,Multivalent binding based cell targeting therapy and gene delivery for cancer ,Drug delivery system using self-assembly- environmentally responsive materials.

Learning Resources	1. *Yoseph Bar-Cohen,"Biomimetics biologically inspired technologies", Published by CRC press Taylor and francis group, 2006* 2. *Esmaiel Jabbari, Deak Ho Kim ,Luke plee, Amir Ghaemmaghami,"Handbook of Biomimetics and Bioinspiration", World scientific series in nanoscience nanotechnology, Vol 9, 2014.* 3. *Maki Habib, "Handbook of Research on Biomimetics and Biomedical Robotics", IGI Global's InfoSci platform, 2017*	4. *Sandy B primrose,"Biomimetics, Nature inspired design", John willy and ltd 2020* 5. *Insup noh editor, "Biomimetic medical meterials from nanotechnology to 3D printing", Springer nature singapore 2018.* 6. *Helen Sharp, Yvonne Rogers, Jennifer Preece,"Interaction Design: beyond human-computer interaction", Fifth Edition, Published by John Wiley & Sons, Inc 2018.* 7. *Raymond K.Y Tong, "Wearable technology in medicine and healthcare", Elsevier, 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**
Mr. Anbuselvan T, General Manager – Sales, Wipro GE Healthcare Pvt. Ltd., Tamil Nadu, Srilanka & Maldive	*Dr. S. Poonguzhali, Professor, Centre for Medical Electronics, Anna University*	*1. Dr.T.Jayanthi , SRMIST*
		2. Dr. .Lakshmi Prabha.P, SRMIST

Course Code	21BME482T	Course Name	BIOMECHANICAL MODELING AND SIMULATION	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:	*express the basic modeling and simulation procedures on medical images*
CLR-2:	*describe the principles of finite element analysis (FEA)*
CLR-3:	*apply the modeling and simulation concepts in lower limb bone.*
CLR-4:	*implement the modeling and simulation procedures in spine*
CLR-5:	*define the dynamics of multi rigid musculoskeletal system*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*apply the modeling and simulation concepts on medical images*	*1*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*1*	*-*	*1*
CO-2:	*implement the finite element analysis method in different structures*	*1*	*1*	*1*	*-*	*1*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*1*	*-*	*1*
CO-3:	*evaluate the modeling and simulation analysis in hip joint*	*2*	*2*	*2*	*-*	*1*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*2*	*-*	*1*
CO-4:	*analyze the effect of biomechanical modeling and simulation in spine*	*2*	*2*	*2*	*-*	*1*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*1*	*-*	*2*
CO-5:	*employ the modeling and simulation of multi rigid body dynamics*	*2*	*2*	*2*	*-*	*1*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*1*	*-*	*2*

Unit -1 : Modeling and Simulation	***9 Hour***
Need for Modeling- Image Acquisition - Three-Dimensional Modeling of Musculoskeletal System based on Medical Images – Modeling- Image Preprocessing - 3D Model Reconstruction- Case studies.	
Unit -2 : Finite Element Analysis	***9 Hour***
Introduction: Finite element analysis (FEA) and Finite difference method - Basic equations in elasticity- Matrix displacement formulation- Element shapes- Nodes and nodal unknowns- Shape functions-Strain Displacement matrix -Assembling stiffness matrix-Discretization of structures – Case studies.	
Unit -3 : Biomechanical Modeling and Simulation of Lower Limb	***9 Hour***
Biomechanics of the Hip Joint - Finite Element Model of the Hip Joint – Meshing - Biomechanical Evaluation - Biomechanical Simulation – Case studies	
Unit -4 : Biomechanical Modeling and Simulation of Spine	***9 Hour***
Biomechanics Model of Cervical Spine - Modeling and Simulation of Artificial Disc Replacement - Definition of Material and Section Properties – Meshing - Definition of Contacts and Constraints – Post Processing – Case studies.	
Unit -5 : Modeling and Simulation of Multi-rigid Body Dynamics	***9 Hour***
Introduction to Dynamics of Multi-rigid Body System - Geometric Reference for Human Modeling - Motor Units of Human Body - Multi-rigid Body System Modeling of Human Musculoskeletal System -Case studies.	

Learning Resources	1. *Yubo Fan, Lizhen Wang, "Biomechanical modelling and Simulation on Musculoskeletal System", Springer,1st Edition. 2021.* 2. *Susan J Hall, "Basic Biomechanics", Tata Mcgraw hill, 7th Edition, 2014.* 3. *Gerhard A. Holzapfel,Ray W. Ogden" Biomechanics:Trends in Modeling and Simulation", 1st Edition, 2014.*	4. *Cees Oomens, Marcel ,Brekelmans, Frank Baaijens, and John J. W. van Osch "Biomechanics: Concepts and Computation" 2nd Edition,2018* 5. *Tirupathi R. Chandrupatla, Ashok D. Belegundu, "Introduction to Finite Elements in Engineering", Pearson education, 1st Edition, 2011.* 6. *S.S. Bhavikati, "Finite Element Analysis", New Age International Ltd, 1st 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 (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**
Mr. Anbuselvan T, General Manager – Sales, Wipro GE Healthcare Pvt. Ltd., Tamil Nadu, Srilanka & Maldive	*Dr. S. Poonguzhali, Professor, Centre for Medical Electronics, Anna University*	*1. Dr. D. Ashok Kumar, SRMIST*
		2. Mrs.Oinam Robita Chanu, SRMIST

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