B. Tech in Biomedical Engineering

2018 Regulations

Professional Elective Courses (O)

Department of Biomedical Engineering
SRM Institute of Science and Technology
SRM Nagar, Kattankulathur – 603203, Kancheepuram District, Tamilnadu

Course Code	18BME261T	Course Name	BIOPHOTONICS AND BIOIMAGING	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:	Learning

		Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	To Know the concepts of spectroscopy			
CLR-2 :	To Know the concepts of various biosensors			
CLR-3 :	Outline the various applications of biosensors in medicine			
CLR-4 :	To understand the concepts of various microscopes used in medicine			
CLR-5 :	Acquire knowledge on the treatment mechanism of Phototherapy			
CLR-6 :	To understand the special techniques like optical holography			
Course Learning Outcomes (CLO):	At the end of ***this*** course, learners will be able to:			
CLO-1 :	Implement spectroscopy for biological imaging	1, 2	80	70
CLO-2 :	Implement the various applications of biosensors in medicine	1, 2	80	70
CLO-3 :	Implement Microscopy in medical diagnosis	2	80	70
CLO-4 :	Identify the principle behind modern imaging techniques	1	80	70
CLO-5 :	Describe the medical applications of phototherapy	1	80	70
CLO-6 :	Analyze the physics behind optical holography	1,2	80	70

Program Learning Outcomes (PLO)														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
M	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	M	-	-	-	-	-	-	-	M	M	-	-
-	-	-	M	-	-	-	-	-	-	-	M	M		-
-	-		M	-	-	-	-	-	-	-	M	-	M	-
-	-	-	M	-	-	-	-	-	-	-	M	-	-	-
-	-	-	-	-	-	-	-	-	-	-	H	-	-	-

Duration (hour)		*Light - Matter Interaction &Principle Of Optics*	*Optical Biosensors*	*Bio-Imaging*	*Photodynamic Therapy*	*Optical Holography*
		9	9	9	9	9
S-1	SLO-1	Concepts of Light matter interaction	Biosensors: Definition	Introduction of optical imaging	Basics of radiation therapy	Fundamentals – Object wave
	SLO-2	Interactions Between Light and a Molecule	Block diagram & description	Needs of optical imaging	Basic principles	Photography
S-2	SLO-1	Interaction of light with bulk matter	Principles of Optical Bio sensing	Microscopy: Principles	Mechanism of Photodynamic Photo oxidation	Holography
	SLO-2	Fate of Excited State	Bio recognition	Types of microscopy: Transmissionmicroscopy	Photosensitizers For Photodynamic Therapy	Interference during recording
S-3	SLO-1	Spectroscopy: Principles	Optical Transduction	Fluorescence microscopy	Photosensitizers For Photodynamic Therapy	Diffraction during reconstruction
	SLO-2	System description	Fluorescence Sensing, FluorescenceEnergy Transfer Sensors	Scanning microscopy	Mechanism of photodynamic action	Imaging techniques –In line hologram

S-4	**SLO-1**	*Types of spectroscopy*	*Molecular Beacons, Optical Geometries of Bio sensing*	*Inverted and Upright Microscopes*	*Three Principal Mechanisms of Photodynamic Therapy*	*Off axis hologram, Fourier hologram*
	SLO-2	*Conventional Spectrometers*	*Immobilization of bio-recognition elements*	*Confocal Microscopy*	*Light Irradiation For Photodynamic Therapy*	*Fraunhofer hologram, Reflection hologram*
S-5	**SLO-1**	*Fourier Transform Spectrometers*	*Fiber optic Biosensors*	*Multi-photon- microscopy*	*Light sources*	*Optical properties of holographic imaging*
	SLO-2	*Michelson interferometer*	*Operating principles of Fiber optic Biosensors*	*Optical Coherence Tomography*	*Laser dosimetry*	*Hologram of an object*
S-6	**SLO-1**	*Electronic absorption spectroscopy*	*Types of optical biosensor: Fiber optic Biosensor*	*Total Internal Reflection Fluorescence Microscopy*	*Light delivery*	*Image equation, Angular magnification*
	SLO-2	*Types of Electronic Transitions*	*Planar waveguide Biosensor*	*Near-Field Optical Microscopy*	*Two-Photon Photodynamic Therapy*	*longitudinal magnification, Imageaberrations*
S-7	**SLO-1**	*Electronic luminescence spectroscopy*	*Evanescent Wave Biosensors*	*Fluorescence Resonance Energy Transfer (FRET) Imaging*	*PUVA technique*	*Properties of light source -spectral bandwidth*
	SLO-2	*Electronic luminescence spectroscopy*	*Principle of Evanescent Wave Biosensors*	*Fluorescence Lifetime Imaging Microscopy (FLIM)*	*PUVA technique*	*Image plane holograms*
S-8	**SLO-1**	*Vibrational spectroscopy*	*Interferometric biosensor*	*Advantages and disadvantages of optical imaging*	*Applications of PDT*	*Image luminance- Without pupil*
	SLO-2	*Principle of Vibrational spectroscopy*	*Surface plasmon resonance Biosensor*	*Applications of Bio imaging, Fluorophores as Bio imaging Probes*	*Applications of PDT*	*With pupil, Image plane holograms*
S-9	**SLO-1**	*Fluorescence spectroscopy*	*Applications of optical Biosensors in medicine*	*Green Fluorescent Protein, CellularImaging*	*Advantages of PDT*	*Speckles- diffuser*
	SLO-2	*Fluorescence Correlation Spectroscopy*	*Advantages and Disadvantages*	*Tissue Imaging, In Vivo Imaging*	*Disadvantages of PDT*	*Resolution, Incoherent illumination*

Learning Resources	*1. Wilson J and Hawkes J.F.B, "Optoelectronics – An Introduction", Prentice Hall of India Pvt. Ltd., NewDelhi, 3rd edition, 2003.* *2. Leon Goldman, M.D., & R.James Rockwell, Jr., Lasers in Medicine, Gordon and Breach Science PublishersInc., 1975.*	*3. Tuan Vo Dirh, Biomedical Photonics – Handbook, CRC Press, Bocaraton, 2003.* *4. Paras N, Prasad, "Introduction to Biophotonics", John Wiley & Sons, FirstEdition, 2003.* *5. Gerhard K. Ackermann, Jürgen Eichler, "Holography: A Practical Approach", WILEY-VCH Verlag GmbH & Co, first edition, 2008.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*40 %*	-	*40 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*20 %*	-	*20 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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 & Maldives	*Dr. S. Poonguzhali, Professor, Centre for Medical Electronics, Anna University*	*1.Dr.P.Vinupritha,SRMIST*

Course Code	18BME262T	Course Name	HOME MEDICARE TECHNOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning		
		1	2	3
CLR-1 :	Utilize the Home health Nursing practice	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-2 :	Utilize homecare care working with different clients			
CLR-3 :	Utilize the various medical devices used at home			
CLR-4 :	Utilize the advancement in medical technologies			
CLR-5 :	Utilizte the use of wireless technology in health care			
CLR-6 :	Utilize the various mode of healthcare technology at home			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:			
CLO-1 :	Applying Home health Nursing practice	3	80	75
CLO-2 :	Illustrate the homecare care working with different clients	3	80	70
CLO-3 :	Analyze the various medical devices used at home	3	75	70
CLO-4 :	Identify the advancement in medical health technologies	3	80	75
CLO-5 :	Analyze the use of wireless technology in health care	3	80	70
CLO-6 :	Describe the various type of healthcare technology at home	3	80	70

Program Learning Outcomes (PLO)															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
L	-	-	-	-	-	-	-	-	-	-	-	L	-	L
L	-	-	-	-	-	-	-	-	-	-	-	L	-	L
M	-	-	-	-	-	-	-	-	-	-	-	L	-	L
M	-	-	-	-	-	-	-	-	-	-	-	L	-	L
M	-	-	-	-	-	-	-	-	-	-	-	L	-	L
L	-	-	-	-	-	-	-	-	-	-	-	L	-	L

Duration (hour)		Introduction to Home health Nursing	Working With Clients	Medical Devices At Home	Advancement In Medical Technologies	Wireless Technology
		9	9	9	9	9
S-1	SLO-1	Home health care – purpose	Basic human needs	Medical devices at home	Advances and trends in health care technologies	Wireless communication basics
	SLO-2	Organization of homecare system	Communication and interpersonal skills	Medical devices at home	Advances and trends in health care technologies	Wireless communication basics
S-2	SLO-1	Historical development of home care	Caregiver observation	ECG monitors	Driver impacting the growth of medical Technologies	Types of wireless network
	SLO-2	Environmental influences of home care	Caregiver observation	ECG monitors	Driver impacting the growth of medical Technologies	Types of wireless network
S-3	SLO-1	Home care Organization	Recording and reporting, confidentiality.	Smart watch	Impact of Moore"s law of medical imaging-	Body area network
	SLO-2	Legal and ethical issues in home care	Recording and reporting, confidentiality.	Smart watch	Impact of Moore"s law of medical imaging	Body area network
S-4	SLO-1	Case management and leadership strategies	Working with elderly – aging and body systems.	Wireless infant monitoring system	E-health and personal healthcare	Emergency rescue
	SLO-2	Organisation of home care system	Working with elderly – aging and body systems.	Wireless infant monitoring system	E-health and personal healthcare	Emergency rescue
	SLO-1	Home care organization	Working with children	PCG monitors,	Defining the future of health Technology	Remote recovery

S-5	**SLO-2**	*Home care organization*	*Working with children*	*PCG monitors,*	*Defining the future of health Technology*	*Remote recovery*
S-6	**SLO-1**	*Role of home care nurse and orientation*	*Need for home care*	*Medical alert services.*	*Inventing the future -tools for self-health*	*Personalized ambient monitoring*
	SLO-2	*Role of home care nurse and orientation strategies*	*Need for home care*	*Medical alert services.*	*Inventing the future -tools for self-health*	*Personalized ambient monitoring*
S-7	**SLO-1**	*Environmental influences on home care*	*Mobility transfers and ambulation*	*Activity monitors*	*Future of Nano fabrication molecular scaledevices*	*Future trends in healthcare technology.*
	SLO-2	*Environmental influences on home care*	*Mobility transfers and ambulation*	*Automatic wireless healthcare monitoringsystem*	*Future of Nano fabrication molecular scaledevices*	*Future trends in healthcare technology.*
S-8	**SLO-1**	*Infection control in home*	*Range of motion exercises*	*The ventilator dependent patient*	*Future of telemedicine*	*Multi model interaction and technologies forcare at home*
	SLO-2	*Infection control in home*	*Range of motion exercises,*	*Device for patient with congestive heart failure*	*Future of telemedicine*	*Multi model interaction and technologies forcare at home*
S-9	**SLO-1**	*Patient education in home.*	*Skin care and comfort measures*	*Device for Patient with chronic Obstructive pulmonary disease*	*Future of medical computing*	*Cost of home healthcare*
	SLO-2	*Patient education in home.*	*Skin care and comfort measures*	*Device for patient with Diabetic Mellitus*	*Future of medical computing*	*Direction for emerging technology*

Learning Resources	*1. Robyn Rice, "Home care nursing practice: Concepts and Application", 4th edition, Elsevier, 2006.* *2. 2. LodewijkBos, "Handbook of Digital Homecare: Successes and Failures", Springer, 2011.*	*3.* Yadin David, Wolf W. von Maltzahn, Michael R. Neuman, Joseph. D,Bronzino,"Clinical Engineering", CRC Press, 2010. *4.* Kenneth J. Turner, "Advances in Home Care Technologies: Results of the match Project", Springer, 2011.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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		2. Mrs.Lakshmi Prabha.P, SRMIST

Course Code	18BME263T	Course Name	CELLULAR AND MOLECULAR BIOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR): *The purpose of learning this course is to:*

		Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	Have an idea about the basics of cells			
CLR-2 :	Know the basic aspects of cell structure and functions			
CLR-3 :	Learn the principles of cell signaling and cell regulation			
CLR-4 :	To understand the concept of molecular biology			
CLR-5 :	Understand the concept behind DNA and RNA			
CLR-6 :	Learn about cell replication and repair			

Course Learning Outcomes (CLO): *At the end of **this** course, learners will be able to:*

		Learning			Program Learning Outcomes (PLO)													
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design,Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	Explain the basics of cell and its structure	1, 2	80	70	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	Describe the basic concepts of cell structure and its function	1, 2	80	70	-	-	-	M	-	-	-	-	-	-	-	M	M	-	-
CLO-3 :	Implement the various processes of cell signaling and cell regulation	2	80	70	-	-	-	M	-	-	-	-	-	-	-	M	M		-
CLO-4 :	Understand the concept of molecular biology	1	80	70	-	-		M	-	-	-	-	-	-	-	M	-	M	-
CLO-5 :	Explain the structures and paring of DNA and RNA	1	80	70	-	-	-	M	-	-	-	-	-	-	-	M	-	-	-
CLO-6 :	Apply the recent advancements in cell repair and replication	1,2	80	70	-	-	-	-	-	-	-	-	-	-	-	H	-	-	-

Duration (hour)		*An Overview Of Cells*	*Cell Structure And Function*	*Cell Signaling –Cell Regulation*	*Introduction To MolecularBiology– DNA And RNA*	*Replication And Repair*
		9	*9*	*9*	*9*	*9*
S-1	SLO-1	Origin and evolution of cells	Introduction to Nucleus	General principles of cell signaling	Scope and history	Replication in prokaryote and eukaryote
	SLO-2	Origin and evolution of cells	Endoplasmic reticulum	Modes of cell	Structure of DNA	Types and function of DNA
S-2	SLO-1	Evolution of metabolism	Golgi apparatus and Lysosomes	Cell signaling	Nucleoside	Polymerases
	SLO-2	Origin of Prokaryotes	Golgi apparatus and Lysosomes	Pathways of intracellular signal transduction	Nucleotide	Proof reading activity
S-3	SLO-1	Origin of Eukaryotes	Bioenergetics and Metabolism	Function of cell surface receptors	Base pairing	5´- 3´ exonuclease activity
	SLO-2	Development of multicellular organisms	Mitochondria	G-protein coupled receptor pathway(GPCR) pathway	Base stacking	Topoisomerase activity
S-4	SLO-1	Development of multicellular organisms	Chloroplasts	Cyclic adenosine 3',5'-monophosphate (cAMP) pathway	Double helix	Telomeric DNA replication and Plasmid replication
	SLO-2	Cells as experimental models	Peroxisomes	Receptor protein tyrosine kinase pathway	Features of Watson and crick model	Theta model

S-5	**SLO-1**	*Tools of cell biology*	*The cytoskeleton and cell movement*	*Mitogen-activated protein kinase (MAPK) pathway*	*Major and minor groove*	*Strand replacement model*
	SLO-2	*Tools of cell biology*	*Cell surface*	*Cell division : Cell cycle*	*Supercoiling*	*Rolling circle model*
S-6	**SLO-1**	*Molecular composition*	*Transport of small molecules*	*Mitosis - Stages of mitosis*	*Twist*	*DNA repair*
	SLO-2	*Biosynthesis of cellular constituents*	*Endocytosis*	*Meiosis - Meiosis I and Meiosis II*	*Writhe and linking number*	*Nucleotide excision repair*
S-7	**SLO-1**	*Central role of enzymes as biocatalysts*	*Cell –cell interactions*	*Cell death: Necrosis*	*Forms of DNA*	*Mismatch repair*
	SLO-2	*Central role of enzymes as biocatalysts*	*Cell –cell interactions*	*Programmed cell death*	*A, B, Z - Structure and function of RNAs*	*Photo-reactivation*
S-8	**SLO-1**	*Metabolic energy*	*Adhesion junctions*	*Apoptosis*	*mRNA*	*Recombination repair*
	SLO-2	*Metabolic energy*	*Tight junctions*	*Extrinsic pathway, Intrinsic pathway*	*rRNA*	*Recombination repair*
S-9	**SLO-1**	*Cell membrane*	*Gap junctions*	*Cell differentiation: Stem cells-embryonicstem cells*	*tRNA*	*SOS repair*
	SLO-2	*Cell membrane*	*Plasmodesmata*	*Adult stem cells, therapeutic applications ofstem cells*	*Secondary structures in RNA*	*SOS repair*

Learning Resources	1. *Channarayappa, "Cell biology," Universities Press, 2010* 2. *Rastogi, S.C, "Cell biology," New Age International publishers, 2005.*	

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*40 %*	-	*40 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*20 %*	-	*20 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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..Vinupritha, SRMIST*

Course Code	18BME264T	Course Name	BIOMEDICAL LASER INSTRUMENTS	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:	Learning		
CLR-1 :	Know the functioning of a laser system			
CLR-2 :	Learn about the working principle of laser	1	2	3
CLR-3 :	Learn the optical characteristics of tissue	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-4 :	Familiarise the applications of laser in Urology, Gynecology and dentistry			
CLR-5 :	Learn the non- thermal applications of laser in medicine			
CLR-6 :	Acquire knowledge on laser safety and management			
Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:			
CLO-1 :	Have a deep understanding on technical aspects of a LASER system	3	80	75
CLO-2 :	Learn about the working principle of laser	3	80	70
CLO-3 :	Describe the optical properties of tissues	3	75	70
CLO-4 :	Describe the applications of laser in Urology, Gynecology and dentistry	3	80	75
CLO-5 :	Explain the non- thermal applications of laser in medicine	3	80	70
CLO-6 :	Implement the aspects of laser safety	3	80	70

Program Learning Outcomes (PLO)														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design,Research	Modern Tool Usage	Society & Culture	Environment &Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
M	-	-	-	-	-	-	-	-	-	-	-	M	-	-
-	M	-	-	-	-	-	-	-	-	-	-		M	
-	M	-	-	-	-	-	-	-	-	-	-	M		
-	-M	-	-	-	-	-	-	-	-	-	-	M		
-	-	-	-	-	-	-	M	-	-	-	-	L		

Duration (hour)		Laser System	Types Of Laser	Mechanism Of Laser TissueInteraction	Laser Applications	Non Thermal Applications Of LaserAnd Laser Safety Management
		9	9	9	9	9
S-1	SLO-1	Absorption and Emission of Radiation by atoms	Classification of Laser	Photochemical interaction	Disorders in Eye	Optical coherence tomography
	SLO-2	Ions and Molecules	Solid state Laser Construction	Bio stimulation	Diagnostic and Therapeutic Applications of laser in ophthalmology	System description
S-2	SLO-1	Laser - Definition	Working principle	Thermal interaction	Dermatological disorders	Applications of Optical coherence tomography
	SLO-2	Properties of laser	Atomic laser Construction	Heat generation	Applications of Lasers in dermatology	Laser Induced Fluorescence (LIF)-Imaging,
S-3	SLO-1	Characteristics of Laser	Working principle	Heat transport	Diagnostic Applications of Lasers in cardiology	FLIM Raman Spectroscopy and Imaging
	SLO-2	Construction and working principle of lasersystem	Molecular Laser Construction	Heat effects	Therapeutic Applications of Lasers incardiology	FLIM – Holographic and speckle
	SLO-1	Mono-chromaticity, Coherence	Working principle	LASER induced interstitial thermotherapy (LITT)	Lasers in Surgery	Laser hazards

S-4	**SLO-2**	*Directionality, Brightness*	*Dye Laser Construction*	*Photoabalation*	*Tissue welding andSoldering*	*Laser hazards*
S-5	**SLO-1**	*Pumping mechanism*	*Working principle*	*Model, cytotoxicity of UV radiation*	*Lasers in urology- Lithotripsy*	*Laser hazards classification*
	SLO-2	*Optical pumping*	*Semiconductor Laser Construction*	*Plasma induced ablation*	*Therapeutic applications of Lasers in urology*	*Laser hazards classification*
S-6	**SLO-1**	*Electrical pumping*	*Working principle*	*Model, analysis of plasma parameters*	*Laparoscopy- System description*	*Laser hazards to eye and skin*
	SLO-2	*Laser pumping, Levels of laser*	*Gas Laser Construction*	*Photo distribution*	*Applications of laser in Gynecology*	*Viewing laser radiation*
S-7	**SLO-1**	*Resonators*	*Working principle*	*Plasma formation*	*Applications of laser in Gynecology*	*Non beam hazards*
	SLO-2	*Q-switching*	*Chemical Laser Construction*	*Shock wave generation*	*Applications of laser in laryngeal surgery*	*Non beam hazards*
S-8	**SLO-1**	*Methods of Q-switching*	*Working principle*	*Shock wave generation*	*Applications of laser in Otology*	*Laser safety control*
	SLO-2	*Gain switching*	*Metal-vapor lasers construction*	*Cavitation*	*Applications of laser in neurology*	*Laser signage*
S-9	**SLO-1**	*Mode locking and its types*	*Working principle*	*Jet formation.*	*Applications of Lasers in dentistry*	*Laser risk management*
	SLO-2	*Cavity damping*	*Free-electron laser construction and working*	*Jet formation.*	*Applications of Lasers in Orthopedics*	*Good laser safety practices*

Learning Resources	1. *Leon Goldman, M.D., & R.James Rockwell, Jr., Lasers in Medicine, Gordon and BreachScience Publishers Inc., 1975.* 2. *Abraham Katzir, Lasers and Optical Fibers in Medicine, Academic Press Edition,1998.* 3. *Markolf H.Niemz, "Laser Tissue Interaction-Fundamentals and Applications", Springer,Third edition, 2007.*	4. *Tuan Vo Dirh, Biomedical Photonics – Handbook, CRC Press, Bocaraton, 2003.* 5. *Glasser, O., Medical Physics -- Vol 1, 2, 3 Adam Hilgar Brustol Inc, 1987.* 6. *G.David Baxter, Therapeutic Lasers – Theory and practice, Churchill Livingstone Publications*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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.Vinupritha, SRMIST*

Course Code	18BME265T	Course Name	ARTIFICIAL ORGANS AND TISSUE ENGINEERING	Course Category	E	Professional Electives	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Basic Biology and Biomaterials	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Biomedical Engineering	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	To study the learners to acquire knowledge to the basic properties of biomaterials and various biomaterials used in biomedical applications.	Learning			Program Learning Outcomes (PLO)														
CLR-1 :	learn the fundamentals of various organs	1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-2 :	Study the different biomaterials used in artificial organs	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLR-3 :	Acquire basic knowledge of various types of artificial organs																		
CLR-4 :	Familiarize with basic biological system in human system																		
CLR-5 :	Obtain the concept of different types biomaterials applied in-vitro test tissue engineering application																		
CLR-6 :	Have an Gain the knowledge about technology transfer and ethical problem																		
Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:																		
CLO-1 :	Understand the basic Knowledge of artificial organs	1, 2	80%	70%	L				L							L			M
CLO-2 :	Analyze various types of materials used in implant applications.	2	80%	70%	L				M							M			M
CLO-3 :	Explain the process of importance of Tissue organization	2	80%	70%	L				M							L			M
CLO-4 :	Select appropriate class of polymers using scaffold applications	3	80%	70%	M											L	M	M	
CLO-5 :	Understand the concepts different types biomaterials applied in-vitro and in-vivo biomedical implant application.	3	80%	70%	M											M	M	M	
CLO-6 :	Apply the various biomaterials used in implants and artificial organs	3	80%	70%	M		M	H										M	M

		Basics of artificial organ	Types of Artificial organs	Basics concepts of tissue engineering	Types and application of tissue engineering	Recent advancement of tissue engineering
Duration (hour)		9	9	9	9	9
S-1	SLO-1	Introduction -artificial organ	Introduction to Biomaterials in Ophthalmology	Introduction to Tissue engineering	Scaffolds for tissue engineering	Immunochemical techniques in tissue engineering and biomaterial science
	SLO-2	Immunological considerations	Anatomy of eye	Cell source	Classes of potential scaffold materials	Basic immunological principles
S-2	SLO-1	Blood transfusion	Viscoelastic solution	Types of cell Sources	The criteria for an ideal scaffold	Common immunochemical techniques usedin biomaterials
	SLO-2	Artificial kidney	Contact lenses	Three-dimensional interactions	Polymer scaffolds	Immunochemical applications in biomaterial science and tissue engineering research
S-3	SLO-1	Cardiovascular organ	Optical implants	Cells as therapeutic Agents with examples,Cell numbers and growth rates.	Polymer scaffolds applications	Clinical applications of tissue engineering
	SLO-2	Vascular organ	Scleral buckling materials for retinaldetachment	Tissue organization	Bioactive ceramic scaffolds	Cell source, Stable 3D constructs
S-4	SLO-1	Cardiac pacemakers	Artificial exchange systems: Blood viscosity	Tissue Components,	Bioactive ceramic scaffolds and its applications	Cartilage
	SLO-2	Introduction to Kidney organ	Effects of shear on blood cells	Tissue types, Functional subunits.	Substrate Scaffold Materials	Tendons, ligaments and bone

S-5	**SLO-1**	*Artificial Kidney*	*Blood–air interactions*	*Tissue Dynamics, Dynamic states of tissues*	*Nano Composites*	*Regeneration in the cardiovascular system*
	SLO-2	*Artificial Lung*	*Blood flow in artificial devices*	*Homeostasis in highly prolific tissues andTissue repair. Angiogenesis*	*Control of architecture*	*3D printing techniques in cardiac stent andbone scaffold*
S-6	**SLO-1**	*Liver implant*	*Exchangers*	*Measurement of cell characteristics - cell morphology*	*A guide to basic cell culture and applications in biomaterials and tissue engineering*	*Regulatory classification of biomaterialsand medical devices*
	SLO-2	*Artificial Pancreas*	*Hemodialysis*	*Cell number and viability*	*sterilization of scaffolds*	*Classification of medical devices*
S-7	**SLO-1**	*Bone, Bone Marrow, and Hands*	*Soft Tissue Applications*	*Cell-fate processes, cell motility,*	*Sterilization methods*	*Differences between FDA and EU regulations*
	SLO-2	*Skin and Hair organ*	*Bulk space fillers*	*Cell function.*	*Cell culture protocols*	*How do companies get through the FDA Process?*
S-8	**SLO-1**	*Artificial ear*	*Maxillofacial implants*	*Cell-extracellular matrix interactions -*	*Basic techniques for assessment of cell viability*	*Technology transfer and Technology transfer paths*
	SLO-2	*Artificial Nose*	*Fluid transfer implants*	*Binding to the ECM, Modifying the ECM, .*	*culture environment*	*Efficient technology transfer and Factorsaffecting rapid technology transfer*
S-9	**SLO-1**	*Regeneration and Potential Future Uses forStem Cells*	*Functional load-carrying and supportingimplants*	*Malfunctions in ECM signaling*	*maintenance of cells in vitro, cryopreservation*	*Ethical issues, The ethical problem and Moral uncertainties*
	SLO-2	*Ethical consideration*	*Microencapsulation of live animal cells*	*Direct Cell-Cell contact - Cell junctions in tissues, malfunctions in direct cell-cell contact Signaling.*	*Regeneration stimulated electrically*	*Principles of distributive justice, Sources of conflict and Specific ethical concerns about biomaterials*

Learning Resources	1. Larry L. Hench and Julian R. Jones, Biomaterials, artificial organs and tissue engineering, CRC Press 2010 2. Sujata V. Bhat "Biomaterials" springer 2002

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*40 %*	-	*40 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*20 %*	-	*20 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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.Gnanavel, SRMIST*

Course Code	18BME266T	Course Name	BIOMEDICAL NANOTECHNOLOGY	Course Category	E	Professional Electives	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	To study the learners to acquire knowledge to the basic propertiesof biomaterials and various biomaterials used in biomedical applications.
CLR-1 :	Attain the knowledge on different synthesis method and application of Nano material
CLR-2 :	Study the phenomena various characterization techniques used in Nano material method
CLR-3 :	Acquire knowledge on Nanotubes and its applications
CLR-4 :	Acquire knowledge importance of nanotechnology based biomedical diagnostics
CLR-5 :	Familiarize with biological system, prosthetic and medical implants in nanotechnology
CLR-6 :	Have an Gain the knowledge about nano material used in biomedical application

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1 :	Explain the familiarity with different synthesis method and application of Nano material in medical application	1, 2	80%	70%	L				L							L			M
CLO-2 :	Analyze the phenomena taking various characterization techniques used in Nano material method	2	80%	70%	L				M							M			M
CLO-3 :	Explore the technology of Nanotubes and its applications	2	80%	70%	L				M							L			M
CLO-4 :	Explain the process of importance of nanotechnology based biomedical diagnostics	3	80%	70%	M											L	M	M	
CLO-5 :	Select appropriate class of Nano materials using knowledge of, prosthetic and medical implants in nanotechnology	3	80%	70%	M											M	M	M	
CLO-6 :	Understand the concepts of biomedical application of different organic particles	3	80%	70%	M		M	H										M	M

		Nano materials preparation techniques	Characterization techniques of Nano Material	Nanotubes and its applications	Biomedical implants in nanotechnology	Organic - Inorganic nanoparticles and is applications
Duration (hour)		9	9	9	9	9
S-1	SLO-1	Introduction - synthesis Nano material	Introduction to Nano scale phenomena	Introduction to carbon Nano tube and its types	Introduction to prosthesis and implants	Introduction to Nano-bio conjugates
	SLO-2	Types of bulk synthesis Material	Nano particle determination	Carbon Nano tube for biomedical application	Nano materials used in Neural implant	Nano-bio conjugates and their significance
S-2	SLO-1	Top Town approaches	Introduction to characterization techniques	Introduction to Improved diagnosis by in vivo imaging	Recent and advancement in Neural implant	Introduction -Nano Biodegradable material
	SLO-2	Bottom up approaches	X-Ray diffraction method	Types of In vivo imaging and its application	Nano materials and coating used in HIPimplant	Nano Biodegradable material for biomedical application
S-3	SLO-1	Insert Gas condensation techniques	Particles size determination	Detection of tumors for Nano materials	Recent and advancement in Hip implant	synthesis methods of Magnetic nanoparticles
	SLO-2	Application of gas condensation techniques	Principle of Scanning electron microscopy	Nano particle using drug delivery system	Knee implant coating in Nano technology	Magnetic nanoparticles for biomedical application
S-4	SLO-1	Types of Physical Vapour deposition Method	Construction and working of SEM	Different types in drug delivery system	Recent advancement in Knee implant	Multi-functional inorganic Nano particles
	SLO-2	Sputtering Techniques	Application of SEM	Nano particle using genetic defect diagnostics	Nano materials and coating used in Dentalimplant	Multi-functional inorganic Nano particles for biomedical application
S-5	SLO-1	Evaporation techniques	Energy dispersive X-ray spectroscopy	Introduction to Nano robotic medical devices	Recent advancement in Dental implant	Carbon nano tube (CNT) based inorganicNano particles

	SLO-2	*Chemical evaporation techniques*	*EDS Using elemental analysis*	*Application of Nano robotic medical devices*	*Nano Technology in ocular implant*	*Biomedical application of CNT based inorganic Nano particles.*
S-6	**SLO-1**	*Laser ablation method*	*Principle and working of Transmissionelectron microscope*	*Cantilever Sensors in biomedical application.*	*Recent advancement in Ocular implant*	*Carbon nano tube (CNT) based organic Nano particles*
	SLO-2	*Pulsed laser deposition*	*Application of TEM*	*Introduction to Nano material in medical imaging*	*Nano Technology in ear implant*	*Biomedical application of CNT based organic Nano particles.*
S-7	**SLO-1**	*Introduction to chemical synthesis*	*Principle and working of atomic forcemicroscope*	*Magnetic resonance imaging based contrast reagent used in Nano particles*	*Recent advancement in ear implant*	*Introduction to Nano biosensor*
	SLO-2	*Sol gel process and micro emulsion method*	*Application of AFM*	*Organic Nano particles and Its applications*	*Artificial skin in Nano material*	*Nano Biosensor: Fabrication methods*
S-8	**SLO-1**	*Hydrothermal process and wet chemical*	*Fourier transform infrared (FTIR) spectroscopy and its application*	*Nanoprobes for CT images*	*Introduction to regenerative medicine in Nano technology*	*Nano Materials based in breathing gassensor*
	SLO-2	*Spray pyrolysis Techniques*	*Application of Scanning probe microscopy(SPM)*	*Different types of nanoprobe in CT image*	*Tissue engineering in nanotechnology*	*Fabrication of breathing gas sensor*
S-9	**SLO-1**	*Spin coating methods*	*Contact angle measurement*	*PET based contrast reagent used as a Nano particle.*	*Nano fiber scaffold technology*	*Glucose Nano sensor for Diabetic diagnostics*
	SLO-2	*Electrochemical deposition method*	*Nano indentation techniques*	*SPET based contrast reagent used as a Nano particle.*	*Nano fiber scaffold technology in Biomedical application*	*Nano oxygen sensor and its application.*

Learning Resources	1.W.Gaddand, D.Brenner, S.Lysherski and G.J.Infrate(Eds.), "Handbook of NanoScienceEngineering and Technology", CRC Press, 2013 2.K. Barriham, D.D. Vvedensky, "Low dimensional semiconductor structure fundamental and device applications", Cambridge University Press, 2010.. REFERENCE BOOKS / OTHER READING MATERIAL 1.Cao,G,Nanostructures Nanomaterials Synthesis: Properties Applications", Imperial College Press, 2011. Brian, R Eggins; Wiley; New York, Chichester, 3rdedition,2012 2.Allen J Bard and Larry R Faulkner; Wiley, "Electrochemical Methods: Fundamentals and Applications", New YorkChichester, 4th edition, 2009 3. David Wild; "The Immunoassay Handbook", Elsevier, 4thedition, 2013.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*40 %*	-	*40 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*20 %*	-	*20 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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.Gnanavelu, SRMIST*

Course Code	18BME267T	Course Name	BIOMETRICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning			Program Learning Outcomes (PLO)													
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	Understand the basics of biometric systems	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO – 1: Professional	PSO – 2: Project Management	PSO – 3: Analyze& Reseach
CLR-2 :	Acquire the knowledge about the finger print and hand geometry recognition																		
CLR-3 :	Utilize the knowledge in face recognition system																		
CLR-4 :	Identify the applications of biometrics in gait recognition.																		
CLR-5 :	Analyze the concepts of voice biometrics																		
Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:																		
CLO-1 :	Analyze the performance and characteristics of biometric systems	3	80	75	M												M		
CLO-2 :	Explain the image processing techniques used in finger print technology	3	80	70	M													M	
CLO-3 :	Illustrate the concepts of face recognition system in 2D and 3D imaging	3	75	70	M														M
CLO-4 :	Implement the gait algorithm in gait recognition process and perform on line signature verification using image processing techniques	3	80	75			M												M
CLO-5 :	Analyze the concept of palm print identification system	3	80	70				M											M
CLO-6:	Explain the application of voice biometrics technology	3	80	70				M											M

		Fundamentals of biometrics	Finger print and Hand geometry recognition	Face Recognition	Gait Recognition and Palm print identification	Voice biometrics
Duration (hour)		9	9	9	9	9
S-1	SLO-1	Introduction to biometrics	Introduction to finger print technology	Face recognition -Introduction	Gait -Introduction	Voice biometrics-Technology
	SLO-2	Definition and Evolution	General description		Human ID gait challenge problem	
S-2	SLO-1	Operation of biometric systems	Finger print sensing-optical sensors	Techniques-Eigen faces, Linear discriminant analysis	Base line gait Algorithm	Identity information in the speech signal
	SLO-2	Block diagram description	Solid state sensor and ultrasound sensors	Independent component analysis , Local feature analysis	Base line gait Algorithm	Language generation and speech production
S-3	SLO-1	Biometric functionalities	Feature extraction-segmentation	Face recognition databases-FRGC,FERET	Recognition Approaches-Temporal alignment	Feature extraction and Tokenization-shortterm analysis
	SLO-2	Verification vs identification	Enhancement, minutiae extraction	PIE, AR,Yale face database	Shape based approach	parameterization
S-4	SLO-1	Performance of biometric systems	Finger print matching-correlation basedmethods	Advanced correlation filters	Palm print identification system-block diagram	Phonetic and word Tokenization
	SLO-2		Rigid feature based techniques	Kernel class dependent analysis	Image preprocessing techniques	Prosodic Tokenization
S-5	SLO-1	Biometric system errors-failure to acquire	Performance evaluation-finger printverification competition	Support vector machine for classification	Feature extraction	Text dependent speaker recognition-classification
	SLO-2	Failure to enroll	Finger print vendor technology evaluation	Algorithm	Feature matching	Databases and benchmarks
S-6	SLO-1	Benefits of biometrics	Synthetic finger print generation	Tensor faces method-multilinear analysis of training images	Online signature verification	Text –independent speaker recognition-shortterm spectral systems
	SLO-2	Parameters of good biometrics	Securing finger print based biometric systems	multilinear analysis of testing images	Architecture	Idiolectal systems
S-7	SLO-1	Application of biometrics-Forensics	Hand geometry: Historical perspective	3D sensor and data for face recognition	Data acquisition and preprocessing	Phonotactic systems
	SLO-2	Government, commercial	Modern hand reader		Feature extraction and enrolment	Prosodic systems
S-8	SLO-1	Characteristics of biometrics	Processing steps –hand capture, processing	3D Face image processing-smoothing	Similarity computation	Applications of voice biometrics-voice authentication

	SLO-2	*Commonly used biometrics characteristics*	*Classification, template adaptation*	*Local feature extraction*	*Matching*	*Speaker detection*
S-9	SLO-1	*Accuracy in biometric systems*	*Performance metrics*	*Representation and features for 3d face recognition- Global and local set point model*	*Resources for online signature verification systems-Reference systems*	*Strength of voice biometrics*
	SLO-2	*Legal consideration in use of biometricsystems*	*Standardization*	*Deformation model*	*On-line signature databases*	*Weakness*

Learning Resources	1. *Anil K jain, Patrick Flynn, Arun A. (Eds.), Handbook of Biometrics, Springer, 2008.* 2. *John D. Woodward, Jr. Nicholas M. Orlans Peter T. Higgins, "Biometrics", dreamtech, 2003* 3. *J. Wayman, A. Jain, D. Maltoni and D. Maio (Eds.), Biometric Systems: Technology, Design and Performance Evaluation, Springer, 200*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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*

Course Code	18BME361T	Course Name	BioMEMS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR): The purpose of learning this course is to:

CLR-1 :	Understand the fundamental principles of microsensors and microactuators
CLR-2 :	Get an idea about the materials used in MEMS and fabrication processes
CLR-3 :	Acquire an idea about the micromachining
CLR-4 :	Get an idea about the biomedical application of MEMS in POCT
CLR-5 :	Get an idea about the research based development in the area of BioMEMS
CLR-6 :	Understand the different biomedical application of MEMS

Course Learning Outcomes (CLO): At the end of this course, learners will be able to:

		Learning: 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)
CLO-1 :	Analyze the working principle of MEMS & Microsystems in healthcare domain	1, 2	80	70
CLO-2 :	Explain the micro system fabrication processes and materials used for MEMS	1, 2	80	70
CLO-3 :	Differentiate the various Micromanufacturing techniques	2	80	70
CLO-4 :	Illustrate the concepts of BioMEMS in POCT	1	80	70
CLO-5 :	Illustrate the concepts of BioMEMS with suitable examples	1	80	70
CLO-6 :	Outline the research areas in the field of BioMEMS	1,2	80	70

Program Learning Outcomes (PLO)

CLO	1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2	M	-	-	-	-	-	-	-	-	-	-	-	M	-	-
CLO-3	-	-	L	-	-	-	-	-	-	-	-	-	M		-
CLO-4	-	-	L	-	-	-	-	-	-	-	-	-	-	M	-
CLO-5	-	-	L	-	-	-	-	-	-	-	-	-	-	-	-
CLO-6	-	-	L	-	-	-	-	-	-	-	-	-	-	-	-

Duration (hour)		MEMS and Microsystem	MEMS Materials and Fabrication Processes	Overview of Micro-manufacturing	BioMEMS-1	BioMEMS-2
		9	9	9	9	9
S-1	SLO-1	MEMS and microsystems- Introduction	Substrates and wafers	Micro-Machining- Introduction	Introduction to BioMEMS	Microcantilever BioMEMS
	SLO-2	Typical MEMS and microsystem products	Silicon as a substrate material	Micromachining Techniques	Home Pregnancy Test	Basic Principles of Sensing Biomechanical Interactions
S-2	SLO-1	Difference between MEMS and Microsystems	Silicon compounds, Silicon piezoresistor	Bulk Micromanufacturing (BM)	Lab on a Chip	Detection Modes of Biomechanical Interactions- Static Mode
	SLO-2	Application of Microsystems in healthcareindustry	Gallium arsenide, Quartz	Steps in Bulk Micromanufacturing	Lab on a cellphone	Detection Modes of Biomechanical Interactions- Dynamic Mode
S-3	SLO-1	Working Principles for Microsensor	Piezoelectric crystals, Polymers	Construction of a Microcantilever using BM	Mobile Point of Care Monitors	Fabrication and Functionalization of Microcantilevers
	SLO-2	Types of microsensors: Chemical Sensors	Packaging materials	Types of Etching process in bulk micromanufacturing	DNA Sensors	Fabrication and Functionalization of Microcantilevers
S-4	SLO-1	Biomedical Sensors & Biosensor	Photolithography	Types of Etching process in bulk micromanufacturing	Drug Delivery- Insulin Delivery	Tissue scaffold fabrication using MEMSapproaches
	SLO-2	Optical Sensors	Ion implantation	Surface Micromachining (SM)	Artificial Retinal Prosthesis	Tissue scaffold fabrication using MEMSapproaches
S-5	SLO-1	Pressure Sensors	Diffusion	Construction of a Microcantilever using SM	Endoscopic Wireless Pill	Applications of MEMS-fabricated tissuescaffold
	SLO-2	Pressure Sensors	Oxidation	Steps in Surface Micromachining	Medtronic Reveal	Applications of MEMS-fabricated tissuescaffold

S-6	**SLO-1**	*Thermal Sensor*	*Chemical vapor deposition (CVD)*	*Steps in Surface Micromachining*	*Microsystem Approaches to PCR*	*Paper-Based Microfluidic Devices*
	SLO-2	*Acoustic Wave Sensors*	*Types of CVD*	*LIGA*	*Microsystem Approaches to PCR*	*Paper-Based Microfluidic Devices*
S-7	**SLO-1**	*Working Principle for Microactuator*	*Physical vapor deposition (PVD)*	*Steps in LIGA process*	*Implantable Microelectrodes*	*Lens-Based Glucose Sensor*
	SLO-2	*Actuation using Thermal Forces*	*Types of PVD*	*Difference between LIGA, SM, BM*	*The Michigan Probes*	*Lens-Based Glucose Sensor*
S-8	**SLO-1**	*Actuation using Shape-Memory Alloys, Piezo-Electric Crystals*	*Epitaxy*	*Difference between LIGA, SM, BM*	*The Utah Electrode Array*	*Catheter based sensors*
	SLO-2	*Actuation using Electrostatic Forces, Magnetic field*	*Types of Epitaxy*	*Applications of LIGA*	*Microfabricated Cochlear Implants*	*Catheter based sensors*
S-9	**SLO-1**	*Application of Microactuations*	*Etching*	*Applications of Surface Micromachining*	*Microfabricated Electrocorticography Arrays*	*Microneedles*
	SLO-2	*Application of Microactuations*	*Types of Etching*	*Applications of Bulk Micromachining*	*Microelectrodes for Visual Prostheses*	*Types of Microneedles*

Learning Resources	*1. Tai-Ran Hsu, "MEMS & Microsystems- Design, Manufacture and Nanoscale Engineering John Wiley & Sons, 2nd Edition, 2008* *2. NitaigourPremchandMahalik, "MEMS", Tata McGraw Hill, 2nd Reprint, 2008* *3. Steven S.Saliterman, "Fundamentals of BioMEMS & Medical Microdevices", International Society for Optical Engineering, 1st Edition, 2006* *4. Ellis Meng, "Biomedical Microsystems", CRC Press, 1st Edition, 2011* *5. Simona Badilescu and Muthukumaran Packirisamy, "BioMEMS Science and Engineering Perspectives", CRC Press, 1st Edition, 2011* *6. Albert Folch, "Introduction to BioMEMS", CRC Press, 1st Edition, 2013*	*7. Wanjun Wang & Steven A.Soper, "BioMEMS- Technologies and applications", CRC Press, 1st Edition, 2007* *8. Walter Karlen and Krzysztof Iniewski, "Mobile Point-of-Care Monitors and Diagnostic Device Design", CRC Press, 1st Edition, 2015* *9. Chao-Min Cheng, Chen-MengKuan & Chien-Fu Chen, "In-Vitro Diagnostic Devices: Introduction to Current Point of Care Diagnostic Devices", Springer, 1st Edition, 2016* *10. Mel L. Mendelson, "Learning Bio-Micro-Nanotechnology", CRC Press, 1st Edition, 2013*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*40 %*	-	*40 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*20 %*	-	*20 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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. Ms Oinam Robita Chanu, SRMIST*

Course Code	18BME362T	Course Name	BIOTRANSPORT PHENOMENON	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:*

		Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	To expose the students to the fundamental physics, modeling of transport phenomena in biological systems			
CLR-2 :	To understand the momentum, heat and mass transport phenomena in biological systems			
CLR-3 :	To employ various coordinate systems for transport phenomena problems			
CLR-4 :	To enable the learners to formulate conservation equations			
CLR-5 :	To enable the learners to apply the mathematical techniques to solve conservation equations			
CLR-6 :	To solve the conservation equations in transport phenomena			

Course Learning Outcomes (CLO):	At the end of **this** course, learners will be able to:	Learning			Program Learning Outcomes (PLO)													
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	To identify the mechanism and fundamentals behind the transport phenomena in biological systems	1, 2	80	70	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	To develop an equation for momentum, heat and mass transport process in biological systems	1, 2	80	70	-	-	-	M	-	-	-	-	-	-	-	M	M	-	-
CLO-3 :	To visualize the various coordinate systems in transport phenomena	2	80	70	-	-	-	M	-	-	-	-	-	-	-	M	M		-
CLO-4 :	To formulate conservation equations of transport phenomena in biological systems	1	80	70	-	-		M	-	-	-	-	-	-	-	M	-	M	-
CLO-5 :	To apply mathematical techniques to solve the conservation equations	1	80	70	-	-	-	M	-	-	-	-	-	-	-	M	-	-	-
CLO-6 :	To understand the complex transport phenomena in biological systems	1,2	80	70	-	-	-	-	-	-	-	-	-	-	-	H	-	-	-

Duration (hour)		Rheology of Biological Fluids	Macroscopic/Shell Balance Approach for One-Dimensional Bio-fluid Transport	Microscopic Approach for Bio fluid Transport	Fundamentals and macroscopic approach to Bio-heat transfer	Mass Transfer
		9	9	9	9	9
S-1	SLO-1	Introduction - Solids and Fluids	Shell Momentum Balances and Velocity Distributions in Laminar Flow: Shell momentum balances and boundary conditions, Flow of a falling film.	The equation of continuity	Heat Transfer Fundamentals Modes of Heat transfer: Conduction, Convection and Thermal Radiation Thermal Resistance in Conduction Thermal Resistance in Convection Biot Number	Diffusivity and the Mechanisms of Mass Transport: Fick's law of binary diffusion (Molecular Mass Transport). Temperature and pressure dependence of diffusivities
	SLO-2	Introduction - Solids and Fluids	Shell Momentum Balances and Velocity Distributions in Laminar Flow: Shell momentum balances and boundary conditions, Flow of a falling film.	The equation of continuity	Heat Transfer Fundamentals Modes of Heat transfer: Conduction, Convection and Thermal Radiation Thermal Resistance in Conduction Thermal Resistance in Convection Biot Number	Diffusivity and the Mechanisms of Mass Transport: Fick's law of binary diffusion (Molecular Mass Transport). Temperature and pressure dependence of diffusivities

S-2	**SLO-1**	*Flow Regimes: Laminar and Turbulent Flow Boundary Conditions*	*One-Dimensional Shell Balances in Cylindrical Coordinates*	*The equation of motion for Newtonian fluids*	*Heat Transfer with Phase Change Steady and Unsteady-State*	*Concentration Distributions in Solids and in Laminar Flow : Shell mass balances; boundary conditions, Diffusion through a stagnant gas film*
	SLO-2	*Flow Regimes: Laminar and Turbulent Flow Boundary Conditions*	*One-Dimensional Shell Balances in Cylindrical Coordinates*	*The equation of motion for Newtonian fluids*	*Heat Transfer with Phase Change Steady and Unsteady-State*	*Concentration Distributions in Solids and in Laminar Flow : Shell mass balances; boundary conditions, Diffusion through a stagnant gas film*
S-3	**SLO-1**	*Viscous Properties of Fluids*	*Shell Momentum Balances and Velocity Distributions in Laminar Flow: Flow through a circular tube,*	*The equation of motion for Newtonian fluids*	*Macroscopic Heat Transfer Applications*	*Diffusion with a heterogeneous chemical reaction, Diffusion with a homogeneous chemical reaction*
	SLO-2	*Viscous Momentum Flux and Shear Stress*	*Shell Momentum Balances and Velocity Distributions in Laminar Flow: Flow through a circular tube,*	*The equation of motion for Newtonian fluids*	*Macroscopic Heat Transfer Applications*	*Diffusion with a heterogeneous chemical reaction, Diffusion with a homogeneous chemical reaction*
S-4	**SLO-1**	*Newtonian and*	*Flow through an annulus*	*Use of Navier – stokes equations in rectangular coordinates – Hydrostatics, reduction of equations of motion*	*Radiation: Flame Burn Injury*	*Diffusion and chemical reaction inside a porous catalyst Equations of Change for Multicomponent Systems: The equations of continuity for a multicomponent mixture, Use of the equations of change for mixtures*
	SLO-2	*Non-Newtonian Fluid Models*	*Flow through an annulus*	*Use of Navier – stokes equations in rectangular coordinates – Hydrostatics, reduction of equations of motion*	*Human Thermoregulation*	*Diffusion and chemical reaction inside a porous catalyst Equations of Change for Multicomponent Systems: The equations of continuity for a multicomponent mixture, Use of the equations of change for mixtures*
S-5	**SLO-1**	*Rheology of Biological Fluids*	*Shell Momentum Balances and Velocity Distributions in Laminar Flow: Flow of two adjacent immiscible fluids*	*Use of Navier – stokes equations in rectangular coordinates – Hydrostatics, reduction of equations of motion*	*Steady-State Conduction with Heat Generation in a Slab, cylinder*	*Analogies between momentum, heat and mass transport*
	SLO-2	*Rheological Properties of Extravascular Body Fluids - Blood*	*Shell Momentum Balances and Velocity Distributions in Laminar Flow: Flow of two adjacent immiscible fluids*	*Use of Navier – stokes equations in rectangular coordinates – Hydrostatics, reduction of equations of motion*	*Steady-State Conduction with Heat Generation in a Slab, cylinder*	*Analogies between momentum, heat and mass transport*
S-6	**SLO-1**	*Rheology - Biorheology and Disease*	*Laminar flow in a narrow slit*	*Use of Navier – stokes equations in rectangular coordinates – Hydrostatics, reduction of equations of motion*	*Steady-State Conduction with Heat Generation in a Slab, cylinder*	*Convection, Diffusion, and Chemical Reaction*
	SLO-2	*Rheology - Biorheology and Disease*	*Laminar flow in a narrow slit*	*Use of Navier – stokes equations in rectangular coordinates – Hydrostatics, reduction of equations of motion*	*Steady-State Conduction with Heat Generation in a Slab, cylinder*	*Transcapillary Exchange of O2 and CO2 -*
S-7	**SLO-1**	*Fluid Inertia*	*Flow of a Casson Fluid Through a Circular Cylinder*	*Navier – stokes equations in cylindrical and rectangular coordinates and its applications in Newtonian flow*	*Heat Exchange in Tissue: Transient and Steady-State Pennes Equation*	*Tissue Solute Exchange*
	SLO-2	*Fluid Inertia*	*Flow of a Casson Fluid Through a Circular Cylinder*	*Navier – stokes equations in cylindrical and rectangular coordinates and its applications in Newtonian flow*	*Heat Exchange in Tissue: Transient and Steady-State Pennes Equation*	*Tissue Solute Exchange*

S-8	***SLO-1***	*Blood Flow in Organs*	*Flow of a Casson Fluid Through a Circular Cylinder*	*Constitutive Relationships for Non-Newtonian Fluids*	*General Microscopic Formulation of Conservation of Energy*	*Krogh Cylinder - Bioreactors One-Dimensional*
	SLO-2	*Blood Flow in Organs*	*Flow of a Casson Fluid Through a Circular Cylinder*	*Constitutive Relationships for Non-Newtonian Fluids*	*General Microscopic Formulation of Conservation of Energy*	*Krogh Cylinder - Bioreactors One-Dimensional*
S-9	***SLO-1***	*Osmotic Pressure and Flow*	*Osmotic Pressure and Flow in a Cylindrical Pore*	*Power Law Fluid - Bingham Fluid - Casson Fluid - Herschel–Bulkley Fluid*	*Thermal Injury Mechanisms and Analysis*	*Unsteady-State Shell Balance Applications - Diffusion to Tissue*
	SLO-2	*Osmotic Pressure and Flow*	*Osmotic Pressure and Flow in a Cylindrical Pore*	*Power Law Fluid - Bingham Fluid - Casson Fluid - Herschel–Bulkley Fluid*	*Thermal Injury Mechanisms and Analysis*	*Unsteady-State Shell Balance Applications - Diffusion to Tissue*

Learning Resources	*1. Biotransport: Principles and Applications, Robert J. Roselli, Kenneth R. Diller* *2. Byron R.Bird., Warren E. Stewart and Edwin N. Lightfoot, "Transport Phenomena", 2nd edition, John Wiley & Sons, New York, 2007.*	*3. Continuum Analysis of Biological systems: Conserved quantities, Fluxes and Forces by G. K. Suraish kumar, 2014 Springer.* *4. Transport Phenomena in Biological Systems, 2nd Edition, by G.A. Truskey, F. Yuan, and D.K. Katz, Pearson Prentice Hall, 20092010.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*40 %*	-	*40 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*20 %*	-	*20 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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. Sam David, SRMIST* *2. Dr. Ashish Kapoor*

Course Code	18BME363T	Course Name	HUMAN ELECTROPHYSIOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Anatomy and Physiology	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 cell elcrophysiology
CLR-2 :	Know about neuronal communication
CLR-3 :	Learn about electrophysiology at neuromuscular junctions
CLR-4 :	Understand the cardiac electrophysiology
CLR-5 :	Understand the importance of neural control with other body systems
CLR-6 :	Explore the latest technologies with Electrophysiology studeies

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning: Level of Thinking (Bloom)	Learning: Expected Proficiency (%)	Learning: Expected Attainment (%)	PLO 1 Engineering Knowledge	PLO 2 Problem Analysis	PLO 3 Design & Development	PLO 4 Analysis, Design, Research	PLO 5 Modern Tool Usage	PLO 6 Society & Culture	PLO 7 Environment & Sustainability	PLO 8 Ethics	PLO 9 Individual & Team Work	PLO 10 Communication	PLO 11 Project Mgt. & Finance	PLO 12 Life Long Learning	PSO 1	PSO 2	PSO 3
CLO-1 :	Describe the physiology of cellular communication	1, 2	80%	70%															
CLO-2 :	Explain how neuron communicate and about perception	2	80%	70%															
CLO-3 :	Elaborate on hoe skeletal muscles working with neural system	2	80%	70%															
CLO-4 :	Describe how human systems are controlled by the electrical signals from btrain	3	80%	70%															
CLO-5 :	Explain the cardiac electrophysiology	3	80%	70%		L													
CLO-6 :	Undertake basic electrophysiological studies using EEG and other acquired signals.	3	80%	70%			M	L	L									L	

		Cell electrophysiology	Neural communication and perception	Neuromuscular physiology	Electrophysiology of human systems	Electrophysiology studies
Duration (hour)		9	9	9	9	9
S-1	SLO-1	Physiology- levels of organization in the body	Synapse	Autonomic nervous system	Heart anatomy review	Electrophysiology studies (EPS)
	SLO-2	Concept of homeostasis	Process involved in synapse	Somatic nervous system	Electrical activity of heart	Facts -EPS
S-2	SLO-1	Homeostasis control systems	Intracellular communication	Neuromuscular junction	Pacemaker activity	Need for EPS
	SLO-2	Cell structure overview	Signal transduction	Chemical linkage	Refractory periods	Risks involved
S-3	SLO-1	Plasma membrane structure	Organization of nervous system	Skeletal muscles	ECG- Spread of electrical activity	Procedure involved
	SLO-2	Plasma membrane functions	Organization of nervous system- Overview	Skeletal muscles structure and functions	ECG- diagnostic applications	Procedure involved ctd.
S-4	SLO-1	Membrane transport overview	Brain review	Molecular basis of muscular contraction	Cardiac output	Pacing Maneuvers
	SLO-2	Assisted , unassisted transports	Spinal cord review	Skeletal muscle mechanics	Cardiac output and its control	Pace mapping
S-5	SLO-1	Membrane potential	Peripheral nervous system	Muscle mechanics ctd.	Blood pressure (BP)	Vagal Maneuvers (VM)
	SLO-2	Membrane potential causes	Receptor physiology	Shortening of skeletal muscles	Reflexes responsible for BP	Indications of VM
S-6	SLO-1	Neural communication- Introduction	Pain	Skeletal muscle mechanism	Respiratory mechanics	Technologies for VM
	SLO-2	Graded potentials	Pain perception	Fiber types	Adjustments in ventilation	Special considerations
S-7	SLO-1	Action potential	Eye revisited	Nervous control of motor movements	Nervous control of respiration	Supra ventricular tachycardia (SVT)
	SLO-2	Action potential-generation	Visual perception	Nervous control of motor movements ctd.	Nervous control of respiration ctd.	Causes, types SVT
S-8	SLO-1	Action potential-Propagation	Ear and hearing	Smooth muscle	Nervous control of digestive system	Symptoms of SVT

	SLO-2	*All or none law*	*Ear and equilibrium*	*Phasic contraction*	*Defecation reflex*	*Treatments for SVT*
S-9	**SLO-1**	*Myelination*	*Chemical sensing*	*Cardiac muscles*	*Nervous control of excretory system*	*Latest trends in EPS*
	SLO-2	*Myelination challenges*	*Taste and Smell*	*Blend with smooth and skeletal muscles*	*Micturition reflex*	*Future scope*

Learning Resources	1. *Laura lee Sherwood, "Human Physiology from cell to system", Brooks Cole , 2012.* 2. *Laura lee Sherwood, "Fundamental of Physiology of Excitable Cells", 2010* 3. *Lionel Opie, "Heart Physiology" , Lippincott-Raven, 1998*	4. *Aidley, "The Physiology of Excitable Cells", Cambridge Press.,2008* 5. *Francis D Murgatroyd, Andrew D. Krahn, "Handbook of cardia Electrophysiology, A practical guide to invasive EP studies and catheter Ablation",Remedica Publisher, 2002*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*40 %*	-	*40 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*20 %*	-	*20 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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Course Code	18BME364T	Course Name	BIOMEDICAL DEVICE DESIGN FUNDAMENTALS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses		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:	Learning	Program Learning Outcomes (PLO)

		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	Understand the basic concepts of design issues in medical devices																		
CLR-2 :	Get an idea about the forming applications in the design of medical devices																		
CLR-3 :	Acquire an idea about the laser processing applications																		
CLR-4 :	Get an idea about the machining applications and different advanced techniques																		
CLR-5 :	Acquire an idea about the applications of various technical methods																		
CLR-6 :	Get an overall idea about the regulation and protection in medical device design																		
Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:																		
CLO-1 :	Understand the challenges in the Medical Device Industry	1, 2	80	70	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	Have a thorough understanding of typical process parameters	1, 2	80	70	M	-	-	M	-	-	-	-	-	-	-	-	M	-	-
CLO-3 :	Understand the basics of microscale medical device applications	2	80	70	-	-	-	M	-	-	-	-	-	-	-	-	L		-
CLO-4 :	Identify the importance of different biomaterials used in device design	1	80	70	H	-		M	-	-	-	-	-	-	-	M	-	L	-
CLO-5 :	Analyze the knowledge on machining based fabrication of medical devices	1	80	70	-	-	-	M	-	-	-	-	-	-	-	L	-	-	-
CLO-6 :	Extend the basics of safety regulation and protection risk in medical device design	1,2	80	70	H	-	-	-	-	-	-	-	-	-	-	H	-	-	-

Duration (hour)		Design Issues in Medical Devices	Forming Applications on Implantable Devices	Laser Processing Applications on Medical Devices	Machining Applications and Advanced Techniques on Medical Implants	Regulation and Protection of Medical Devices
		9	9	9	9	9
S-1	SLO-1	Introduction - Need for Medical Devices	Forming Applications - Forming	Laser Processing procedures	Machinability of Biocompatible Metal Alloys	Minimisation of exposure to radiation
	SLO-2	Technology Contribution to Medical Devices	Typical Process Parameters	Microscale Medical Device Applications	Surfaces Engineering of Metal Implants	Medical devices intended to emit radiation
S-2	SLO-1	Subtractive Technologies	Typical Process Parameters - Temperature	Microscale Medical Device Applications	Surfaces Engineering of Metal Implants	Minimisation of exposure to unintendedradiation
	SLO-2	Net-Shape Technologies	Typical Process Parameters - Strain	Processing Methods for Medical Device Fabrication	Wear and Failure of Metal Implants	Medical devices intended to emit ionisingradiation – additional requirements
S-3	SLO-1	Additive Technologies	Typical Process Parameters - Strain Rate	Processing Methods for Medical Device Fabrication	Wear and Failure of Metal Implants	Medical devices intended to emit ionisingradiation – additional requirements
	SLO-2	Challenges in the Medical Device Industry	Tribology and Micro-Tribology	Processing Methods for Medical Device Fabrication	Wear and Failure of Metal Implants	Medical devices connected to or equipped withan energy source
S-4	SLO-1	Medical Device Development	Tribology and Micro-Tribology	Biomaterials Used in Medical Devices	Micromilling-Based Fabrication of Metallic Microchannels for Medical Devices	Medical devices incorporating electronic programmable systems
	SLO-2	Biomedical Product Life Cycle	Manufacturing Process Chain	Biomaterials Used in Medical Devices	Micromilling-Based Fabrication of Metallic Microchannels for Medical Devices	Safety dependent on internal power supply
S-5	SLO-1	Biomedical Product Life Cycle	Manufacture of Alloys and Raw Materials	Biomaterials Used in Medical Devices	Machining-Based Fabrication of Polymeric Microneedle Devices	Safety dependent on external power supply
	SLO-2	Medical Device Development Process	Forming	Microjoining of Similar and Dissimilar Materials	Machining-Based Fabrication of Polymeric Microneedle Devices	Medical devices intended to monitor clinical parameters
	SLO-1	Medical Devices' Design Process	Machining and Finishing	Microjoining of Similar and Dissimilar Materials	Degenerative Disc Disease	Minimisation of risk of electromagnetic fields

S-6	SLO-2	*Scapholunate Interosseous Ligament*	*Coating*	Microjoining of Similar and Dissimilar Materials	*Degenerative Disc Disease*	*Protection against electrical risks associated with mechanical, vibration, electrical, heat andnoise*
S-7	SLO-1	*Conceptual Design*	*Packaging and Sterilization*	Laser Micromachining for Microfluidics	*Intervertebral Spinal Spacers*	*IEC standards: IEC 60601-2-44: Computed tomography*
	SLO-2	*Conceptual Design*	*Implantable Devices*	Laser Micromachining for Microfluidics	*Intervertebral Spinal Spacers*	*IEC 60601-2-43: Interventional procedures*
S-8	SLO-1	*Embodiment Design*	*Implantable Devices*	Laser Micromachining for Microfluidics	*Inkjet Technology*	*IEC 60601-2-45: Mammographic X-rayequipment*
	SLO-2	*Detailed Design*	*Bone Implants*	Laser Micromachining for Metallic CoronaryStents	*Medical Applications of Inkjet Technology*	*IEC 60601-1-3: Radiation protection in diagnostic X-ray equipment*
S-9	SLO-1	*Manufacturing a Prototype*	*Bone Implants*	Laser Micromachining for Metallic Coronary Stents	*Material Extrusion Technology*	*IEC 60601-2-54: X-ray equipment forradiography and radioscopy*
	SLO-2	*Manufacturing a Prototype*	*Bone Implants*	Laser Micromachining for Metallic CoronaryStents	*Medical Applications of Extrusion-Based Systems*	*IEC 60601-2-63: Dental extra-oral X-ray equipment; IEC 60601-2-65: Dental intra-oralX-ray equipment*

Learning Resources	1. *Claudio Becchetti,Alessandro Neri , "Medical Instrument Design and Development: From Requirements to Market Placements",Wiley; 1st edition, 2013.* 2. *Andreoni, Giuseppe, Barbieri, Massimo, Colombo, Barbara,"Developing Biomedical Devices Design, Innovation and Protection", Springer, 2014.* 3. *Tugrul Özel, Paolo Jorge Bártolo, Elisabetta Ceretti, Joaquim De Ciurana Gay, Ciro Angel Rodriguez, Jorge Vicente Lopes Da Silva, "Biomedical Devices: Design, Prototyping, and Manufacturing", 1st Edition, 2016.*	4. *Brendan Cooper, "Design Control for Medical Devices: A Short Introduction", Tata McGraw-Hill, New Delhi, 2nd edition, 2016.* 5. *Paul H. King, Richard C. Fries, Arthur T. Johnson, "Design of Biomedical Devices and Systems", CRC Press, 4th edition, 2018.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*40 %*	-	*40 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*20 %*	-	*20 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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. Mr.P. Muthu, SRMIST*

Course Code	18BME365T	Course Name	INNOVATION, TRANSLATION AND ENTREPRENEURSHIP	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:	Learning			Program Learning Outcomes (PLO)														
CLR-1 :	Learn a range of creative thinking tool and how to practically apply these to the innovation and entrepreneurial process.	1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-2 :	Explain the business environment and idea generation																		
CLR-3 :	Understand Marketing feasibility and feasibility plan																		
CLR-4 :	Understand about Entrepreneurship																		
CLR-5 :	Familiarizing with the nuances of Intellectual Property Rights																		
CLR-6 :	Apply deep learning in real life medical problems																		
Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Level of Thinking	Expected Proficiency(%)	Expected Attainment(%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	Understand the basic of creative thinking learning techniques and correlate to innovation	1, 2	80%	70%	M														
CLO-2 :	Understand the business environment and idea generation	2	80%	70%	M						L								
CLO-3 :	Apply knowledge of Marketing feasibility and feasibility plan	2	80%	70%			M		M				L				M		L
CLO-4 :	Apply Knowledge about entrepreneurship and new opportunities	3	80%	70%					M				L						
CLO-5 :	Use Knowledge about current scenario on entrepreneurship	3	80%	70%	M		L										M		L
CLO-6 :	Apply innovation to come up with new business plan	3	80%	70%	M			L					M						

Duration (hour)		Innovation & Creative thinking	Business Plan / Idea	Marketing Feasibility and Planning	Entrepreneurship	Intellectual properties and responsibilities
		9	9	9	9	9
S-1	SLO-1	Introduction to Creativity	Scanning of Environment	Market survey & Assessment	Understanding the Meaning of "Entrepreneur"	Product Strategies
	SLO-2	Introduction to Innovation	Understanding factors	Market survey & Assessment	Universal definitions	Product Strategies
S-2	SLO-1	Need for Creativity & Innovation	Sensing Opportunities	Demand and Supply	Characteristics of an Entrepreneur	Distribution Strategies
	SLO-2	Need for Creativity & Innovation	Identify and evaluate factors	Nature of Competition	Characteristics of an Entrepreneur	Distribution Strategies
S-3	SLO-1	The process of Technological Innovation	harnessing different sources of knowledge and information	Fixing cost and price of product	Classification of Entrepreneurs	Promotional Strategies
	SLO-2	The process of Technological Innovation	harnessing different sources of knowledge and information	Fixing cost and price of product	Classification of Entrepreneurs	Promotional Strategies
S-4	SLO-1	Sources of Innovative Opportunity : ProcessNeed	Generation of Ideas	Project Innovation and Changes	The Entrepreneurial Scene in India	Concept of Intellectual Property Rights (IPR)
	SLO-2	Sources of Innovative Opportunity: Industry and market structures	Methods for Generating ideas	Identification of applicable Entrepreneurial Opportunities	The Entrepreneurial Scene in India	Patents, Trademarks
	SLO-1	Sources of Innovative Opportunity : demographics	Product Planning	Data collection for setting up small ventures	Factors Influencing Entrepreneurship	Copyright, Industrial Designs Registrations

S-5	**SLO-2**	*Sources of Innovative Opportunity: changes in perception*	*Product Planning*	*Data collection for setting up small ventures*	*Factors Influencing Entrepreneurship*	*Geographical Indications, Trade Secrets*
S-6	**SLO-1**	*Organization and personal factors to promote creativity*	*Writing a Business Plan*	*Financial, Economic Feasibilities*	*Entrepreneurial Growth*	*Territoriality of IPR*
	SLO-2	*Organization and personal factors to promote creativity*	*Writing a Business Plan*	*Technical Feasibilities*	*Entrepreneurial Growth*	*Concept and procedures of obtaining rightsand ownership for creative works in India*
S-7	**SLO-1**	*Creativity and analytical skill*	*Using and Implementing the Business Plan*	*Legal Feasibilities*	*Problems of Entrepreneurs*	*Environment protection*
	SLO-2	*Difference between Creativityand Analytical skill*	*Using and Implementing the Business Plan*	*managerial, Locational and Other Feasibilities*	*Problems of Entrepreneurs*	*Environment protection*
S-8	**SLO-1**	*Creativity and Problem Solving*	*Difference between 'Basic Ideas'and post scanning ideas*	*Preliminary screening*	*HEIs Strategies & Governance for Promoting Innovation & Entrepreneurship*	*importance of Business Ethics and Values in Business*
	SLO-2	*Creativity and Problem Solving*	*Difference between 'Basic Ideas' and post scanning ideas*	*Preliminary screening in market*	*National Innovation and Startup Policy (NISP) for Higher Educational Institutions (HEIs)*	*importance of Business Ethics and Values in Business*
S-9	**SLO-1**	*Different Techniques for Creative Intelligence*	*Self Assessment of idea*	*Preparation of detailed feasibility plan*	*Creating Innovation Pipeline and Pathwaysfor Entrepreneurs*	*Role of entrepreneur in economic growth*
	SLO-2	*Brain storming technique*	*Reasons for Business Plans Failure*	*Key features of detailed feasibility plan*	*Collaboration Co-creation and Business Relationship and Knowledge Exchange*	*Role of entrepreneur in economic growth*

Learning Resources

1. *Peter Drucker, "Innovation and Entrepreneurship", Routledge Classics 2015*
2. *Carolina Machado, J. Paulo Davim, "Entrepreneurship and Organizational Innovation", Springer 2020*
3. *Norman M. Scarborough , "Essentials of Entrepreneurship and Small Business Management" (6th Edition) by (Paperback - Jan 13, 2010)*
4. *Dr.Jayashree suresh –Entrepreneurship Development.-Margham Publication-2012*
5. *Ganguli Prabuddha "Intellectual Property Rights--Unleashing the Knowledge Economy", Tata McGrawHill (2001)*
6. *S.S.Khanka, Entrepreneurial Development, S.Chand and Company Limited, New Delhi. 2013*
7. *Gupta C.B. & Khanka. S.S, —Entrepreneurship and small business management‖, 5th edition , sultan chand & sons, 2014*
8. *Jayshree Suresh, —Entrepreneurial Development‖, Margham Publishers, Chennai, 2011.*
9. *Jeff Cornwall, —Entrepreneurship -- From Idea to Launch‖, Udemy online Education, https://www.udemy.com/entrepreneurship-from-idea-to-launch/*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember / Understand	*40 %*	-	*40 %*	-	*40 %*	-	*30 %*	-	*30%*	-
Level 2	Apply / Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate / Create	*20 %*	-	*20 %*	-	*20 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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. Mrs.P.Bhargavi Haripriya, SRMIST*

Course Code	18BME366T	Course Name	BIOMEDICAL MICROSCOPY AND QUANTITATIVE IMAGING	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:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	Understand the basics of optics in microscopy	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLR-2 :	Understand the basics of fluorescence microscopy																		
CLR-3 :	Understand the techniques in low light microscopy																		
CLR-4 :	Analyze the various methods for quantitative analysis of microscopic images																		
CLR-5 :	Analyze the various methods for quantitative analysis of fluorescence microscopic images																		
CLR-6 :	Understand the optics of microscopy and the various methods of quantitative analysis																		
Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:																		
CLO-1 :	Describe optics and principle of operation of microscopic image formation	1, 2	80%	70%	M														
CLO-2 :	Describe optics and principle of operation of fluorescence microscopic image formation	2	80%	70%	M														
CLO-3 :	Demonstrate the techniques for low light microscopy	2	80%	70%			M		M								M		L
CLO-4 :	Apply the different methods for quantitative analysis of microscopic images	3	80%	70%					M										
CLO-5 :	Apply the different methods for quantitative analysis of fluorescence microscopic images	3	80%	70%	M												M		L
CLO-6 :	Apply the knowledge in microscopic image formation and its quantitative analysis	3	80%	70%	M														

Duration (hour)		Optics of microscope image formation	Fluorescence Microscopy	Low-light microscopy	Quantitative Analysis of digital microscope images	Quantitative Fluorescence microscopy
		9	9	9	9	9
S-1	SLO-1	Finite tube length microscope	Fluorescence Microscopy	Low light imaging	Optical systems as block boxes	Quantitative fluorescence—detectors
	SLO-2	Upright microscope	Beer's Law	Detection of low light	Calibration toolkit	Limits on linearity
S-2	SLO-1	Infinity optics microscope	Atomic fluorescence	Parameters characterizing imaging devices	Simple calibration curve-relative scale	Illumination variations
	SLO-2	Objective basics	Organic molecular fluorescence	Sensitivity and quantum efficiency	Simple calibration curve-Absolute scale	Detector noise
S-3	SLO-1	Physical optics: superposition of waves	Excited state lifetime	Spectral response, Units	Precision in a calibration curve	Photon shot noise
	SLO-2	Huygen's Principle	Excited state saturation	Fill factor (CCD format), Camera noise andthe signal-to-noise ratio	Standard deviation and errors	Characterizing the performance of an imaging system
S-4	SLO-1	Young's experiment : two slit interference,Diffraction from single slit	Nonradiative decay mechanisms	Shot noise, Readout noise	Signal to noise ratio	Preprocessing of images for quantitativeanalysis
	SLO-2	Microscope resolution, Issues in Microscope resolution	Fluorescence Resonance energy	Background and noise, Example calculation	Signal to background ratio	Processing data for quantitative analysis
S-5	SLO-1	Key components of light microscope	Fluorescence Depolarization	Spatial resolution, Example	Propagation of error in calculated quantities	Methodologies for quantitative imaging
	SLO-2	Illumination Section, Light source	Measuring fluorescence in steady state	Linearity and uniformity, Time response	Error propagation in imaging	Approaches for image deblurring by deconvolution
S-6	SLO-1	Lamp collector	Construction of monochromator	Dynamic range, Gain	Accuracy and precision	Deblurring or neighbor-based methods
	SLO-2	Internal components of illumination paths	Construction of photomultiplier tube	Frame rate and speed, Resolution, sensitivity,and imaging rate	Flatfield Correction	Restoration methods
S-7	SLO-1	Field diaphragm, Condenser, Stage and specimen holder	Measuring fluorescence in the time domain	Imaging Detectors and features	Spatial corrections	Image deconvolution: effects and results
	SLO-2	Microscope imaging section, Objective	Boxcar-gated detection method	Video CCD cameras, Slow-scan and fastCCD cameras	Maximizing resolution	Image deconvolution: practical issues

S-8	***SLO-1***	*Objective Back Focal Plane*	*Streak Camera method*	*Intensified Cameras*	*Converting pixels to microns*	*Applications for Image Deconvolution*
	SLO-2	*Revolving nosepiece Turret*	*Photon correlation method, Phase modulation method*	*Digital still cameras, SIT Cameras*	*Imaging warping*	*Quantitative Ratiometric Imaging of FRET-Biosensors in Living Cells*
S-9	**SLO-1**	*Infinity space, Tube lens, Eyepieces*	*Filters for the selection of wavelength*	*CMOS imagers*	*Two color coincidence*	*Image processing methods*
	SLO-2	*Koehler Illumination, Conjugate light paths*	*Power of fluorescence of microscopy*	*Image acquisition*	*Two camera and two color imaging*	*Imaging considerations and caveats and pitfalls*

Learning Resources	1. Greenfield Sluder, David E. Wolf," Digital Microscopy", 4th Ed, Academic Press, 2013. *3.* Irving J. Bigio, Sergio Fantini "Quantitative Biomedical Optics: Theory, Methods, andApplications" , Cambridge University Press, 2016	*2. Jennifer Waters, Torsten Wittmann, "Quantitative Imaging in Cell Biology" Academic Press, 2014.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*40 %*	-	*40 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*20 %*	-	*20 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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.Vinupritha, SRMIST*

Code	18BME367T	Course Name	HOSPITAL MANGEMENT SYSTEM	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	Understand about quality and performance improve methods																		
CLR-2 :	Analysis of performance management methods and project management																		
CLR-3 :	Gain the knowledge of process redesign and data analytics																		
CLR-4 :	Understand the analytics in healthcare organizations and population health																		
CLR-5 :	Gain knowledge strategically manage hospital system																		
CLR-6 :	Understand the setup of Hospital Information System(HIS)																		
Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	Describe performance improve methods	1, 2	80%	70%	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	Identify the project management in healthcare	2	80%	70%	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	Apply the process redesign and data analytics in population health	2	80%	70%	-	-	M	-	M	-	-	-	-	-	-	-	M	-	L
CLO-4 :	Gain the knowledge of health care organizations	3	80%	70%	-	-	-	-	M	-	-	-	-	-	-	-	-	-	-
CLO-5 :	Analyzes the population health management	3	80%	70%	M	-	-	-	-	-	-	-	-	-	-	-	M	-	L
CLO-6 :	Understand hospital management system	3	80%	70%	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-

		Quality and Performance improve Methods	Performance Management Methods and Project Management	Process Redesign, Data analytics and Population health	Analytics in healthcare organizations and population health management	Strategically Hospital management system
Duration (hour)		9	9	9	9	9
S-1	SLO-1	Introduction to Quality management system	Introduction to Quality Measures	Introduction to process redesign	Introduction to healthcare organizations	Strategic, Tactical, and Operational Information Management
	SLO-2	Quality Management	Process and outcome Measures	Importance of Process Improvement in system implementation	Analytical challenges	Information Management
S-2	SLO-1	Core components of Quality managements	Plan do check act	Basic process Improvement Approach	The values of analytics in health care	Strategic Information Management
	SLO-2	Planning, Improvement and control	Six sigma and Lean	Lean Six Sigma	Types of data in health care organizations	Operational Information Management
S-3	SLO-1	Need for health improvement	Theory of constraints and process modeling	Documenting the process	Understanding managing data (Analytical tooland data)	Organizational Structures for Information Management
	SLO-2	Performance improvement	Others Tools and Techniques	Communication Planning	Statistical analysis in health analytics and performance improvement.	Typical Organizational Structures forStrategic Information Management
S-4	SLO-1	Introduction to performance management	Introduction to developing new quality teams	Solidifying the process ImprovementApproach	Introduction to population health management	Typical Organizational Structures for Tacticaland Operational Information Management
	SLO-2	Performance management	Building a new Quality	Creating Future State	Measure of population health status	Examples: Organizational Structures for Information Management in a Hospital
	SLO-1	Health care strategy	Managing performance improvement	Identify metrics and Information capturepoints	Interaction with community Public health service Provider	Information Systems Managers as Architects

S-5	**SLO-2**	*Performance frame work*	*Measure the project status*	*Gap Analysis definition*	*Factors influencing population health status*	*Organizational Structures for Information Management in a Hospital*
S-6	**SLO-1**	*Change versus improvement*	*Recommendation of Building capacity*	*Introduction to Big data analysis*	*Impact of health disparities and inequities*	*Strategic Planning of Hospital InformationSystems*
	SLO-2	*Performance based planning*	*Recommendation of Building capacity to all*	*Decision Model*	*Healthcare delivery systems*	*Strategic Alignment of Business Plans and Information Management Plans*
S-7	**SLO-1**	*Benchmarking*	*Introduction to project management in healthcare*	*Predictive Modeling*	*Continuum of care*	*The Strategic Information ManagementPlan*
	SLO-2	*Identifying problem and gap*	*Project initiation and design*	*Define the objects and data collection*	*Care of co-ordination*	*Purpose of Strategic Information Management Plans*
S-8	**SLO-1**	*Research and Prepare benchmarking visit.*	*Project risk*	*Applying algorithm*	*Network Affiliation Strategies*	*Strategic Monitoring of Hospital Information Systems*
	SLO-2	*Guideline for performance management*	*Project Execution and Control*	*Apply Prediction to decisions*	*Community needs assessment*	*Certification, Accreditation, and Excellence Programs of HIS*
S-9	**SLO-1**	*Measure the Historical Performance*	*Change Management*	*Information sharing beyond theOrganizational walls*	*Evaluating Community Health status measures*	*Assessment Study of a Telemedicine System to Improve Care*
	SLO-2	*Forecast the desired Improvement target*	*Project Communication*	*Health information Exchanges*	*Data sources and incentive for health program*	*Strategic Directing of Hospital InformationSystems*

Learning Resources	1. *James R. Lang beer II "Performance Improvement in Hospitals and Health Systems Managing Analytics and Quality in Healthcare 2nd Edition", Taylor francs, 2018.* 2. *Kathryn J. Hannah Marion J. Ball Series Editors, "Health Informatics", Springer Scienc Business Media, LLC2ndedition, 2009*	3. *Pradip Kumar Ray, Jhareswar Maiti, "Healthcare Systems Management: Methodologies and Applications: 21st Century Perspectives of Asia", Springer, 2018* 4. *Gerald L. Glandon, Donna Jean Slovensky, Detlev Herb Smaltz," Information Systems for Healthcare Management", Health Administration Press, 2014*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*40 %*	-	*40 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*20 %*	-	*20 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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. Gnanavel, SRMIST*

Course Code	18BME368T	Course Name	SOFT TISSUE AND BIOFLUID MECHANICS	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:*

Learning	1	2	3
	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 : Understand the fundamental of soft tissue mechanics			
CLR-2 : Get an idea about the biotransport			
CLR-3 : Acquire an idea about the fundamental concepts of biofluid mechanics			
CLR-4 : Get an idea about the mechanics of cardiovascular system			
CLR-5 : Get an idea about the biofluid mechanics of various human body organ systems			
CLR-6 : Understand the soft tissues and biofluid mechanics			

Course Learning Outcomes (CLO): At the end of this course, learners will be able to:	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design,Research	5 Modern Tool Usage	6 Society & Culture	7 Environment &Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1 : Understanding of the fundamental of the mechanics soft tissue	1, 2	80	70	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 : Analyze the various transport in biological system	1, 2	80	70	M	-	-	-	-	-	-	-	-	-	-	-	M	-	-
CLO-3 : Conceptualization of biofluid mechanics	2	80	70	H	M	-	-	-	-	-	-	-	-	-	-	M		-
CLO-4 : Illustrate of the concepts of cardiac system and its biofluid mechanics	1	80	70	-	-	L	-	-	-	-	-	-	-	-	H	-	M	M
CLO-5 : Illustrate the role of biofluid mechanics in various organ system	1	80	70	-	-	L	-	-	-	-	-	-	-	-	H	-	-	-
CLO-6 : Outline the importance of understanding soft tissues and biofluid mechanics	1,2	80	70	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Duration (hour)		Fundamental of Soft Tissue mechanics	Basic concept of Biofluids	Macrocirculation and microcirculation system	Cardiac mechanics	Biofluid mechanics of organs system
		9	9	9	9	9
S-1	SLO-1	Introduction: Structural organizationof skeletal muscle	Introduction –Body fluids, Dimension and unit	Introduction of macrocirculation andmicrocirulation	Introduction	Kidney :Structure and function
	SLO-2	Muscle fiber	Basic Concepts and Definitions of Fluid Mechanics	Pulsatile flow properties	Cardiac Geometry and Structure	Fluid flow in an artificial kidney model
S-2	SLO-1	Motor unit	Fluid Kinematics and Viscosity	Arteries	Cardiac Geometry and Structure	Fluid flow in an artificial kidney model
	SLO-2	Fiber types	Newtonian Fluids	Veins	Ventricular Geometry	Mass transfer in an artificial kidney model
S-3	SLO-1	Fiber architecture	Non-Newtonian Fluids	Vascular bifurcations and branches	Ventricular Geometry	Mass transfer in an artificial kidney model
	SLO-2	Muscle function	Dimensionless Numbers of Biofluid Mechanics	Blood flow through curved vessels	Myofiber Architecture	Liver: structure and function
S-4	SLO-1	Muscle function	Steady versus Unsteady Flow and Laminar Versus Turbulent Flow	Mechanical and elasticity properties of vessels	Myofiber Architecture	Hepatic acinus model
	SLO-2	Maximum Muscle Stress	Boundary Conditions and No Slip Boundary Condition	Atherosclerosis characteristics	Extracellular Matrix Organization	Fluid flow in hepatic acinus model
S-5	SLO-1	Maximum Muscle Contraction Velocity	Compressible and Incompressible Flows, Stress Tensor	Blood flow through stenosis	Cardiac Pump Function: Ventricular Hemodynamics	Mass transfer in hepatic acinus model
	SLO-2	Types of Muscle Models	Viscoelasticity and Viscoplasticity	Arterioles and blood flow aspects	Ventricular Pressure--Volume Relations and Energetics	Lung : Structure and function

S-6	**SLO-1**	*Huxley biochemical models*	*Basic Equations of Fluid Mechanics- conservation of Mass, Momentum and Energy*	*Capillaries and venules*	*Ventricular Pressure--Volume Relations and Energetics*	*Elasticity of the lung blood vessels and alveoli*
	SLO-2	*Hill phenomenological models*	*NavierStokes Equations*	*Fahraeus and Fahraeus lindqvist effects*	*Myocardial Material Properties*	*Pressure-volume relationship for air flowin the lungs*
S-7	**SLO-1**	*Constitutive models*	*Bernoulli Equation*	*Fahraeus and Fahraeus lindqvist effects*	*Myocardial Material Properties: Muscle Contractile Properties*	*Oxygen/carbon dioxide diffusion and transport in the blood*
	SLO-2	*Tendon-morphology*	*Hagen Poiseuille Equation*	*Mass transport in tissue*	*Muscle Contractile Properties*	*Compressible fluid flow*
S-8	**SLO-1**	*Tendon-properties*	*Steady Flow Along Tube, Pulsatile Flow in Rigid and Elastic Tubes*	*Porosity, tortuosity and permeability*	*Resting Myocardial Properties*	*Lubrication of joints: function*
	SLO-2	*Ligament –morphology*	*Resistance, Compliance and Inertance, Two-Phase Flows*	*Governing equations in porous media*	*Resting Myocardial Properties*	*Formation of synovial fluid*
S-9	**SLO-1**	*Ligament -properties*	*Hematology and blood rheology*	*Governing equations in porous media*	*Regional Ventricular Mechanics: Stress andStrain*	*Synovial fluid flow*
	SLO-2	*Articular cartilage –morphology and properties*	*Hematology and blood rheology*	*Fluid transport in poroelastic media*	*Regional Ventricular Mechanics: Stress andStrain*	*Mechanical forces within joint*

Learning Resources	*1. David A. Rubenstein,Wei Yin&Mary D. Frame "Biofluid mechanics:An introduction to fluid mechanics,macrocirculation and microcirculation(Biomedical Engineering)", Elsevier,2nd edition ,2012* *2. Clement Kleinstreuer "Biofluid Dynamics: Principles and Selected Applications ", CRC Press; 1 edition, 2016* *3. Benjamin Loret, Fernando Manuel & Fernandes Simoes"Biomechanical Aspects of Soft Tissues", CRC Press; 1 edition, 2017* *4.* Yuan-Cheng Fung,"Biomechanics: Mechanical Properties of Living Tissues", Second Edition, 1993	*5. Susan Hall, "Basic Biomechanics" McGraw-Hill Education,6th edition August 2011* *6.* Ali Ostadfar," Biofluid Mechanics -Principles and Applications," Elsevier,1st edition,20167.Jagan N. Mazumdar,"Biofluid Mechanics," World Scientific, 2nd edition,1992

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*40 %*	-	*40 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*20 %*	-	*20 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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. Ms. Oinam Robita Chanu*

Course Code	18BME369T	Course Name	TROUBLESHOOTING OF MEDICAL DEVICES	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Basic Electronic devices and circuits, Linear Integrated circuits, Biomedical Instrumentation	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:*

		Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	Understand the fundamental troubleshooting procedures and testing of basic electronic components			
CLR-2 :	Learn the methods to ensure electrical safety			
CLR-3 :	Get an idea about the fault diagnosis in analog and digital ICs.			
CLR-4 :	Acquire an idea about the basic troubleshooting procedures for biomedical equipment			
CLR-5 :	Learn the methods of troubleshooting Diagnostic medical Equipments			
CLR-6 :	Understand the methods of troubleshooting therapeutic medical Equipments			

Course Learning Outcomes (CLO): *At the end of this course, learners will be able to:*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	Apply the common troubleshooting procedures in Electronic Equipment and Outline the testing procedures of active and passive components	1, 2	80	70	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	Analyze the faults in analog circuits and digital ICs	1, 2	80	70	M	-	-	-	-	-	-	-	-	-	-	-	M	-	-
CLO-3 :	Identify the problems in common biomedical equipment in hospitals when it is not working and provide a suitable solution	2	80	70	-	M	-	-	-	-	-	-	-	-	-	-	M		-
CLO-4 :	Apply the acquired knowledge in fault diagnosis of medical equipments	1	80	70	-	-	H	-	-	-	-	-	-	-	-	M	-	M	-
CLO-5 :	Explain the methods of troubleshooting Diagnostic medical Equipments	1	80	70	-	-	-	-	-	-	-	-	-	-	-	M	-	-	-
CLO-6 :	Implement the methods of troubleshooting therapeutic medical Equipments	1,2	80	70	-	-	-	-	-	-	-	-	-	-	-	L	-	-	-

Duration (hour)		Basic Troubleshooting Techniques & Procedures	Grounding Systems	Troubleshooting Active and Passive components	Troubleshooting of diagnostic Equipments	Troubleshooting of Therapeutic & Surgical Equipments
		9			9	9
S-1	SLO-1	Making of an electronic equipment	Electrical Hazards	Testing of passive components: Fixed Resistors	Parts of an ECG Machine	Troubleshooting of Defibrillator
	SLO-2	description	Causes	Testing of passive components: variableResistors	Sources of ECG artifacts	Preventive maintenance of Defibrillator
S-2	SLO-1	PCB	Types of electrical shock	Testing of passive components: Capacitors	Troubleshooting- ECG Machine	Troubleshooting of Electrosurgical unit
	SLO-2	PCB types	Threshold levels of electrical shock	Testing of passive components: variableCapacitors	Preventive maintenance of ECG system	Preventive maintenance of Electrosurgicalunit
S-3	SLO-1	Causes of Equipment Failure	Electrical grounding	Testing of passive components: Inductors	Parts of an EEG Machine	Troubleshooting of Incubator
	SLO-2	Types of Equipment Failure	Need for grounding	Testing of passive components: variableInductors	Sources of EEG artifacts	Preventive maintenance of Incubator unit
S-4	SLO-1	Functional block diagram of a troubleshooting system	Grounding Systems in Electronic Equipment	Testing of PN Diodes	Troubleshooting- EEG Machine	Troubleshooting of Suction apparatus
	SLO-2	Description of a troubleshooting system	Methods	Testing of Zener Diodes	Preventive maintenance of EEG system	Preventive maintenance of Suction apparatus
S-5	SLO-1	TroubleshootingProcess	Temperature Sensitive Intermittent Problems	Testing of NPN transistor	X ray System	Troubleshooting of Anaesthesia Machine
	SLO-2	Description	Methods to rectify	Methods	Sources of errors	Preventive maintenance of Anaesthesia Machine

S-6	**SLO-1**	*Fault finding Aids*	*Correction Action to repair the Equipment*	*Testing of PNP transistor*	*Troubleshooting- X-ray Machine*	*Troubleshooting of Nebulizer Machine*
	SLO-2	*Description*	*Correction Action to repair the Equipment*	*Methods*	*Preventive maintenance of X-ray system*	*Preventive maintenance of Nebulizer Machine*
S-7	SLO-1	*Troubleshooting techniques: Preliminary Observations*	*Tools & Aids for Servicing & Maintenance*	*Testing of FET*	*Endoscopy: Sources of artifacts*	*Oxygen cylinders*
	SLO-2	*Troubleshooting techniques: Functional block diagram approach*	*Tools & Aids for Servicing & Maintenance*	*Methods*	*Troubleshooting of endoscope& its preventive maintenance*	*Preventive maintenance of Oxygen cylinders*
S-8	SLO-1	*Troubleshooting techniques: Split half method*	*Situations where repair not to be attempted*	*Typical op-amp based medical circuits*	*Ultrasound: Sources of artifacts*	*Radiation Monitors-trouble shooting*
	SLO-2	*Application of Split half method in circuit troubleshooting*	*Situations where repair not to be attempted*	*Fault diagnosis in op-amp circuits*	*Troubleshooting of Ultrasound system& its preventive maintenance*	*Radiation Monitors-calibration*
S-9	SLO-1	*Troubleshooting techniques: Systematic Troubleshooting*	*Types of power supply*	*Digital IC Troubleshooter:, Logic clip, Logicprobe*	*Troubleshooting of Pulse oximeter*	*Troubleshooting of Autoclaves & sterilizers*
	SLO-2	*Correction action*	*World power supply types*	*Logic pulser, Logic current tracer*	*Troubleshooting of Sphygmomanometers*	*Preventive maintenance of Autoclaves &sterilizers*

Learning Resources

1. Joseph D Bronzino & Donald R Peterson, "Medical Devices and Human Engineering", CRC Press, 4th Edition, 2015
2. Myer Kutz, "Biomedical Engineering and Design Handbook- Volume 2: Applications", McGraw-Hill, 2nd Edition, 2009
3. Richard Fries, "Reliable Design of Medical Devices", CRC Press, 2nd Edition, 2006
4. Basem S EL-Haik & Khalid S Mekki, "Medical Device Design for Six Sigma: A Road Map for Safety and Effectiveness", John Wiley & Sons, 1st Edition, 2008
5. John J Tobin & Gary Walsh, "Medical Product Regulatory Affairs- Pharmaceutical, Diagnostics, Medical Devices", Wiley-Blackwell, 1st Edition, 2008
6. Norbert Leitgeb, "Safety of Electromedical Devices Law – Risks – Opportunities", SpringerWienNewYork, 1st Edition, 2010
7. "Medical Device Regulations Global overview and guiding principles", World Health Organization Geneva, 2003
8. Jack Wong and Raymond K Y Tong, "Handbook of Medical device regulatory affairs in Asia", Pan Stanford Publishing Pte. Ltd., 2nd Edition, 2018
9. Khandpur R S, "Troubleshooting Electronic Equipment- Includes Repair & Maintenance", Tata McGraw-Hill, 2nd Edition, 2009
10. Nicholas Cram & Selby Holder, "Basic Electronic Troubleshooting for Biomedical Technicians", TSTC Publishing, 2nd edition, 2010
11. Dan Tomal & Neal Widmer, "Electronic Troubleshooting", McGraw Hill, 3rd edition, 2004
12. Ministry of Health &Family Welfare, "Medical Equipment Maintenance Manual- A first line maintenance guide for end users", New Delhi, 2010

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*40 %*	-	*40 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*20 %*	-	*20 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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*	*Dr.D.Kathirvelu, SRMIST*

Course Code	18BME370T	Course Name	QUALITY ASSURANCE AND REGULATORY ASPECTS FOR MEDICAL DEVICES	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Basic Electronic devices and circuits, Linear Integrated circuits, Biomedical Instrumentation	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:*

		Learning		
CLR-1 :	Understand the fundamental troubleshooting procedures and testing of basic electronic components	1	2	3
CLR-2 :	Get an idea about the fault diagnosis in analog circuits and digital ICs.			
CLR-3 :	Acquire an idea about the basic troubleshooting procedures for biomedical equipment			
CLR-4 :	Get an idea about the medical device classification globally and regulatory standards			
CLR-5 :	Get an idea about the Indian perspective medical device regulatory system			
CLR-6 :	Get an overall idea about the importance of troubleshooting and medical device classification in India			
CLR-1 :	Understand the fundamental troubleshooting procedures and testing of basic electronic components			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Program Learning Outcomes (PLO)														
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
					Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO -1	PSO -2	PSO – 3
CLO-1 :	Apply the common troubleshooting procedures in Electronic Equipment and Outline the testing procedures of active and passive components	1, 2	80	70	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	Analyze the faults in analog circuits and digital ICs	1, 2	80	70	M	-	-	-	-	-	-	-	-	-	-	-	M	-	-
CLO-3 :	Identify the problems in common biomedical equipment in hospitals when it is not working and provide a suitable solution	2	80	70	-	M	-	-	-	-	-	-	-	-	-	-	M		-
CLO-4 :	Outline the importance of medical device classification based on the application and ISO standards	1	80	70	-	-	H	-	-	-	-	-	-	-	-	M	-	M	-
CLO-5 :	Describe the Indian medical device regulatory system	1	80	70	-	-	-	-	-	-	-	-	-	-	-	M	-	-	-
CLO-6 :	Outline the job opportunities in regulatory affairs in India	1,2	80	70	-	-	-	-	-	-	-	-	-	-	-	L	-	-	-

Duration (hour)		*Fundamentals Of QualityManagement*	*Quality Management Principles*	*Statistical Process Control Tools*	*Quality Management Techniques*	*Regulatory Strategy*
		9	9	9	9	9
S-1	SLO-1	Definition of Quality	Customer satisfaction	The seven tools of quality: Flow chart	Benchmarking	Purpose of regulation
	SLO-2	Dimensions of Quality	Customer Perception of Quality	Check list	Benchmarking	Principles of regulation
S-2	SLO-1	Dimensions of Quality	Customer Complaints	Histograms	Reasons to Benchmark	Legal frame work for regulation: National Legislative process
	SLO-2	Quality Planning	Service Quality	Pareto Diagram	Reasons to Benchmark	Legal frame work for regulation: EU Legislative process
S-3	SLO-1	Quality costs.	Customer Retention	Cause and Effect diagram	Benchmarking Process	Relationship between national and EU legal instruments
	SLO-2	Analysis Techniques of quality Cost	Employee Involvement- Motivation	Scatter diagram	Benchmarking Process	Basic legialation
S-4	SLO-1	Analysis Techniques of quality Cost	Empowerment	Control Charts for variables	Quality Function Deployment (QFD)	Scope of legislation
	SLO-2	Basic concepts of Total Quality Management	Teams	Control Charts for attributes	Quality Function Deployment (QFD)	Basic regulatory stratergy
S-5	SLO-1	Historical Review	Recognition and Reward	New seven Management tools: Affinity diagram	House of Quality	Need for Accreditation of hospitals
	SLO-2	Historical Review	Performance appraisal	Relationship diagram	House of Quality	Need for Accreditation of hospitals
S-6	SLO-1	Principles of TQM	Continuous process improvement	Tree diagram	QFD Process	FDA Regulations
	SLO-2	Leadership	Juran Trilogy	Matrix Diagram	Taguchi Quality Loss Function	Joint Commission

S-7	SLO-1	*Role of Senior Management -*	*PDSA Cycle*	*Matrix diagram*	*Total Productive Maintenance (TPM*	*Regulatory Bodies of India-Medical Council of India*
	SLO-2	*Quality Council*	*5S*	*Matrix data analysis diagram*	*Six sigma*	*Importance of regulatory system*
S-8	SLO-1	*Quality Statements*	*Kaizen*	*Matrix data analysis diagram*	*Six sigma*	*Market Overview*
	SLO-2	*Strategic Planning*	*Performance Measures-Basic concepts*	*Process decision program chart*	*FMEA*	*Overview of Regulatory Environment*
S-9	SLO-1	*Deming Philosophy*	*Strategy*	*Process decision program chart*	*Types of FMEA*	*Details of Key Regulator*
	SLO-2	*Barriers to TQM Implementation*	*Performance measurement.*	*Arrow diagram*	*Benefits of Fmea*	*Organization Chart — CDSCO*

Learning Resources	*1. Rose, J.E., "Total Quality Management", Kogan Page Ltd., 1993* *2. Cesar A. Cacere& Albert Zana, :ThePractise of clinical Engineering". Academic Press, Newyork, 1997* *3. John Bank, "The Essence of Total Quality Management", Prentice Hall of India, 1993* *4. Webster J.G and Albert M.Cook, "Clinical Engineering, Principles & Practices", Prentice Hall Inc., Engle wood cliffs, New Jersey, 1979* *5. John J Tobin & Gary Walsh, "Medical Product Regulatory Affairs- Pharmaceutical, Diagnostics, Medical Devices", Wiley-Blackwell, 1st Edition, 2008* *6. Medical Device Regulations Global overview and guiding principles", World Health Organization Geneva, 2003*	*7. Jack Wong and Raymond K Y Tong, "Handbook of Medical device regulatory affairs in Asia", Pan Stanford Publishing Pte. Ltd., 2nd Edition, 2018* *8. Khandpur R S, "Troubleshooting Electronic Equipment- Includes Repair & Maintenance", Tata McGraw-Hill, 2nd Edition, 2009* *9. Nicholas Cram & Selby Holder, "Basic Electronic Troubleshooting for Biomedical Technicians", TSTC Publishing, 2nd edition, 2010* *10. Dan Tomal& Neal Widmer, "Electronic Troubleshooting", McGraw Hill, 3rd edition, 2004* *11..Ministry of Health &Family Welfare, "Medical Equipment Maintenance Manual- A first line maintenance guide for end users", New Delhi, 2010*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*40 %*	-	*40 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*20 %*	-	*20 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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. Rajalakshmi T, SRMIST*

Course Code	18BME371T	Course Name	NEUROENGINEERING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning

		1	2	3
CLR-1 :	Understand the basic principles of brain anatomy and function	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-2 :	Learn about the principles of nervous system and neurotransmission			
CLR-3 :	Learn about the applications of neural engineering in sensory disorders			
CLR-4 :	Understand the concepts of BCI and neurophysiologic recording and imaging technologies			
CLR-5 :	Understand the basics of neuro prosthetic devices and neuron modelling			
CLR-6 :	Learn about the concepts of neural imaging and its modeling techniques for various applications			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	Understand the anatomy of brain and its functions	1, 2	80	70
CLO-2 :	Understand the nervous system	1, 2	80	70
CLO-3 :	Identify the applications of neural engineering	2	80	70
CLO-4 :	Understand BCI system and neuro imaging techniques	1	80	70
CLO-5 :	Identify the various neuro prosthetic devices and neuron modelling	1	80	70
CLO-6 :	Understand the concepts of neuro prosthetics and its modeling techniques	1,2	80	70

Program Learning Outcomes (PLO)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
M	-	-	-	-	-	-	-	-	-	-	-	M	-	-
M	-	-		-	-	-	-	-	-	-		M	-	-
M	-	-		-	-	-	-	-	-	-		-	-	M
M	-			-	-	-	-	-	-	-		-	-	M
M	-	-		-	-	-	-	-	-	-		-	-	M
M	-	-	-	-	-	-	-	-	-	-		-	-	M

Duration (hour)		Introduction To Neurons And Nervous Systems	Neuro-Transmission And Neuro-Transmitters	Neural Imaging Techniques	Neural stimulation and Neural modeling	Neuro-Prosthetics
		9	9	9	9	9
S-1	SLO-1	Brain anatomy	Nervous system	Brain Computer Interface	Sensory prosthetics	Deep brain stimulation
	SLO-2	Structure of neurons	Nervous system	History of BCI	Retinal prosthetics	Deep brain stimulation
S-2	SLO-1	Function of neurons	Central nervous system	Components of a BCI System	Visual prosthetics	Spinal cord stimulation
	SLO-2	Types of neurons	Peripheral nervous system	Functional Components	Bionic eye	Spinal cord stimulation
S-3	SLO-1	Neuroglia	Neurotransmission	Feedback	Bionic eye	Cortical stimulation
	SLO-2	Myelinated and unmyelinated nerve fibers	Stages in neurotransmission	Signal Acquisition	Auditory prosthetics	Cortical stimulation
S-4	SLO-1	Properties of nerve fibres	Synaptic transmission	Invasive Techniques	Cochlear implant	Transcranial direct current stimulation
	SLO-2	Excitability, conductivity, all-or none law, accommodation, adaptation, summation, refractory period, indefatiguability	Synaptic transmission	Noninvasive Techniques	Cochlear implant	Transcranial direct current stimulation

S-5	**SLO-1**	*Synapse*	*Chemical synaptic transmission*	*Feature Extraction and Translation Techniques*	*Bionic ear*	*Single neuron model*
	SLO-2	*Glial cells*	*Chemical synaptic transmission*	*Types of BCI Signals*	*Bionic ear*	*Single neuron model*
S-6	**SLO-1**	*Myelination*	*Electrical synaptic transmission*	*Training of BCI signals*	*Spinal cord stimulator*	*Hodgkin Huxley neuron model*
	SLO-2	*Neuronal differentiation*	*Electrical synaptic transmission*	*Signal Processing and Feature Extraction*	*Motor prosthetics*	*Hodgkin Huxley neuron model*
S-7	**SLO-1**	*Characterization of neuronal cells*	*Neurotransmitters and their release*	*BCI development*	*Bladder control implant*	*Fitzhugh Nagumo models*
	SLO-2	*Characterization of neuronal cells*	*Neurotransmitters and their release*	*Electroencephalography (EEG)*	*Bladder control implant*	*Fitzhugh Nagumo models*
S-8	**SLO-1**	*Blood Brain barrier*	*Types of neurotransmitters*	*Principle and working of EEG*	*Sacral anterior root stimulator*	*Morris lecar model*
	SLO-2	*Blood Brain barrier*	*Types of neurotransmitters*	*Computerized axial tomography (CAT) scans in brain imaging*	*Sacral anterior root stimulator*	*Morris lecar model*
S-9	**SLO-1**	*Meninges*	*Fast and slow neurotransmission*	*Functional Magnetic Resonance Imaging (fMRI)*	*Prosthetics for conscious control of movements*	*Hind marsh rose model*
	SLO-2	*Cerebrospinal fluid*	*Fast and slow neurotransmission*	*Functional Magnetic Resonance Imaging (fMRI)*	*Prosthetics for conscious control of movements*	*Hind marsh rose model*

Learning Resources	1. **Bin He, Neural Engineering, Plenum Publishers, 2005.** **2. R.S.Khandpur, Handbook of Biomedical Instrumentation, Mc Graw Hill, 3rd Edition, 2015.**	

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*40 %*	-	*40 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*20 %*	-	*20 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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*	*Dr.A.K.Jayanthy SRMIST*

Course Code	18BME372T	Course Name	IOT AND TELEHEALTH TECHNOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Understand the building blocks of IoT
CLR-2 :	Understand the technologies in IoT
CLR-3 :	Gain knowledge in system management in wearable devices
CLR-4 :	Explore the architecture of smart healthcare systems
CLR-5 :	Gain knowledge in basics of tele-health technology and architecture involved
CLR-6 :	Gain knowledge in architecture of IoT systems and its applications in healthcare

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (Bloom)	Learning 2 Expected Proficiency (%)	Learning 3 Expected Attainment (%)	PLO 1 Engineering Knowledge	PLO 2 Problem Analysis	PLO 3 Design & Development	PLO 4 Analysis, Design, Research	PLO 5 Modern Tool Usage	PLO 6 Society & Culture	PLO 7 Environment & Sustainability	PLO 8 Ethics	PLO 9 Individual & Team Work	PLO 10 Communication	PLO 11 Project Mgt. & Finance	PLO 12 Life Long Learning	PSO 1	PSO 2	PSO 3
CLO-1 :	Explain the various models and protocols in IoT	1, 2	80%	70%	M	-	-	-	-	-	-	-	-	-	-	-	M	-	-
CLO-2 :	Demonstrate the various technologies for building IOT	2	80%	70%		-	-	L	-	-	-	-	-	-	-	-	M	-	-
CLO-3 :	Explain the IoT system management and its applications	2	80%	70%		-	-	L	-	-	-	-	-	-	-	-	M	-	-
CLO-4 :	Apply the techniques in Realtime healthcare applications	3	80%	70%	M	-	-	-	-	-	-	-	-	-	-	-	M	-	-
CLO-5 :	Explain the architecture in tele health technology	3	80%	70%	M	-	-	-	-	-	-	-	-	-	-	-	M	-	-
CLO-6 :	Demonstrate the IoT system architecture for healthcare applications	3	80%	70%	M	-	-	-	-	-	-	-	-	-	-	-	M	-	-

Duration (hour)		Building blocks of IoT	IoT Enabling Technologies	Machine-to-Machine and system management	Smart healthcare applications	Telehealth Technology
		9	9	9	9	9
S-1	SLO-1	Characteristics of IoT	Wireless sensor network	Smart healthcare	Real time smart healthcare model using IoT	Mobile application for medical diagnosis
	SLO-2	Physical design of IoT	Cloud computing	Distributed Analytics and Edge Intelligence	Sensor modules	Architecture of the program, design of the modules
S-2	SLO-1	IoT protocols	Big data analytics	Smart Healthcare Use Cases and Applications	Model Architecture	Telecardiology to detect cardiac abnormalities
	SLO-2	IoT devices	Communication protocols	Healthcare Monitoring	Wearable smart health management clothing	Telecommunications, Wearable device forECG monitoring
S-3	SLO-1	Network/internet layer	Embedded systems	Wearable Devices	Data acquiring	Virtual clinic – a telemedicine framework
	SLO-2	Transport layer,	Key components	architecture of wearable devices in healthcare	Training and testing, accuracy prediction	System model
S-4	SLO-1	Application layer	IoT levels and deployment templates	Pulse Rate Monitoring System	Fog based Real time analytics	Research methodology
	SLO-2	Layer protocols	System components	Smart Glove for Paralyzed Patients	IoT analytics	Proposed clinical decision support systems
	SLO-1	Logical design of IoT	IoT level - 1	Automatic Medicine Dispenser	Data gathering and Consumptions	Personalized Telehealth care

S-5	**SLO-2**	*IoT functional blocks*	*IoT level - 2*	*Smart Healthcare Applications and Real-Time Analytics Through Edge Computing q*	*Protocols used for IoT platform*	*Categories based tele-based services*
S-6	**SLO-1**	*Communication models*	*IoT level - 3*	*Comparison cloud, fog and edge computing*	*Real-Time Stream Processing*	*Telediagnosis*
	SLO-2	*Request response model*	*Applications*	*Edge Computing and Healthcare Systems*	*Fog Computing*	*Machine learning approach for telediagnosis*
S-7	**SLO-1**	*Publish subscribe model*	*IoT Level – 4*	*Edge Computing General Framework*	*Fog computing architecture*	*Architecture of Mobile Telemedicine Systemusing MMS for telediagnosis*
	SLO-2	*Push pull model, Exclusive pair model*	*IoT Level – 5*	*Edge Computing Use Cases*	*Characteristics of fog computing*	*Teleconsultation, Telenursing*
S-8	**SLO-1**	*IoT communication APIs*	*IoT Level – 6*	*Edge Computing for Real-Time Analysis*	*Comparison of fog, cloud, and edge*	*Teletreatment and Telerehabilitation*
	SLO-2	*Rest based communication APIs*	*Applications*	*Serverless Framework for Real-Time Analysis*	*Role of Fog Computing in Healthcare*	*Tele-Psychiatry*
S-9	**SLO-1**	*Request response model used by REST*	*Wellness monitoring and diagnosis*	*Real-Time Map-Reduce Framework UsingEdge*	*Deployment of Healthcare Applications*	*Ethical Challenges, TelemedicineAuthorization*
	SLO-2	*WebSocket based communication APIs*	*Wearable electronics*	*Challenges for IoT-based Edge computing and deployment*	*Case Study: A Real-Time Fog HealthcareScenario, Patient monitoring system*	*Challenges to Tele-Based Healthcare*

Learning Resources	*1. Arshdeep Bahga, Vijay Madisetti ," Internet of things-Hands on approach"VPT Edition 1, 2014.* *2. Pethuru Raj, Jyotir Moy Chatterjee, Abhishek Kumar, B. Balamurugan. "Internet of ThingsUse Cases for the Healthcare Industry" Springer, 2020*	*3. Rajkumar Buyya, Amir Vahid Dastjerdi, "Internet of Things: Principles and Paradigms" ,Elsevier, 2016.* *4. Hemanth D. Jude, Valentina Emilia Balas, "Telemedicine Technologies: Big Data, Deep Learning, Robotics, Mobileand Remote Applications for Global Healthcare", Academic Press, 2019*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*40 %*	-	*40 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*20 %*	-	*20 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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*

Course Code	18BME373T	Course Name	MICRO FLUIDICS	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:*

		Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	Understand the basic concepts o the microfludic and nanofluidic			
CLR-2 :	Get an idea about the Interfaces in Microfluidic and Nanofluidic Systems			
CLR-3 :	Acquire an idea about the materials and various fabrication methods and techniques			
CLR-4 :	Get an idea about the fluidic control methods and detection methods			
CLR-5 :	Get an idea about the application of various microfludic and nanofluidic in biological system			
CLR-6 :	Get an overall idea about the microfluidic and nanofluidic system importance in Medical Domain			

Course Learning Outcomes (CLO): *At the end of this course, learners will be able to:*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	Understanding of the fundamental of the microfluidic and nanofluidic	1, 2	80	70	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	Analyze the various interfaces with surface and devices	1, 2	80	70	M	-	-	-	-	-	-	-	-	-	-	-	M	-	-
CLO-3 :	Describes about the techniques and methods with materials used for fabrication of micofluidic and nanofluidic structures	2	80	70	-	M	-	-	-	-	-	-	-	-	-	-	M		-
CLO-4 :	Overview of problem for control and detection 's of fluid interaction and techniques used for solving	1	80	70	-	-	H	-	-	-	-	-	-	-	-	M	-	M	-
CLO-5 :	Explain the various Microdevice Technologies	1	80	70	-	-	-	-	-	-	-	-	-	-	-	M	-	-	-
CLO-6 :	Outline the importance of microfluidic and nanofluidic in biological application				-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Duration (hour)		Basic Microfludic concepts	Materials and fabrication Processes for Microfluidic	Fluidic control methods and Detection methods	Microdevice Technologies	Applications to Biological System
		9	9	9	9	9
S-1	SLO-1	Introduction to Microfluidics	Materials for Microfluidic Devices	Fluid Control :Basic theory	Actuators for micropumps	Electrophoresis:DNA separation
	SLO-2	Introduction to Microfluidics	Silicon Based Materials	Pressure –Driven Flow	Actuators for micropumps	Case study :DNA separation
S-2	SLO-1	The microfluidic advantage	Glass Based Materials	Shear driven Flow	Actuators for Microvalves	Shear-driven flow: Biomolecular separation
	SLO-2	Fluidics and Transport Fundamentals: The continuum approximation	Polymers Based Material	Shear driven flow examples	Actuators for Microvalves	Case study : Biomolecular separation
S-3	SLO-1	Laminar flow	Fabrication of Microfluidics devices	Electrokinetically –driven flow	Flow sensors	Ion Transport with case study
	SLO-2	Laminar flow(contd.)	Photolithography & its techniques	Electrokinetically –driven flow problem and examples	Microarrays	Concentration with case study
S-4	SLO-1	Diffusion in microfluidic systems	Additive Techniques	Single Molecule Detection Methods	Microarrays	Bioanalysis:Immunoassay
	SLO-2	Diffusion in microfluidic systems(contd.)	Subtractive Techniques	Optical detection methods	Microreactors	DNA analysis
S-5	SLO-1	Surface forces and droplets	Silicon microfabrication	Optical detection methods examples	Microreactors	On-chip separations and combinations

	SLO-2	*Surface forces and droplets(contd.)*	*(Dry Reactive Ion Etching) DRIE*	*Electrochemical method*	*Pipettes and Dispensers*	*Sample injection and separation*
S-6	**SLO-1**	*Pumps and valves*	*Surface micromachining*	*Electrochemical method examples*	*Pipettes and Dispensers*	*Micro-gas chromatography:*
	SLO-2	*Pumps and valves(contd.)*	*Glass Microfabrication – wet isotropic etching*	*Measurement of Fluidic Properties: Nonintrusive flow measurement techniques*	*Microanalytical Chips*	*Micro gas sensors for micro GC*
S-7	**SLO-1**	*Electrokinetics*	*Wafer Bonding – Fusion, Anionic and Adhesive*	*Streaming potential/current measurementin pressure-driven flows*	*Microanalytical Chips*	*Case study for a micro GC*
	SLO-2	*Electrokinetics(contd.)*	*Polymer microfabrication*	*Current monitoring in electroosmotic flow*	*Electrochemical microfluidics devices*	*Micro-scale impedance measurements*
S-8	**SLO-1**	*Electro-osmosis*	*Injection molding and Hot embossing*	*Optical flow imaging techniques using a tracer: Properties of flow tracers*	*Electrochemical microfluidics devices(contd.)*	*Biosensor*
	SLO-2	*Electro-osmosis(contd.)*	*Casting & Lithography*	*Scalar image velocimetry*	*Paper Microfluidics devices*	*Biosensors: Case study 1*
S-9	**SLO-1**	*Electrophoresis*	*Fabrication of microfluidic channels in SU-8*	*Scalar image velocimetry*	*3D Printed Microfluidic Devices*	*Nano- Biosensors*
	SLO-2	*Dielectrophoresis*	*Microfluidic networks created in biodegradable materials.*	*Laser-induced fluorescence photo bleaching anemometer with stimulated emission depletion*	*3D Printed Microfluidic Devices(contd.)*	*Nano-Biosensors: Case study 2*

Learning Resources	*1. Patric Tabeling "Introduction to Microfluids" Oxford U. Press, New York 2005.* *2. Yujun Song, Daojian Cheng& Liang Zhao," Microfluidics: Fundamentals, Devices, and Applications", Wiley- VCH,First edition ,2018* *3.* Xiujun (James) Li and Yu Zhou," Microfluidic devices for biomedical applications", Woodhead Publishing Limited,16th edition,2013. *4.* Jeffrey D. Zahn," Methods in Bioengineering -Biomicrofabrication and Biomicrofluidics",Artech House ,1st edition,2010	*5. Wei-Cheng Tian, Erin Finehout," Microfluidics for Biological Applications"Springer,2008* *6. Nam-Trung Nguyen, Steven T. Wereley,"Fundamentals And Applications of Microfluidics, Artech Print on Demand,Second Edition,2006* *7. Sushanta K. Mitra, Suman Chakraborty "Microfluidics and Nanofluidics Handbook: Fabrication, Implementation, and Applications", CRC Press; 1 edition, 2017.* *8. Jan Korvink, Oliver Haber,"MEMS: A Practical Guide to Design, Analysis, and Applications",Springer,2006* *9.*Chandra K. Dixit, Ajeet Kaushik," Microfluidics for Biologists: Fundamentals and Applications",Springer,2016

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*40 %*	-	*40 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*20 %*	-	*20 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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. Ms. Oinam Robita Chanu*

Course Code	18BME374T	Course Name	MEDICAL ETHICS AND INTELLECTUAL PROPERTY RIGHTS	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:*

		Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	Understand the fundamentals of medical ethics			
CLR-2 :	Get an idea about the codes of medical ethics			
CLR-3 :	Acquire an idea about intellectual property rights			
CLR-4 :	Get an idea about patents			
CLR-5 :	Get an idea about copyrights			
CLR-6 :	Get an overall idea about trademarks and geographical indicators			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	Outline the importance of medical ethics	1, 2	80	70
CLO-2 :	Analyze the development of IPR	1, 2	80	70
CLO-3 :	Understand the principle of various agreements	2	80	70
CLO-4 :	Outline the importance of patents	1	80	70
CLO-5 :	Understand the importance of copyrights	1	80	70
CLO-6 :	Understand the concept of trademarks and geographical indicators	1,2	80	70

Program Learning Outcomes (PLO)

1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
-	-	-	-	-	-	-	H	-	-	-	M	-	-	-
-	-	-	-	-	M	-	-	-	-	-	M	M	-	-
-	-	-	-	-	-	-	-	-	-	-	M	M		-
-	-	-	-	-	M	-	-	-	-	-	M	-	M	-
-	-	-	-	-	M	-	-	-	-	-	M	-	-	-
-	-	-	-	-	-	-	-	-	-	-	M	-	-	-

Duration (hour)		Medical Ethics	Introduction to Intellectual Property Rights	Patents	Copyrights	Trademarks and Geographical Indicators
		9	9	9	9	9
S-1	SLO-1	Definition and historic evolution of bioethics	Origin and development of IPR	Definition of patents	What is copyright	Trademark and purpose of a trademark
	SLO-2	Codes and guidelines, universal principles	History of IPR	Purpose of a patent	Why copyright	Characteristics of trademark
S-2	SLO-1	Medical ethics:some basic issues	Importance and need for protection of intellectual property	What sort of things can be patented, Patentable and non-patentable inventions,	Literature and artistic works	Functions of trademarks
	SLO-2	Medical ethics:some basic issues	Rights to be given	Conditions for an invention to be patentable	Protection of copyright	Guidelines for the registration of a trademark
S-3	SLO-1	Teaching and learning medical ethics	Patentable subject matter	Invention vs Innovation	Right of reproduction	Nontraditional trademarks
	SLO-2	Teaching and learning medical ethics	Emerging trends and issues in IPR	Process Patent	Right of public performance	Major types of trademarks
S-4	SLO-1	Codes of conduct	Creativity and Invention	Product Patent	Right of broadcasting	Protection of a trademark
	SLO-2	Codes of conduct	Theories on concept of property	Types of patent applications	Right of translation	Purpose of a trademark
	SLO-1	Rights of patients	Public Vs. Private	Precautions while patenting	Right of Adaptation	Madrid system for the International registrationof trademarks

S-5	SLO-2	*Rights of patients*	*Tangible Vs. Intangible Industrial Vs. Intellectual*	*Patent specification*	*Transfer of copyright*	*Madrid system for the International registrationof trademarks*
S-6	SLO-1	*Rights of life*	*World Intellectual Property Organization(WIPO)*	*Patent claims*	*Limitations of copyright*	*Industrial design*
	SLO-2	*Rights of life*	*World Trade Organisation (WTO)*	*Disclosures and non-disclosures*	*Enforcement of Rights*	*Purpose of industrial design*
S-7	SLO-1	*Malpractice*	*General Agreement on Tariffs and Trade(GATT) agreement*	*Patent rights and infringement*	*International conventions and treaties*	*Protection of industrial design*
	SLO-2	*Negligence*	*Major Conventions on IP*	*Patent rights and infringement*	*International conventions and treaties*	*The Hague agreement*
S-8	SLO-1	*Care of the terminally ill*	*Berne Convention*	*Rights of a patent owner*	*Benefits from copyright protection*	*Geographical indication*
	SLO-2	*Distributive Justice in Health Care*	*Paris Convention*	*Patent cooperation treaty*	*Benefits from copyright protection*	*Appellation of origin*
S-9	SLO-1	*Human experimentation*	*TRIPS agreement*	*Paris convention for the protection of industrial property*	*Works that are protected by copyright*	*Protection of geographical indication(GI)*
	SLO-2	*Clinical trials*	*Basic forms of intellectual property rights*	*Importance, advantages and disdvantagesof patents*	*Works that are not protected by copyright*	*Difference between a GI and a trademark*

Learning Resources	1. *Ramakrishna B and Anil Kumar H S, 'Fundamentals of Intellectual Property Rights: For Students,Industrialist and Patent Lawyers', Notion Press, 2017.* 2. *C M Francis, Medical Ethics, Second Edition, Jaypee Brothers, 2004.*	3. *Chawla H S, Introduction To Intellectual Property Rights, Oxford and IBH Publishing, 2020.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*40 %*	-	*40 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*20 %*	-	*20 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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Course Code	18BME375T	Course Name	VIRTUAL INSTRUMENTATION FOR BIOMEDICALENGINEERS	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:	Learning

		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	Understand the fundamental Virtual Instrumentation			
CLR-2 :	Get an idea about the software used in Virtual Instrumentation and function			
CLR-3 :	Acquire a concept about the VI programming			
CLR-4 :	Get an idea about the biomedical application of Virtual Instrument			
CLR-5 :	Get an idea about the research based development in the area of Virtual Instrument			
CLR-6 :	Understand the different biological application of LabVIEW			
Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:			
CLO-1 :	Analyze the Virtual Instrument in healthcare domain	1, 2	80	70
CLO-2 :	Explain the Virtual Instrument processes and software	1, 2	80	70
CLO-3 :	Differentiate the various Programming techniques	2	80	70
CLO-4 :	Illustrate the concepts of LabVIEW in Real time experimental	1	80	70
CLO-5 :	Illustrate the concepts of LabVIEW with suitable examples	1	80	70
CLO-6 :	Outline the research application in Biological	1,2	80	70

Program Learning Outcomes (PLO)														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
M	-	-	-	-	-	-	-	-	-	-	-	-	-	-
M	-	-	-	-	-	-	-	-	-	-	-	M	-	-
-	-	L	-	-	-	-	-	-	-	-	-	M		-
-	-	L	-	-	-	-	-	-	-	-	-	-	M	-
-	-	L	-	-	-	-	-	-	-	-	-	-	-	-
-	-	L	-	-	-	-	-	-	-	-	-	-	-	-

Duration (hour)		Virtual Instrumentation	Programming Mode& Techniques	Hardware Instrument	Common Instrument Interface	Labviews Tools & Its Applications
		9	9	9	9	9
S-1	SLO-1	Virtual Instrumentation - *Introduction*	Data Flow Programming	Digital I/O Techniques	General Purpose Interface Bus(GPIB)	*Signal Process:* Fourier transform
	SLO-2	Conventional Instrumentation	G' Programming Concepts	Digital I/O Techniques	GPIB :IEEE 488.2 STANDARD	Fourier transform problem
S-2	SLO-1	Architecture of VI	Creating and Saving VIs, SubVIs	Data Acquisition in LabVIEW	RS232	Power spectrum
	SLO-2	Architecture of VI	Wiring, Editing, and Debugging VI	Data Acquisition in LabVIEW	RS485	Correlation
S-3	SLO-1	Conventional Virtual Instrumentation	Control Structures such as the For Loop andthe While Loop	Hardware Installation and Configuration	Virtual Instrument Software Architecture(VISA)	Windowing
	SLO-2	Distributed Virtual Instrumentation	Shift Registers and Their function	Components of DAQ	VXI	Filters
S-4	SLO-1	Virtual Instruments Versus Traditional Instruments	Selection Structures: Case and sequencestructures	Components of DAQ	VXI	Oscilloscope
	SLO-2	Advantages of VI	Selection Structures: Formulae nodes, feedback nodes	DAQ Signal Accessory	USB	Waveform generator

S-5	**SLO-1**	Evolution of LabVIEW	Arrays	DAQ Signal Accessory	USB	Multi-channel data acquisition
	SLO-2	Creating Virtual Instruments Using LabVIEW	Arrays	DAQ Assistant: Create a MAX-Based Task	PCI	*Vision and Motion tools*
S-6	**SLO-1**	Creating Virtual Instruments Using LabVIEW	Cluster :Creating Cluster Controls and Indicator	DAQ Assistant: Create a Project-Based Task	PCI Express	*Vision and Motion tools- problems*
	SLO-2	Advantages of LabVIEW	Cluster functions	DAQ Hardware	PXI	*Vision and Motion tools -problems*
S-7	**SLO-1**	Front Panel of Virtual Instruments	Waveform Chart and graph	DAQ Hardware	PCMCIA	Bio Bench
	SLO-2	Block Diagram of Virtual Instruments	XY Graph	DAQ Software	PCMCIA	Biomedical work bench
S-8	**SLO-1**	LabVIEW Environment and its Menus	Strings, Creating String Controls and Indicators	4–20mA Current Loop	SCXI	*Biomedical real time application- ECG*
	SLO-2	LabVIEW Environment and its Menus	String Functions	4–20mA Current Loop	SCXI	*Biomedical real time application-EMG*
S-9	**SLO-1**	Palletes of LabVIEW	Tables and List Boxes	60 mA Current Loop	LXI	*Biomedical real time application-EEG*
	SLO-2	Palletes of LabVIEW	File Input/Output Functions	60 mA Current Loop	LXI	*Biomedical real time application-EOG*

Learning Resources	*1. S. Sumathi and P. Surekha, "Labview based Advanced Instrumentation Systems ", Springer, First edition, 2007* *2. Gary Jonson, "Labview Graphical Programming", Second Edition, McGraw Hill, New York, Fourth edition2006.* *3. Lisa K. wells and Jeffrey Travis, "Labview for everyone", Prentice Hall Inc., New Jersey;First edition 1997.* *4. Gupta S and Gupta J P, "PC interfacing for Data Acquisition & Process Control", Instrument Society ofAmerica, Second Edition, 1994*	*5. Jon B. Olansen and Eric Rosow, "Virtual Bio-Instrumentation: Biomedical, Clinical, and Healthcare Applications in LabVIEW ",Prentice Hall,First edition, 2001* *6.* Ronald W. Larsen ,"LabVIEW for Engineers", Pearson ,First edition, 2010 *7. Robert H. Bishop," Learning with LabVIEW" , Pearson, First edition, 2014* *8. John Essick ," Hands-On Introduction to LabVIEW for Scientists and Engineers ",Oxford University Press, Fourth edition ,2018*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*40 %*	-	*40 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*20 %*	-	*20 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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. Ms Oinam Robita Chanu, SRMIST*

Course Code	18BME376T	Course Name	HEALTH CARE DATA ANALYTICS	Course Category	*E*	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses		Co-requisite Courses		Progressive Courses	
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 basics of Health care data*
CLR-2 :	*Understand the basics of data analysis*
CLR-3 :	*Understanding about complexity of health care data and information system*
CLR-4 :	*Utilize the knowledge of data analytics to solve health problems*
CLR-5 :	*Data security and Ethics in Health care data*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	**Learning**			**Program Learning Outcomes (PLO)**														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO – 1: Professional Achievement	PSO – 2: Project Management Techniques	PSO – 3: Analyze & Reseach
CLO-1 :	*Understand the conceptual and practical difficulties in getting health care data*	*3*	*80*	*75*	L	M	-	L	L	-	M	M	L	-	M	M	L	M	L
CLO-2 :	*Know how to find clean and perform suitable statistical methods for analysis*	*3*	*80*	*70*	M	M	-	L	L	-	M	M	L	-	M	M	L	M	L
CLO-3 :	*Understand the information system design and technical skills to use data for decision making and business development*	*3*	*75*	*70*	M	M	-	L	L	-	M	H	L	L	M	M	L	M	M
CLO-4 :	*Understand the importance of Data standards, security and ethics in health care data*	*3*	*80*	*75*	H	M	L	M	L	H	M	H	L	-	M	M	L	M	M
CLO-5 :	*Understand how data analytics can provide potential solutions to improve health outcomes.*	*3*	*80*	*70*	H	M	L	H	H	H	M	M	L	L	M	M	L	M	H
CLO-6:	*Understand concepts related to health care data innovation, big data analytics and predictive analytics*	*3*	*80*	*70*	H	M	H	H	H	-	M	M	L	-	M	M	L	M	H

Duration (hour)		**Health care data**	**Data management and Information system**	**Pre processing**	**Big data analytics**	**Predictive modelling**
		9	**9**	**9**	**9**	**9**
S-1	SLO-1	*Introduction to health care data*	*Introduction to MIS*	*Introduction to pre processing*	*Introduction to big data analytics*	*Introduction to modelling*
	SLO-2	*Data analytics life cycle*				*Regression models*
S-2	SLO-1	*Complexity of Health care data*	*Management pyramid*	*Concept of Outliers*	*Properties of Big data*	*Introduction to Regression models*
	SLO-2	*Importance of Data in health care*	*Concept of Informatics*	*Ways to Detect outliers*	*Introduction to Big data analytics*	*Types of Regression models*
S-3	SLO-1	*Evidence based medicine*	*Components of information system*	*Ways to deal with outliers*	*Classification and Prediction*	*Types of Link functions*
	SLO-2	*Evidence based medicine*	*Data sources and Data tools*	*Ways to deal with outliers*		*Concept of Correlation*
S-4	SLO-1	*Data sources*	*Management of databases*	*Process of Dealing outliers*	*Data mining*	*Auto correlation*
	SLO-2	*Digital health initiatives*	*Management systems*	*Missing Values*	*Importance of data mining in Health care*	*Multicollinearity and its effects*
S-5	SLO-1		*Decision support system development*	*Concept of Missing values*	*Data mining Technique uses in Health care*	*Ways to detect multicollinearity*
	SLO-2	*Concept of M health*	*Ethical issues in health care data*	*Possible reasons for Missing values*	*Association rule mining*	*Multiple correlation*
S-6	SLO-1	*M Health and data types*	*Ethical issues in health care data*	*Types of missing values*	*Association rule mining using R*	
	SLO-2	*e-Health*	*HIPAA standards*	*Ways to deal with missing values*		*Concept of Validation*
S-7	SLO-1	*e- health and data*	*Standardization - ICD*	*Ways to deal with missing values*		*Types of validation*
	SLO-2	*Telemedicine*	*Steps to Secure Big data*	*Concept of Dimensionality*	*Introduction to Decision trees*	*Cross validation*
S-8	SLO-1	*Telemedicine and its importance*	*Steps to Secure Big data*	*Importance of dimensionality reduction*	*Introduction to CART*	*Internal validation*

	SLO-2	*Ways to manage the different data types*	*Classifying data*	*Statistical methods for dimensionality reduction*		*External Validation*
S-9	SLO-1	*Ways to manage the data types*	*Protecting big data*	*Statistical methods for dimensionality reduction*	*Classification by decision tree induction*	*Concept of over and under fitting*
	SLO-2	*Ways to manage the data types*	*Intellectual property challenge*	*Statistical methods for dimensionality reduction*	*Classification by decision tree induction*	*Ways to deal with over fitting and under fitting*
Learning Resources		1. Big Data Analytics and Its Benefits in Healthcare . Anand J. Kulkarni, Patrick Siarry, Pramod Kumar Singh, Ajith Abraham, Mengjie Zhang 2. Big Data Analytics in Healthcare: A Critical Analysis,Editor(s): Nilanjan Dey, Himansu Das, Bighnaraj Naik, Himansu Sekhar Behera, 3. Ristevski B, Chen M. Big Data Analytics in Medicine and Healthcare. J Integr Bioinform. 2018;15(3):20170030. Published 2018 May 10. doi:10.1515/jib-2017-0030				

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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	*Prof M Bagawandas – Centre for statistics , SRM IST*	*1.Dr.M Prakash , SRMIST*

Course Code	18BME461T	Course Name	BIOMEDICAL 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:	Learning			Program Learning Outcomes (PLO)														
CLR-1 :	Understand what is medical informatics, The types of medical databases and carious theft issues	1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-2 :	Gain knowledge about the structure of Hospital information system, clinical Information system																		
CLR-3 :	Understand the telemedicine technology, and types of data transfer																		
CLR-4 :	Gain knowledge in an automation of clinical laboratories																		
CLR-5 :	Learn different decision making algorithms and computerized imaging techniques																		
CLR-6 :	The learn different types of computer aids for handicapped and computers in the care of critically ill patients																		
Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	Understand applications of computers in health care and different types of medical databases	1, 2	80%	70%	M														
CLO-2 :	Implement Hospital Information system and Clinical Information system	2	80%	70%	M														
CLO-3 :	Gain knowledge on telemedicine technology	2	80%	70%			M		M								M		L
CLO-4 :	Implement automation of clinical laboratories	3	80%	70%					M										
CLO-5 :	Apply different decision making algorithm for imaging and diagnosis	3	80%	70%	M												M		L
CLO-6 :	Gain knowledge on various computer aids for handicapped and computers role in care of critically ill patients	3	80%	70%	M														

Duration (hour)		*Medical informatics and Computer based patient record*	*Hospital Information system and Clinical information system, Telemedicine*	*Computers in a Clinical Laboratory*	*Computer assisted medical Decision making*	*Computer aids for the handicapped & Computers in the care of critically ill patients*
		9	9	9	9	9
S-1	SLO-1	What is Medical Informatics?	Functional capabilities of computerizedHospital information system	Microprocessor for automation	General model of CMD	Mobility, EMG controlled limbs
	SLO-2	Prospects of medical informatics	Need for computerization oh hospitals in India	Database approach to laboratory computerization	Various approaches in decision making	Aids for Blind and visually handicapped
S-2	SLO-1	Historical review of the development of computers and informatics	Security of computer records	Automation of clinical laboratories	Computer assisted decision support systems	Braille system, bat cane
	SLO-2	Foundation ontology	Cost effectiveness of information processing by computer	Automated methods in hematology	Algorithmic methods	Portable reading aids
S-3	SLO-1	What is computer based patient record	Benefits of clinical information system	Chromosome analysis by computer	Elements of a protocol	Artificial vision for the blind
	SLO-2	History taking by computer and Dialoguewith the computer	Sources of data for decision making	Computerized cytology and histology	Probabilistic approaches to decision making	Concept of artificial retina
	SLO-1	Development toolsIntranet	Modes of decision output to Physician	Automated scanning for cervical scanner	Sequential Bayes, Linear discriminant function	Computer aids for the deaf

S-4	**SLO-2**	*CPR in radiology*	*Registry of Computerized Medical record system*	*Computer assisted semen analysis*	*Multivariate analysis*	*Computer speech generation and recognition*
S-5	**SLO-1**	*Types of databases: Bibliographic databases*	*CIS in obstetrics – Gynecology*	*Radio Immunoassays*	*Database comparisons and case based reasoning*	*Robotics to assist the elderly infirm*
	SLO-2	*Non Bibliographic databases*	*Fetal Monitoring*	*Intelligent laboratory information system*	*Production rule systems*	*Cognitive system engineering*
S-6	**SLO-1**	*Medical information retrieval*	*What is telemedicine*	*Computer aided analysis of Echocardiograms*	*Cognitive models*	*Automated computer assisted Fluid and metabolic balance*
	SLO-2	*Medical information retrieval techniques*	*Need for telemedicine*	*Computerized ECG, analysis of signals*	*Semantic networks*	*Pulmonary function Evaluation*
S-7	**SLO-1**	*Legal, Security and privacy issues in computers and internet*	*Telemedicine technology*	*Assessment of performance of ECG computer programs*	*Decision analysis in clinical medicine*	*Computerized decision support for mechanical ventilation*
	SLO-2	*Types of threats*	*Types of data transfer*	*Computerized EEG*	*Computers in nuclear medicine*	*Cardiovascular physiological evaluation*
S-8	**SLO-1**	*Cryptography*	*Mode of transmission*	*Long term monitoring of EEG*	*Data acquisition, manipulation and processing*	*Computer assisted surgery*
	SLO-2	*Digital Signature*	*Internet and telemedicine*	*Computerized EMG*	*Computer assisted medical imaging-CT*	*Robotics in surgery*
S-9	**SLO-1**	*User Authentication*	*Telemedicine websites*	*Single fibre EMG*	*CT-Radiation therapy planning*	*Sensing system*
	SLO-2	*Attacks from inside and outside the system*	*Applications of telemedicine*	*Computerized EEG*	*Computer for MRI*	*Interactive modes*

Learning Resources	1. *Ramchandra Lele., "Computers in Medicine Progress in Medical Informatics", Tata McGraw-Hill Publishing Company Limited, New Delhi First Edition, 2005* 2. *Mohan Bansal, M S., "Medical Informatics A Primer", Tata McGraw-Hill Publishing Company Limited, New Delhi, 2nd edition 2003.*	3. *Edward H.Shortliffe, James J. Climino., "Biomedical informatics Computer Applications in Health Care and Biomedicine", Springer, Third Edition, 2006.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*40 %*	-	*40 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*20 %*	-	*20 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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*

Course Code	18BME462T	Course Name	PHYSIOLOGICAL MODELING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18BMC305T Biocontrol Systems	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:	Learning		
CLR-1 :	Understand the process of modeling to various physiological systems	1	2	3
CLR-2 :	Understand the mathematical tools for static analysis of models	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-3 :	Perform time domain analysis of the physiological models			
CLR-4 :	Perform frequency domain analysis of the physiological models			
CLR-5 :	Understand techniques in system identification and parameter estimation			
CLR-6 :	Understand the techniques in designing physiological system models and to perform analysis			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:			
CLO-1 :	Explain the different techniques in designing physiological model	1,2	80%	70%
CLO-2 :	Detail about the tools for static analysis of physiological system	1,2	80%	70%
CLO-3 :	Describe the techniques for time domain analysis of physiological model	1,2	80%	70%
CLO-4 :	Describe the techniques for frequency domain analysis of the physiological models	1,2	80%	70%
CLO-5 :	Outline the various methods for system identification and parameter estimation	1,2	80%	70%
CLO-6 :	Interpret the various physiological system models	1,2	80%	70%

Program Learning Outcomes (PLO)														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
M	-	-	-	-	-	-	-	-	-	-	-	M	-	-
-	M	-	-	-	-	-	-	-	-	-	-	M	-	-
-	M	-	-	-	-	-	-	-	-	-	-	M	-	-
-	M	-	-	-	-	-	-	-	-	-	-	M	-	-
-	M	-	-	-	-	-	-	-	-	-	-	M	-	-
M	-	-	-	-	-	-	-	-	-	-	-	M	-	-

Duration (hour)		Linear Model	Static Analysis	Time Domain Analysis	Frequency Domain Analysis	System Identification
		9	9	9	9	9
S-1	SLO-1	Introduction to modeling methodology, needfor models, approaches to modeling	Static analysis: Open loop versus closed loop	Introduction to time domain analysis	Frequency response: Open loop frequency response	Identification of physiological control system
	SLO-2	Model identification, model validation and Simulation	Loop gain calculation: Room temperaturecontrol	Linearized respiratory mechanics transient response	Closed loop frequency response	Basic problems in Physiological systemanalysis
S-2	SLO-1	System analysis, fundamental concepts	Steady state characteristics	Linearized respiratory mechanics first ordermodel – impulse response for open loop	Relation between transient and frequencyresponse	Nonparametric and parametric identification methods
	SLO-2	Physiological control system an example	Determination of steady state operating pointfor simple model of muscle stretch reflex	Linearized respiratory mechanics first ordermodel – impulse response for closed loop	Frequency domain specifications	Numerical Deconvolution, Least square estimation
S-3	SLO-1	Engineering control system versus physiological control system	Human body Glucose – Insulin regulatorysystem	Transient response descriptors : Impulse response	Graphical representation of frequency response: Bode plot	Estimation using correlation functions
	SLO-2	Science of modeling	Steady state analysis of glucose –insulin model	Transient response descriptors : Step response	Bode plot :Linearized lung mechanics	Estimation in frequency domain, optimization techniques
S-4	SLO-1	Generalized system properties	Human body chemical regulation of ventilatory system	Concept of sliding theory	Graphical representation of frequency response: Nicholas chart	Problems in parameter estimation
	SLO-2	Models with combinations of system elements	Mechanism of respiration	Neuromuscular reflex action	Nicholas chart : Linearized lung mechanics	Input design
	SLO-1	Linear model of respiratory mechanics	Gas exchanger mathematical modeling	Mathematical model of neuromuscular reflex motion	Graphical representation of frequency response : Nyquist plot	Identification of closed loop systems – "opening the loop"

S-5	**SLO-2**	*Linear model of respiratory mechanics:Derivation of transfer function*	*Respiratory controller mathematical modeling*	*Calculation of transfer function*	*Nyquist plot: Linearized lung mechanics*	*Starling heart- lung preparation*
S-6	**SLO-1**	*Linear model of muscle mechanics*	*Closed loop analysis : lung and controller*	*Stability and transient response*	*Introduction : Circulatory system*	*Kao's cross – circulation experiment*
	SLO-2	*Linear model of muscle mechanics: Derivationof transfer function*	*Calculation of transfer function*	*Root locus and Routh-Hurwitz stability criterion*	*Mathematical model of circulatory system*	*Opening the Pupillary reflex loop*
S-7	**SLO-1**	*Distributed versus lumped parameter model*	*Heart and systemic circulation*	*Stability analysis: root locus method*	*Frequency response of circulatory system*	*Read rebreathing technique*
	SLO-2	*Distributed versus lumped parameter model: Derivation of transfer function*	*Mathematical modeling of cardiac output*	*Introduction to Nyquist plot*	*Graphical representation for frequencyresponse of circulatory system*	*Adaptive control of Physiological variables*
S-8	**SLO-1**	*Linear system and superposition principle*	*Calculation of transfer function for simplifiedmodel of cardiac output regulation*	*Nyquist criterion for stability*	*Frequency response of glucose – insulinmodel*	*General adaptive control system*
	SLO-2	*Laplace transform and transfer function*	*Cardiac characteristics curve analysis*	*Relative stability theory*	*Mathematical model and simulation of glucose – insulin model*	*Multiple model adaptive control*
S-9	**SLO-1**	*Impulse function analysis*	*Venous return curve*	*Physiology: Pupillary reflex control*	*Frequency response approach to pupil control*	*Model reference adaptive control*
	SLO-2	*Basics of Linear convolution*	*Closed loop analysis of heart and systemic circulation*	*Stability analysis of pupillary reflex control*	*Frequency response characteristics curve for pupillary control*	*Optimization in systems with negativefeedback*

Learning Resources	1. Michael C.K. Khoo, "*Physiological Control Systems - Analysis, Simulation and Estimation"*, Prentice Hall of India Private Ltd., 2nd edition, New Delhi, 2001.	2. V.Z. Marmarelis, *"Advanced Methods of Physiological System Modeling"*, Vol.3, Springer Science and Business Media, 2013.
	3. Claudio Cobelli Ewart Carson, , "*Introduction to Modeling in Physiology and Medicine"*, Academic press series, 1st edition, 2008.	4. Johnny T. Ottesen, Mette S. Olufsen, Jesper K. Larsen, "*Applied Mathematical Models in HumanPhysiology",* Vol.9,SIAM, 2004.
	5. Dorf, "*Modern Control Systems"*, Pearson Education India, 1st edition, 2008.	

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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*

Course Code	18BME463T	Course Name	BIOMIMETICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Understand the fundamentals of biomimetics and its applications
CLR-2 :	Study the concepts of biomimetic materials and process
CLR-3 :	Acquire an idea about the mechanism of cognition and open ended design automation
CLR-4 :	Utilize the basic concepts of bio-inspired sensors and actuators
CLR-5 :	Employ the skills about the biomimetics of human motion
CLR-6 :	Get an overall idea about the application of biomimetic technologies

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning: 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO -1	14 PSO -2	15 PSO – 3
CLO-1 :	Apply the basic mechanism in biomimetic design in various applications	1, 2	80	70	L	L	-	-	-	-	-	-	-	-	-	-	L	M	-
CLO-2 :	Identify the basic biologically inspired mechanism, materials and process	1, 2	80	70	M	-	-	-	-	-	-	-	-	-	-	-	L	-	-
CLO-3 :	Identify the mechanism of cognition and open ended design automation	2	75	65	-	L	L	-	-	-	-	-	-	-	-	-	L		-
CLO-4 :	Analyze the importance bio-inspired sensors and biomimetic actuators	1,2	75	65	-	-	M	-		-	-	-	-	-	-	M	-	M	-
CLO-5 :	Analyze the biomechanics and rhythmics of motion	2,3	75	65	L	M	L	-	-	-	-	-	-	-	-	M	-	L	M
CLO-6 :	Outline the application of biomimetic technologies	1,2	75	65	-	L	-	L	-	-	-	-	-	-	-	M	-	-M	-

Duration (hour)		Introduction to Biomimetics	*Mechanism of cognition and open ended design automation*	Bio-Inspired Sensors and Biomimetic Actuators	Biomimetics of motion	Application of Biomimetic Technologies
		9	9	9	9	9
S-1	SLO-1	Introduction : Biologically Inspired Mechanisms	**Mechanized Cognition**	Biomimetic tactile sensing:Human sense oftouch	Biomechanics of motion: Control center	Artificial intelligence through symbolic connectionism
	SLO-2	Biologically Inspired Mechanisms	Training and Education	Biomimetic tactile sensing:Human sense oftouch	Biomechanics of motion: Control center	Localist symbolic connectionism
S-2	SLO-1	Biologically Inspired Structures and Parts	Language Cognition	Biomimetic artificial touch	Passive external and internal actuation	Distributed symbolic connectionism
	SLO-2	Defense and Attack Mechanisms in Biology	Language Cognition	Examples of bio-inspired tactile sensing	Active external and internal actuation	Symbolic connectionism in biological models
S-3	SLO-1	Materials and Processes in Biology	Sound Cognition	Bio-Inspired hair based interial sensors: Hair structures for inertial sensing	Agonist Mechanism: Hygroscopic mechanism	Neurofuzzy systems
	SLO-2	Materials and Processes in Biology	Sound Cognition	Cricket-inspired accelerometer	Muscular actuation	Neurofuzzy systems
S-4	SLO-1	Bio-Sensors	Visual Cognition	Fly-inspired gyroscope	Antagonist mechanism: Spring Antagonism	Bio-Inspired adhesion technologies
	SLO-2	Bio-Sensors	Visual Cognition	Fly-inspired gyroscope	Muscular Antagonism	Bio-Inspired adhesion technologies
S-5	SLO-1	Robotics Emulating Biology	Machine Bodies and Brains: Evolving Controllers and Some Aspects of the Morphology	Olfactory sensor system for the e-nose	Power amplification: Elastic amplification	Bio-Inspired locomotion mechanisms
	SLO-2	Interfacing Biology and Machines	Evolving Bodies and Brains	Olfactory classification-data processing	Deformation of a constant volume	Size and current technology constrains
S-6	SLO-1	Muscle function	Morphology Representations: Tree representations	Polymer network actuators	Mechanics of hydrostatic systems: Single compartment systems	Quadruped robot system: Mechanical components

	SLO-2	*Muscle function*	*Developmental representations*	*Biomimetic vision systems*	*Multiple compartment systems*	*Quadruped robot system: Mechanical components*
S-7	**SLO-1**	*Muscle design*	*Regulatory network representations*	*Novel biomimetic materials :Introduction*	*Rhythmics of motion: Gait*	*Electrical components of quadruped robot*
	SLO-2	*Muscle design*	*Evolving Machines in Physical Reality*	*Design of self-oscillating polymer gel*	*Rhythmics of motion: Gait*	*Electrical components of quadruped robot*
S-8	**SLO-1**	*Muscle adaptation*	*Evolving Machines in Physical Reality*	*Control of self-Oscillating chemomechanical behaviors*	*Passive Locomotion*	*Biologically inspired antenna array design*
	SLO-2	*Biomimetics of muscle design*	*Economy of Design Automation*	*Design of biomimetic soft actuators*	*Passive locomotion*	*Biologically inspired antenna array design*
S-9	**SLO-1**	*Bio-inspired fiber composites*	*Principles of Design*	*Design of autonomous mass transportsystems*	*Limbless locomotion*	*Biologically inspired antenna beam patterndesign*
	SLO-2	*Bio-inspired fiber composites*	*Research Methodology*	*Self-oscillating fluids*	*Multiple limb locomotion*	*Biologically inspired antenna beam pattern design*

Learning Resources	*1. Yoseph Bar-Cohen, "BIOMIMETICS Biologically Inspired Technologies", CRC Press, 1 st Edition, 2006.* *2. Trung Dung Ngo, "Biomimetic Technologies: Principles and Applications", Wood head Publishing Ltd, 1 st Edition, 2015.*	*3. Sandra Persiani, "Biomimetics of Motion: Nature-Inspired Parameters and Schemes for Kinetic Design", Springer, 1 st Edition, 2019.* *4. P Gruber, D Bruckner, C Hellmich, · H B. Schmiedmayer, H. Stachelberger, I C. Gebeshuber, "Biomimetics – Materials,Structuresand ProcessesExamples, Ideas and Case Studies", Springer, 1 st Edition, 2011*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*40 %*	-	*40 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*20 %*	-	*20 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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*

Course Code	18BME464T	Course Name	NEURAL NETWORKS AND GENETIC ALGORITHMS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering withspecialization in BioElectronics	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR): The purpose of learning this course is to:

		Learning		
		1	2	3
CLR-1 :	Understand the fundamental of Artificial Neural Network	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-2 :	Get an insight about various ANN model			
CLR-3 :	Familiarize about the principle of self-organizing map			
CLR-4 :	Study the basic concepts of Genetic algorithm			
CLR-5 :	Get an idea about genetic algorithm operators			
CLR-6 :	Explore on the concepts of ANN for Biomedical Application			

Course Learning Outcomes (CLO): At the end of this course, learners will be able to:

					Program Learning Outcomes (PLO)														
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
					Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	Apply the concepts of Artificial neural network	1, 2	80	70	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	Implement the algorithm of various ANN	1, 2	80	70	M	-	-	-	-	-	-	-	-	-	-	-	M	-	-
CLO-3 :	Apply the concepts of Neural network based on competition	2	80	70	-	M	-	-	-	-	-	-	-	-	-	-	M		-
CLO-4 :	Outline the concepts of genetic algorithm	1	80	70	-	-	H	-	-	-	-	-	-	-	-	M	-	M	-
CLO-5 :	Describe the genetic algorithm operators	1	80	70	-	-	-	-	-	-	-	-	-	-	-	M	-	-	-
CLO-6 :	Implement the concepts of ANN for Biomedical applications	1,2	80	70	-	-	-	-	-	-	-	-	-	-	-	L	-	-	-

Duration (hour)		Artificial neural network: An Overview	Artificial Neural network model	Neural network based on competition	Introduction to Genetic Algorithm	GA Operators and Biomedical Applications
		9	9	9	9	9
S-1	SLO-1	Basics of Artificial Neural network	Feed forward networks	Kohonen SOM : Architecture	Biological Background	Genetic operators:
	SLO-2	Basics of Artificial Neural network	Feed forward networks	Algorithm	Genetic algorithm world	Reproduction, Crossover
S-2	SLO-1	Biological neuron, Properties	Back propagation network- structure	Learning vector Quantization(LVQ) : Architecture	Evolution and optimization	Mutation, Replacement
	SLO-2	Artificial model	Algorithm, Applications	Algorithm	Evolution and Genetic algorithm	Fitness form
S-3	SLO-1	Network parameters: Weight, activation,threshold	Tutorial: BPN	Max net: Architecture	Gradient based local optimization method	Scaling
	SLO-2	Typical architecture: Single layer net, Multilayer net, competitive layer	Tutorial: BPN	Application procedure	Gradient based local optimization method	Population
S-4	SLO-1	Common activation function	Associative memory: Heteroassociative memory : Architecture	Mexican Hat: Architecture	Random search	Data structure
	SLO-2	Common activation function	Applications	Training algorithm	Stochastic Hill climbing	Encoding: Binary , Octal,
S-5	SLO-1	McCULLOCH-PITTS net: Architecture	Associative memory:Autoassociative Net: Architecture	Hamming net : Architecture	Simulated anneling	Encoding: Hexadecimal

	SLO-2	*Algorithm*	*Algorithm, Applications*	*Application procedure*	*Simple genetic algorithm*	*Encoding: Permutation*
S-6	**SLO-1**	*HEBB net: Architecture*	*Hopfield network:Architecture,Algorithm*	*ART Fundamentals*	*Simple genetic algorithm*	*Encoding: Value and Tree*
	SLO-2	*HEBB net: Algorithm*	*Tutorials*	*ART: Basic architecture*	*Comparison of Genetic algorithm with other optimization techniques*	*ECG signal classification using neural network*
S-7	**SLO-1**	*Perceptron: Architecture*	*Hopfield -travelling salesmanproblem*	*Learning in ART*	*Genetic algorithm at work simulation by hands*	*ECG signal classification using neural network*
	SLO-2	*Perceptron: Algorithm*	*Boltzman machine*	*Visualization in U matrix*	*Genetic algorithm at work simulation by hands*	*ECG signal classification using neural network*
S-8	**SLO-1**	*Delta rule*	*Issue in network design*	*Basics of SVM*	*Data structures*	*EMG pattern recognition*
	SLO-2	*Tutorial*	*Radial Basis function*	*Basics of SVM*	*Data structures*	*EMG pattern recognition*
S-9	**SLO-1**	*Tutorial*	*Matlab programing*	*Tutorial*	*Application of Genetic algorithm*	*Breast cancer detection*
	SLO-2	*Tutorial*	*Matlab programing*	*Tutorial*	*Advantages and limitation of Genetic algorithm*	*Breast cancer detection*

Learning Resources	*1. LaureneFausett, "Fundamentals of Neural Networks: Architectures, Algorithms, and Applications", Pearson Education India, 3rd edition, 2008.* *2. Mohamad H. Hassoun, "Fundamentals of Artificial Neural Network", Cambridge, The MIT Press, 1stedition,1995* *3. B.Yegnanarayana, "Artificial Neural Networks", Prentice Hall of India, 3rd edition,2006.* *4 S. N. Sivanandam, S. N Deepa, "Introduction to Neural Networks Using Matlab 6.0", Tata McGrawHill, 2006.*	*5.James A Freeman and David M.Skapra, "Neural Network", Addison – Wesley, India,Third edition, 2008 6.Robert J Schalkoff, "Artificial Neural Networks", McGraw Hill, Third edition, 2011.* *7.David Goldberg, Genetic Algorithms in Search, Optimization and Machine Learning", Pearson Education, Fourth edition, 2009.* *8. Melanie Mitchell, An Introduction to Genetic Algorithms" Prentice Hall of India, New Delhi, First edition, 1998*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*40 %*	-	*40 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*20 %*	-	*20 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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. Rajalakshmi T, SRMIST*

Course Code	18BME465T	Course Name	WEARABLE SYSTEMS AND MOBILE HEALTH CARE	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	The purpose of the learning this course is to provide an overview of the technical background of wearable system and its application in health care using mobile technology	Learning		
		1	2	3
CLR-1 :	Comprehend technical information and challenges in WBAN.	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-2 :	Describe the hardware requirements of BAN			
CLR-3 :	Review the wearable sensors and standards for BAN			
CLR-4 :	Describe the mobile devices that is available for health care			
CLR-5 :	Summarize the possible and latest applications of mobile healthcare			
CLR-6 :	Learn about context-aware health care applications			

Course Learning Outcomes (CLO):	At the end of this course, learns will be able to :			
CLO-1 :	List out the BAN challenges	1	80%	75%
CLO-2 :	Identify the hardware necessary for BAN	1	80%	75%
CLO-3 :	List and describe the various wearable sensors	1,2	80%	75%
CLO-4 :	Appreciate the mobile devices available for healthcare	1.2	80%	75%
CLO-5 :	List the latest applications and research opportunities with mobile healthcare.	2	80%	75%
CLO-6 :	Think about context-aware health care solutions	3	80%	75%

Program Learning Outcomes (PLO)														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
	L													
L														
	L											L		
L														
													L	
														M

Duration (hour)		Basics of BAN	Hardware requirement for BAN	Wireless communication	Application of WBAN	WBAN application in healthcare
		9	9	9	9	9
S-1	SLO-1	BAN-Definition	Processor in BAN	RF communication	Sensors for wearable system	Mobile health technologies
	SLO-2	Terminologies used with BAN	Low Power MCUs	RF communication in and around the body	Wearable system design for specific applications	Mobile nutrition tracking
S-2	SLO-1	Technical Challenges	Mobile Computing MCU	Antennal Design	Wearable system for ECG monitoring,	Accessing existing virtual electronic patientrecord
	SLO-2	Sensor design concepts	Integrated processor	Antenna testing	Wearable system for EEG monitoring,	Mobile personal health records,
S-3	SLO-1	Types of sensors	Radio transceiver along with the processor	Propagation issues	Wearable system for Gait analysis	Monitoring hospital patients,
	SLO-2	Biocompatibility issues	Integrated processor with Memory	Base Station considerations	Evaluation of general performance	Sensing vital signs
S-4	SLO-1	Energy Requirements	Antenna for BAN	Network topology	Evaluation of night time performance	Transmission using wireless networks
	SLO-2	Energy supply	Antenna Requirements	Stand – Alone BAN	Evaluation parameters	Continuous monitoring
S-5	SLO-1	Nodes, number of node	Antenna Considerations	Wireless personal Area Network	Latest health monitoring methods	Patient Monitoring and wearable devices

	SLO-2	*Optimal node placement in BAN*	*Types of antenna*	*Wireless personal Area Network Technologies*	*Smart phone based health care monitoringsystem*	*Patient Monitoring in Diverse Environments*
S-6	**SLO-1**	*System security*	*Wire antenna*	*IEEE 802.15.1*	*Phone based fall risk prediction*	*A framework for Capturing Patient Consent in Pervasive Healthcare Applications*
	SLO-2	*System Reliability*	*Ceramic antenna*	*IEEE P802.15.13*	*Emergency alerts*	*M-health application*
S-7	**SLO-1**	*BAN Standards*	*External antenna*	*IEEE 702.15.14*	*RFID based personal mobile medicalassistance*	*Context aware sensing*
	SLO-2	*BAN with other standards*	*Sensor Interface*	*Zigbee*	*Other similar technologies*	*Technology Enablers for context-Aware healthcare Applications*
S-8	**SLO-1**	*BAN Architecture*	*Considerations on the interface*	*BAN and WBAN technologies*	*Infusing image processing capabilities*	*8 channel ECG using Ultra wide band WBAN*
	SLO-2	*BAN and other technologies*	*Power sources- Batteries*	*Limitations in use*	*Secure medical sensor network with HIP*	*Pulse generator using Ultra wide band WBAN*
S-9	**SLO-1**	*BAN and Healthcare*	*Fuel cells for sensor nodes.*	*Coexistence issues with BAN*	*Diagnostic applications*	*Multichannel neural recording system*
	SLO-2	*Medical Applications of BAN*	*Other novel power sources*	*Other practical considerations*	*Therapeutic applications*	*Electronic pills*

Learning Resources

1. *Annalisa Bonfiglio, Danilo De Rossi, " Wearable Monitoring Systems", Springer, 2011.*
2. *Philip Olla, Josep Tan, " Mobile Health solutions for Biomedical applications", Medical Information science reference, Hershey New York, **IGI Global 2009.***
3. *Zhang, Yuan-Ting, Wearable Medical Sensors and systems, Sringers, 2013.*
4. *Guang-Zhogn Yang(ED), " Body Sensor Networks", Springers, 2013*
5. *Mehmet R. Yuce Jamil Y.Khan, " Wireless Body Area Networks Technology, Implementation and applications", Pan Standford Pte. Ltd., Singapore, 2012*
6. *Konstantina, James C. Lin, Dimitrios, Maria Teresa, " Wireless mobile communication and healthcare", Secon International ICST conference, Mobihealth 2011, Springers 2011.*
7. *Ullah, Sana, Et at, " A review of wireless body area networks for medical applications", arXiv: 1001.083, 2010*
8. *Patel, Shyamal, Et al, " A review of wearable sensors and systems with application in rehabilitation", Neuroeng Rehabil 9.12, 2012, 1-17.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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		2.Mrs. Laskhmi Prabha, SRMIST

Course Code	18BME466T	Course Name	ARTIFICIAL INTELLIGENCE IN 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:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	Understand the basics of Artificial Intelligence and its principles	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLR-2 :	Learn the algorithm of various search techniques																		
CLR-3 :	Become familiar with knowledge representation																		
CLR-4 :	Explore the techniques of machine learning applicable for healthcare																		
CLR-5 :	Understand the use of machine learning in healthcare applications																		
CLR-6 :	Understand the role of artificial intelligence in healthcare																		
Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:																		
CLO-1 :	Demonstrate the basic principles of AI towards problem solving	1, 2	80%	70%	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	Explain the various search techniques in problem solving	2	80%	70%	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	Describe the techniques in knowledge representation	2	80%	70%	-	-	M		M	-	-	-	-	-	-	-	M		L
CLO-4 :	Explain the role of machine learning in healthcare applications	3	80%	70%	-	-			M	-	-	-	-	-	-	-	-	-	-
CLO-5 :	Demonstrate the use of machine learning in healthcare applications	3	80%	70%	M	-	-	-	-	-	-	-	-	-	-	-	M		L
CLO-6 :	Use the AI algorithms for various healthcare applications to solve problems	3	80%	70%	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-

		Principles of Artificial Intelligence	Search Techniques	Knowledge Representation	Machine learning in Healthcare	Machine learning – applications in healthcare
Duration (hour)		9	9	9	9	9
S-1	SLO-1	AI-introduction and definition	Informed search methods	First order logic-syntax and semantics	Data Preparation, Feature Cleaning	Healthcare Survey Dataset with Unsupervised Learning
	SLO-2	Turing Test approach	Best first search-Greedy search	Symbols, terms, sentences	Feature Engineering, Feature Transformation	Feature selection using the Particle swam optimization
S-2	SLO-1	Intelligent agents	A* search-behavior	Quantifiers, equality	Feature Extraction, Feature Selection	Disease Detection System (DDS) UsingMachine Learning Technique
	SLO-2	Structure of intelligent agents, Agentprograms, example	Complexity of A* search	Extensions	Machine learning models	System Implementation and Disease Detection Methodology
S-3	SLO-1	Simple reflex agents	Heuristic functions	notational variations	Machine learning categories	Architecture of DDS
	SLO-2	Goal based agents	Heuristics for constraint satisfaction problem	Higher order logic, A-expression	Machine Learning Challenges	Use Case Diagram of DDS
S-4	SLO-1	Utility based agents	Iterative deepening A* search (IDA*)	Using first order logic-kinship domain	Machine Learning Tools	Accuracy Comparison of DDS with PreviousWorks
	SLO-2	Environment programs	Simplified Memory Bounded A* search	Axioms, definitions and theorems	Patient centric Machine learning model	Simulation for Result
S-5	SLO-1	Problem solving-problem solving agents	Hill-climbing search	Domain of sets	Pre-processing of data, Results and discussions	Deep learning solutions for skin cancer detection
	SLO-2	Formulating problems,	Simulated annealing	special notations for sets, lists and arithmetic	Machine Learning Models to ClassifyHealthcare Data	Convolution neural network, methods,dataset
S-6	SLO-1	Well defined problems and solutions	Applications in constraint satisfactionproblems	Logical agents for Wumpus world	Exploratory Data Analysis	Data augmentation,
	SLO-2	Example-Toy problems, travelling salesman problem	Knowledge and reasoning	Simple reflex agent-limitations	Machine learning techniques-supervised and unsupervised approaches	Network architecture, performance metrics

S-7	**SLO-1**	*Searching solutions*	*Knowledge based agent*	*Representing change in the world-situation calculus*	*Natural language Processing*	*Security of Healthcare Systems with Smart Health Records Using Cloud Technology*
	SLO-2	*Data structures for search trees*	*Representation reasoning and logic*	*Frame problem and its relatives*	*Types of Unsupervised Learning*	*Cloud Computing in Healthcare*
S-8	**SLO-1**	*Search Strategies-breadth first, Uniform cost search*	*Semantics, Inference*	*Deducing hidden properties if the world*	*Clustering*	*Cloud Service Models*
	SLO-2	*Depth first search*	*Propositional logic*	*Preferences among actions, toward a global agent*	*Clustering Algorithms*	*Deployment Models in Cloud Computing*
S-9	**SLO-1**	*Iterative search*	*Syntax, semantics*	*Knowledge engineering - introduction*	*K-Means Algorithm*	*Cloud Computing Security*
	SLO-2	*Bidirectional search*	*Validity and inference*	*Knowledge engineering and programing*	*Density Based Clustering*	*Healthcare Data Security in the Cloud,sample algorithm*

Learning Resources	1. *Eugene Charniak*, "Introduction to Artificial Intelligence", Pearson Education India, 1985 *2. Stuart Jonathan Russell, Peter Norvig, Ernest Davis, "Artificial Intelligence: A Modern Approach,* Prentice Hall series in artificial intelligence*, Prentice Hall, 2010*	*3. Bernard Nordlinger, Cédric Villani, Daniela Rus, "Healthcare and Artificial Intelligence", Springer Nature, 2020* *4. Vishal Jain, Jyotir Moy Chatterjee "Machine Learning with Health Care Perspective: Machine Learning and Healthcare* Volume 13 of Learning and Analytics in Intelligent Systems*", Springer Nature, 2020*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*40 %*	-	*40 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*20 %*	-	*20 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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. Mrs.Bhargavi Haripriya, SRMIST*

Course Code	18BME467T	Course Name	BIO INSPIRED ROBOTICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses		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:	Learning

		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	Understand the basic about bio inspired robots			
CLR-2 :	Get an idea about the musculoskeletal movements			
CLR-3 :	Acquire an idea about the basic of postural balances			
CLR-4 :	Get an idea about assistive and rehabilitation robotics			
CLR-5 :	Get an idea about the stability analysis			
CLR-6 :	Get an overall idea about the importance of Develop skills related to the design, construction and testing of advanced robotic systems			
Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:			
CLO-1 :	Apply the common troubleshooting procedures in Electronic Equipment and Outline the testing procedures of active and passive components	1, 2	80	70
CLO-2 :	Analyze the faults in analog circuits and digital ICs	1, 2	80	70
CLO-3 :	Identify the problems in common biomedical equipment in hospitals when it is not working and provide a suitable solution	2	80	70
CLO-4 :	Outline the importance of medical device classification based on the application and ISO standards	1	80	70
CLO-5 :	Describe the Indian medical device regulatory system	1	80	70
CLO-6 :	Outline the job opportunities in regulatory affairs in India	1,2	80	70

Program Learning Outcomes (PLO)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
M	-	-	-	-	-	-	-	-	-	-	-	-	-	-
M	-	-	-	-	-	-	-	-	-	-	-	M	-	-
-	M	-	-	-	-	-	-	-	-	-	-	M		-
-	-	H	-	-	-	-	-	-	-	-	M	-	M	-
-	-	-	-	-	-	-	-	-	-	-	M	-	-	-
-	-	-	-	-	-	-	-	-	-	-	L	-	-	-

Duration (hour)		Introduction to Bio Inspired Robots	A review of computational Musculoskeletal Analysis of Human Lower Extremities	Personalized Modeling for Home –Based Postural Balance Rehabilitation	Non Invasive brain machine interfaces for assistive and rehabilitation robotics	Psychological modeling of humans by assistive robots
		9	9	9	9	9
S-1	SLO-1	Introduction to Bio-inspired Robotics	Introduction to Musculoskeletal Analysis	Introduction	Introduction to brain machine interfaces	Introduction
	SLO-2	Introduction to Bio-inspired Robotics	Introduction to Musculoskeletal Analysis	Introduction	Introduction to brain machine interfaces	Introduction
S-2	SLO-1	Principles of Biomechanics	Human walking Gait cycle	Home – Based postural balance rehabilitation	BMI for assistive robotics	Dimensions of Human characterization
	SLO-2	Basic Features	Human walking Gait cycle	Home – Based postural balance rehabilitation	BMI for assistive robotics	Dimensions of Human characterization
S-3	SLO-1	What is a biologically Inspired Robotic System,and its advantages and disadvantages	Biomechanics of Normal human walking	Body segment parameters	BMI for rehabilitation robotics	Constructing behavioral models for HRI
	SLO-2	its advantages and disadvantages	Biomechanics of Normal human walking	Body segment parameters	BMI for rehabilitation robotics	Constructing behavioral models for HRI
S-4	SLO-1	Mobility systems Requirements	Quantitative Human Walking Models	Estimating center of mass position for human subjects	Kalman Filter Implementation	Economic decision-making models
	SLO-2	Mobility systems Requirements	Quantitative Human Walking Models	Estimating center of mass position for human subjects	Kalman Filter Implementation	Economic decision-making models

S-5	**SLO-1**	*legs*	*Computational Musculoskeletal AnalysisInteraction with articulated systems*	*Various Methods for balance rehabilitation*	*Challenges in exoskeleton design*	*Interfering psychological models*
	SLO-2	*swimming*	*Computational Musculoskeletal AnalysisInteraction with articulated systems*	*Various Methods for balance rehabilitation*	*Challenges in exoskeleton design*	*Interfering psychological models*
S-6	**SLO-1**	*flying system*	*EMG motion classification*	*Dynamic Model*	*Biomechanical modeling*	*Haptic stability*
	SLO-2	*Sensors*	*EMG motion classification*	*Dynamic Model*	*Biomechanical modeling*	*Haptic stability*
S-7	**SLO-1**	*Characteristics of Sensors*	*Task modeling for human interfaces*	*Dynamic Optimization*	*Development of HRI model*	*Human operator Modeling*
	SLO-2	*tactile,*	*Task modeling for human interfaces*	*Dynamic Optimization*	*Development of HRI model*	*Human operator Modeling*
S-8	**SLO-1**	*vision*	*An EMG –controlled Human Robot Interfaceusing Task modelling*	*Body motion sensing*	*Design examples*	*Haptic assist control*
	SLO-2	*electronic nose*	*An EMG –controlled Human Robot Interfaceusing Task modelling*	*Body motion sensing*	*Design examples*	*Haptic assist control*
S-9	**SLO-1**	*Evolution of Bio Inspired Robot*	*Modeling of joint stiffness*	*Strain-Sensitive conductive polymers*	*Stability analysis*	*System validation and experimental evaluation*
	SLO-2	*Evolution of Bio Inspired Robot*	*Modeling of joint stiffness*	*Strain-Sensitive conductive polymers*	*Stability analysis*	*System validation and experimentalevaluation*

Learning Resources	*1.* Biologically Inspired Robotics 1st Edition by Yunhui Liu (Editor), Dong Sun (Editor) *2* Bio-Inspired Artificial Intelligence: Theories, Methods, and Technologies (Intelligent Robotics and Autonomous Agents series) by Dario Floreano	

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*40 %*	-	*40 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*20 %*	-	*20 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

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Course Code	18BME468T	Course Name	COMPUTATIONAL TOOLS IN BIOENGINEERING AND BIOMEDICINE	Course Category		*Professional Elective*	L	T	P	C
							3	0	0	3

Pre-requisite Courses		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:*	**Learning**

		1	*2*	*3*
CLR-1 :	*Understand the basic concepts of computational tools in bioengineering and biomedicinie*			
CLR-2 :	*Get an idea about the Concept of aortic dissection*			
CLR-3 :	*Acquire an idea about the Mechanistic approach to analysis antioxidant action*			
CLR-4 :	*Get an idea about the Radical adduct formation (RAF) mechanism*			
CLR-5 :	*Acquire an idea about the coupling algorithms on cochlear mechanics*			
CLR-6 :	*Get an overall idea about the advanced computational approach*			
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Understand the need for computational tools in the field of bioengineering and biomedicine*	*1, 2*	*80*	*70*
CLO-2 :	*Have a thorough understanding of basic equations of fluid flow and solid motion*	*1, 2*	*80*	*70*
CLO-3 :	*Understand the basics of antiradical mechanisms in the presence of different free radicals*	*2*	*80*	*70*
CLO-4 :	*Identify the importance of radical adduct formation mechanism*	*1*	*80*	*70*
CLO-5 :	*Analyze the knowledge on the model of cochlea including feedforward and feedbackward forces*	*1*	*80*	*70*
CLO-6 :	*Extend the basics of functional Spaces and functional inequalities*	*1,2*	*80*	*70*

Program Learning Outcomes (PLO)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
H	-	-	-	-	-	-	-	-	-	-	*M*	-	-	-
H	-	-	-	-	*H*	-	-	-	-	-	-	*L*	-	-
-	*L*	-	-	-	*H*	-	-	-	-	-	-	*L*		*L*
H	-		-	-	*H*	-	-	-	-	-	-	-	*M*	-
-	-	-	-	-	*H*	-	-	-	-	-	-	-	-	-
H	-	-	-	-	-	-	-	-	-	-	*M*	-	-	-

Duration (hour)		*Need for computational tools*	*Computational approach in aortic dissection*	*Computational approach in antioxidative mechanisms*	*Computational approach in cochlear mechanics*	*Advanced computational approach*
		9	*9*	*9*	*9*	*9*
S-1	SLO-1	*Elements of computational tools*	*Diagnostic techniques of acute aortic dissection*	*Prevention of oxidative stress*	*Cochlear mechanics*	*Functional Spaces and Functional Inequalities*
	SLO-2	*Elements of computational tools*	*Diagnostic techniques of acute aortic dissection*	*Prevention of oxidative stress*	*Concepts of modeling*	*Metric Spaces*
S-2	SLO-1	*Elements of mathematical modeling*	*Treatment of acute aortic dissection*	*Characteristics of good antioxidants*	*Concepts of modeling*	*Complete Metric Spaces*
	SLO-2	*Elements of mathematical modeling*	*Treatment of acute aortic dissection*	*Characteristics of good antioxidants*	*Solid model*	*Normed Spaces*
S-3	SLO-1	*Elements of physics*	*Basic equations of fluid flow*	*The proposed reaction mechanisms*	*Solid model*	*Banach Spaces*
	SLO-2	*The rational continuum mechanics approachto matter in motion*	*Basic equations of fluid flow*	*The proposed reaction mechanisms*	*Fluid model*	*Banach Spaces*
S-4	SLO-1	*Balance laws in integral form*	*Basic equations of solid motion*	*The proposed reaction mechanisms*	*Fluid model*	*Hilbert Spaces*
	SLO-2	*Balance laws in integral form*	*Basic equations of solid motion*	*Mechanistic approach*	*Loose coupling algorithm*	*Hilbert Spaces*
S-5	SLO-1	*Balance laws in local form*	*Basic equations of solid motion*	*Mechanistic approach*	*Loose coupling algorithm*	*The Nonlinear Differential Model System*
	SLO-2	*Balance laws in local form*	*Solid fluid interaction*	*Thermodynamical parameters for quercetinand gallic acid*	*Strong coupling algorithm*	*Time Semidiscretization*

S-6	SLO-1	*Continuum approach for multicomponent mixtures*	*Solid fluid interaction*	*Thermodynamical parameters for quercetinand gallic acid*	*Strong coupling algorithm*	*Time Semidiscretization*
	SLO-2	*Continuum approach for multicomponent mixtures*	*Concept of aortic dissection*	*Thermodynamical parameters for quercetinand gallic acid*	*Need for finite element modeling of cochlea*	*Time Semidiscretization*
S-7	SLO-1	*Continuum approach for multicomponent mixtures*	*Concept of aortic dissection*	*Antiradical mechanisms in the presence of different free radicals*	*Basic criteria for finite element modeling of cochlea*	*Block Nonlinear Jacobi and Gauss–Seidel Iterations*
	SLO-2	*Constitutive relations for fluids*	*Need for 3D reconstruction*	*Antiradical mechanisms in the presence of different free radicals*	*Concept of finite element modeling of cochlea*	*Block Nonlinear Jacobi and Gauss–Seidel Iterations*
S-8	SLO-1	*Constitutive relations for solids*	*Need for 3D reconstruction*	*Mechanistic approach to analyze antioxidantaction*	*Finite element models of cochlea*	*Block Nonlinear Jacobi and Gauss–Seidel Iterations*
	SLO-2	*Constitutive relations for solids*	*Need for 3D reconstruction*	*Mechanistic approach to analyze antioxidantaction*	*Finite element models of cochlea*	*Application of Functional Iterations to Biological Models*
S-9	SLO-1	*Constitutive relations for multicomponent mixtures*	*Need for geometric 3D modeling*	*Radical adduct formation (RAF) mechanism*	*Model of cochlea including feedforward and feedbackward forces*	*Application of Functional Iterations to Biological Models*
	SLO-2	*Constitutive relations for electromagnetismand electrodynamics*	*Need for geometric 3D modeling*	*Radical adduct formation (RAF) mechanism*	*Model of cochlea including feedforward and feedbackward forces*	*Application of Functional Iterations to Biological Models*

Learning Resources	*1.Nenad Filipovic,"Computational Modeling in Bioengineering and Bioinformatics", Academic Press,1st Edition,2019. 2.Z.C.Yang,"Finite Element Analysis for Biomedical Engineering Applications", CRC Press,1st Edition,2019 3.Butta Singh," Computational Tools and Techniques for Biomedical Signal Processing", IGI Global, 1st edition, 2016.*	*4.Andreas Öchsner, Holm Altenbach, "Applications of Computational Tools in Biosciences and Medical Engineering", Springer, 1st edition, 2015.* *5.Geris, Liesbet,"Computational Modeling in Tissue Engineering", Springer, 1st edition,2013.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*40 %*	-	*40 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*20 %*	-	*20 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

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Course Code	18BME469T	Course Name	NEURO REHABILITATION AND HUMAN MACHINE INTERFACE	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Basic Electronic devices and circuits	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:*

		Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	Explain the basic growth responses of neurons with cellular and molecular mechanism			
CLR-2 :	Analyze the plasticity of cerebral motor function			
CLR-3 :	Summarize the role of inflammatory response in central nervous system			
CLR-4 :	Illustrate the future perspective of human machine interface (HMI)			
CLR-5 :	Explain the motor recovery and compensation in neurorehabilitation			
CLR-6 :	Understanding the usage of Human machine Interface in translational research			

Course Learning Outcomes (CLO): *At the end of this course, learners will be able to:*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	Understanding cellular and molecular mechanisms of neural plasticity	1, 2	80	70	M	M	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	Get an idea of Functional Plasticity in the Central Nervous System	1, 2	80	70	M	M	-	-	-	-	-	-	-	-	-	-	M	-	-
CLO-3 :	Identify the Regeneration in the Injured Nervous System	2	80	70	H	-	-		-	-	-	-	-	-	-	-	M		-
CLO-4 :	Illustrate the future perspective of human machine interface (HMI)	1	80	70	H	-	-	-	-	-	-	-	-	-	-	H	-	M	-
CLO-5 :	Application of Human machine interface in translational research	1	80	70	H	-	-	-	-	-	-	-	-	-	-	M	M	-	-
CLO-6 :	Understanding the usage and design development of HMI for research	1,2	80	70	H	-	M	M	-	-	-	-	-	-	-	H	H	-	-

Duration (hour)		Neural Plasticity: Cellular and Molecular Mechanisms	Functional Plasticity in the Central Nervous System	Determination of Regeneration in the Injured Nervous System	Ambient Intelligence and Ubiquitous Computing Scenario	Translational Research: Application in Human Machine Interface
		9	9	9	9	9
S-1	SLO-1	Learning and memory: basic principles andmodel systems	Plasticity of mature and developing somatosensory systems	Non-mammalian models of nerve regeneration	The advanced human machine interface(HMI) framework	Application uses in robotics
	SLO-2	Learning and memory: basic principles andmodel systems	Plasticity of mature and developing somatosensory systems	Non-mammalian models of nerve regeneration	The advanced human machine interface(HMI) framework	Application uses in robotics
S-2	SLO-1	Cellular and molecular mechanisms of associative and nonassociative learning	Activity-dependent plasticity in the intactspinal cord	Myelin-associated axon growth inhibitors, Inhibitors of axonal regeneration	The advanced human machine interface(HMI) framework	Robotics and wearable technology for measurement
	SLO-2	Cellular and molecular mechanisms of associative and nonassociative learning	Activity-dependent plasticity in the intactspinal cord	Myelin-associated axon growth inhibitors, Inhibitors of axonal regeneration	The advanced human machine interface(HMI) framework	Robotics and wearable technology for measurement
	SLO-1	Degenerative changes and reactive growth responses of neurons following denervation and axotomy	Plasticity of cerebral motor functions: Implications for repairand rehabilitation	Role of the inflammatory response in central nervous system injury and regeneration	Human machine interface systems – structure, protocols,	Clinical application of robotics and technologyin restoration of walking

S-3	**SLO-2**	*Degenerative changes and reactive growth responses of neurons following denervation and axotomy*	*Plasticity of cerebral motor functions: Implications for repairand rehabilitation*	*Role of the inflammatory response in central nervous system injury and regeneration*	*Human machine interface systems – structure, protocols*	*Clinical application of robotics and technologyin restoration of walking*
S-4	**SLO-1**	*Contemporary issue and theories of motorcontrol learning.*	*Plasticity of cerebral motor functions: Implications for repairand rehabilitation*	*Role of the inflammatory response in central nervous system injury and regeneration*	*Human machine interface systems –applications*	*Clinical application of robotics and technologyin children undergoing neurorehablitation*
	SLO-2	*Contemporary issue and theories of motorcontrol learning.*	*Plasticity of cerebral motor functions: Implications for repairand rehabilitation*	*Role of the inflammatory response in central nervous system injury and regeneration*	*Human machine interface systems –applications*	*Clinical application of robotics and technologyin children undergoing neurorehablitation*
S-5	**SLO-1**	*Limbic system influence over motor controland learning*	*Plasticity in visual connection retinal ganglion cell axonal development andregeneration*	*Sensor-motor interaction and erroraugumentation*	*Human machine interface systems –applications*	*Clinical application of robotics and technologyin children undergoing neurorehablitation*
	SLO-2	*Limbic system influence over motor controland learning*	*Plasticity in visual connection retinal ganglion cell axonal development and regeneration*	*Sensor-motor interaction and erroraugumentation*	*. The next-generation advanced HMI 2*	*Biomimetic design of neural prosthesisBrain responses to neural prosthesis*
S-6	**SLO-1**	*Learning of damaged brain/spinal cord neuroplasticity*	*Plasticity in auditory function cross model plasticity in visual system*	*Limbic system influence on motor control and learning*	*The next-generation advanced HMI 2*	*Biomimetic design of neural prosthesisBrain responses to neural prosthesis*
	SLO-2	*Learning of damaged brain/spinal cord neuroplasticity*	*Plasticity in auditory function cross model plasticity in visual system*	*Limbic system influence on motor control and learning*	*The next-generation advanced HMI 2*	*Biomimetic design of neural prosthesisBrain responses to neural prosthesis*
S-7	SLO-1	*Movement neuroscience foundation of neurorehabilitation*	*Plasticity in auditory function cross model plasticity in visual system*	*Normal and impaired cooperative handmovement role of neural coupling*	*A future perspective for next-generation HMI: fNIRS-EEG*	*Intracranial human machine interfaces for communication and control*
	SLO-2	*Movement neuroscience foundation of neurorehabilitation*	*Plasticity in auditory function cross model plasticity in visual system*	*Normal and impaired cooperative handmovement role of neural coupling*	*A future perspective for next-generation HMI: fNIRS-EEG*	*Intracranial human machine interfaces for communication and control*
S-8	SLO-1	*Sensor-motor interaction and error Augumentation*	*Plasticity in auditory function*	*Physiological aspect of adaptation andadjustment during various phase of neurological Disablity*	*A future perspective for next-generation HMI: fNIRS-EEG*	*Intracranial human machine interfaces for communication and control*
	SLO-2	*Sensor-motor interaction and error Augumentation*	*Plasticity in auditory function*	*Physiological aspect of adaptation and adjustment during various phase of neurological Disablity*	*A future perspective for next-generation HMI: fNIRS-EEG*	*Understanding motor recovery and compensation in neurorehabilitation*
S-9	SLO-1	*Physiological aspect of adaptation andadjustment during various phase of neurological Disablity*	*Plasticity in auditory function*	*Multisystem neurorehablitation in rodents w ith spinal cord injury*	*Multi-Modal HMI.*	*Understanding motor recovery and compensation in neurorehabilitation*
	SLO-2	*Physiological aspect of adaptation andadjustment during various phase of neurological Disablity*	*Plasticity in auditory function*	*Multisystem neurorehablitation in rodents w ith spinal cord injury*	*Multi-Modal HMI.*	*Understanding motor recovery and compensation in neurorehabilitation*

Learning Resources	*1. Michael E. Seizer, Stephanie Clarke, Lenardo G. Cohen. GertKwakkel, Robert H. Miller., "Textbook ofNeural repair and rehabilitation", Volume 1-Neural repair and Plasticity", Cambridge university press, 2nd edition, 2014.* *2. Jose L Pons, Diego Torricelli,"Textbook of Neural repair and rehabilitation", Springer, 1stedition,2014. 3.Darcy Ann Umphred, Rolando T. Lazaro, Margaret Roller, Gordon Burton ,Neurological Rehabilitation - E-Book,Elsvier mosby 2013.* *4. Panagiotis Artemiadi , Neuro-Robotics: From Brain Machine Interfaces to Rehabilitation Robotics springer publishing 2014.* *5. David J. Reinkensmeyer, Volker Diet , Neurorehabilitation Technology ,springer publishing 2016.*	*3. Surjo R. Soekadar, NielsBirbaumer, Marc W. Slutzky, Leonardo G. Cohen., "Brain- machine interfaces in neurorehabilitation of stroke', Neurobiology of disease, 2015.* *4. F. Nijboer, "Technology transfer of brain-computer interfaces as assistive techno logy: Barriers and opportunities", Annals of physical and Rehabilitation Medicine, 2015.* *5. U.Chaudhary, N. Birbaumer, M.R.Curado., "Brain-machine interface (BMI) in paralysis", Annals of physical and rehabilitation medicine, 2015.* *6. D.D. Franks and J.H. Turner., "Handbook of Neurosociology", Springer, 1stedition, 2013.* *7. Jose L Pons, Diego Torricelli, Marta Pajaro., "Converging clinical and engineering research on neurorehabilitation", Springer, 1stedition, 2013.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*40 %*	-	*40 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*20 %*	-	*20 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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*	*Mrs.P.Laskhmi Prabha, SRMIST*

Course Code	18BME470T	Course Name	ASSISTIVE AND AUGMENTATIVE 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:*

		Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	Understand the fundamentals of assistive technology tools in various disabilities			
CLR-2 :	Use the universal principles and human factors for Augmentative and alternative communication and assistive technology			
CLR-3 :	Utilize the idea about the low and high technology tools for various disabilities			
CLR-4 :	Study the assistive technology tools for deafness and hearing impairments			
CLR-5 :	Study the assistive technology tools for visual and dual sensory impairments			
CLR-6 :	Get an overall idea about the various assistive technology tools for mobility, seating and daily living			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)													
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	Apply the universal principles of assistive technology tools for various disabilities	1, 2	80	70	M	-	-	-	-	-	-	-	-	-	-	-	L-	L	M
CLO-2 :	Identify the basic principles and human factors for person with disabilities	1, 2	80	70	M	-	-	-	-	-	-	-	-	-	-	-	L		-
CLO-3 :	Identify the utilization of low and high technology tools in various disability conditions	1,2	80	70	-	M	-	-	-	-	-	-	-	-	-	-	L	L	-
CLO-4 :	Analyze the assistive technology tools and its usage in hearing impairments persons	2,3	80	70	M	L	L	-	-	-	-	-	-	-	-	M	-	L	M
CLO-5 :	Analyze the assistive technology tools and its usage in visual and sensory impairments persons	2,3	80	70	M	L	L	-	-	-	-	-	-	-	-	M	-	L	M
CLO-6 :	Identify the basic assistive technology tools for activities of daily living	2,3	80	70	-	M	M	L	-	-	-	-	-	-	-	L	-	L	M

Duration (hour)		Universal Principles and Human factors	Assistive Technology for Communication, Deafness and hearing impairments	Assistive Technology for Visual and Dual sensory impairments and daily living	Augmentative Technology for Prosthetic and Orthopedics	Technology for mobility, seating and
		9	9	9	9	9
S-1	SLO-1	Augmentative and alternative communication (AAC) and Assitive technology (AT) software	Hearing functional assessment	Anatomy of eye, Image formations in eye	Anatomy of upper & lower extremities	Basic assessment and evaluation for mobility
	SLO-2	Evaluation of AAC and AT software	Surgical and non surgical hearing aids	Categories of visual impairment	Classification of amputation types	Mobility devices
S-2	SLO-1	Technical and user considerations	Devices to improve hearing	Artificial vision implants	Prosthesis prescription	Wheel chair :seating assessment
	SLO-2	Quality resources on AAC and AT	Implants: Cochlear implant	Cortical and retinal implants	Hand and arm replacement	Interventions in seating system
S-3	SLO-1	Evaluation of quality resources	Bone anchored hearing aids	External visual devices	Different types of models	Biological aspects of tissue health
	SLO-2	Universal principles in AAC and AT	Assistive listening devices	Low and High technology to improve mobility	externally powered limb prosthesis	Support surface classification
S-4	SLO-1	Evidence based practice in AT	Electronic communication aids	Electronic Travel Aids(ETA)	Foot orthosis	Optimum seated posture
	SLO-2	Human factors in evaluation of AT	Analog and digital recorders	Low and High technology for reading and writing	Pediatric orthoses	Types of wheelchairs : Manual wheel chairs

S-5	**SLO-1**	*Environmental and social factors*	*Assistive listening devices*	*Auditory information display*	*Wrist-hand orthosis*	*Power wheelchairs*
	SLO-2	*Psychological factors influencing the use of technology*	*Devices to improve communication*	*AT for dual sensory impairments*	*feedback in orthotic system*	*Power assisted wheelchairs*
S-6	**SLO-1**	*Various Physiological influencing factors*	*Design constraints in designing Adapted mouse*	*AT for leisure and recreation*	*Components of upper limb prosthesis*	*Control systems, navigation in virtual space by wheelchairs*
	SLO-2	*Sensory and Motor factors*	*Smart pen- technology*	*Activities of daily living (ADL)*	*Components of lower limb prosthesis*	*Control systems, navigation in virtual space by wheelchairs*
S-7	**SLO-1**	*Low technology :Communication displays*	*Keyboard variations for differently abled*	*Daily living aids*	*Lower extremity- and upper extremity-orthoses*	*EOG based voice controlled wheelchair*
	SLO-2	*Object communication displays, Communication Boards*	*Modifying existing technology*	*AT in Home*	*Intelligent prosthesis*	*BCI based wheelchair*
S-8	**SLO-1**	*Principles of high technology assistive devices*	*Voice recognition and word prediction software*	*Technology for writing*	*functional electrical stimulation*	*Wheel chair standards & tests*
	SLO-2	*Difference in high and medium technology*	*Communication devices*	*Alternative devices for safety*	*Electric Electronic Stimulation*	*Wheel chair standards & tests*
S-9	**SLO-1**	*Picture exchange communication system*	*Smart phones, Cell phones and videophones*	*Orientation & navigation Aids*	*Fuzzy logic expert system for automatic tuningof myoelectric prostheses*	*Wheel chair transportation*
	SLO-2	*Issues and considerations for low and hightech tools*	*Visual devices using sign*	*Alert systems*	*Fuzzy logic expert system for automatic tuningof myoelectric prostheses*	*Mobility device Accessories*

Learning Resources	*1. Oliver Wendt, Raymond W Quist, Lyle L Lloyd, "Assistive Technology: Principles and Applications for Communication Disorders and Special Education", Emerald group publishing Ltd, 1st Edition, 2011 .* *2. Albert Cook, Janice Polgar, "Assistive Technologies -Principles and Practice", Mosby, 4th Edition, 2015.* *3. Rory A, Cooper, Hisaichi Ohnabe, Douglas A, Hodson, "An Introduction to Rehabilitation Engineering", CRC press, Ist Edition, 2006.* *4. Marion A Hersh, Michael A, Johnson, "Assistive Technology for Visually impaired and blind people", Springer , 1stEdition, 2008*	*5. Brownsell, Simon, et al,. A systematic review of lifestyle monitoring technologies, Journal of telemedicine and telecare 17.4 (2011): 185-189* *6. Marion. A. Hersh, Michael A. Johnson, Assistive Technology for visually impaired and blind, 1st ed., Springer Science & Business Media, 2010* *7. Kenneth J. Turner, Advances in Home Care Technologies: Results of the match Project, 1st ed., Springer, 2011* *8. Pascal Verdonck, Advances in Biomedical Engineering, 1st ed., Elsevier, 2009*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*40 %*	-	*40 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*20 %*	-	*20 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

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Course Code	18BME471T	Course Name	MACHINE LEARNING AND DEEP LEARNING TECHNIQUES IN MEDICINE	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Neural Networks	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:*

		Learning		
		1	2	3
CLR-1 :	Understand the applications of machine learning and types of learning algorithms	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-2 :	Learn about the parametric model of classification			
CLR-3 :	Gain knowledge in multivariate data handling and analysis			
CLR-4 :	Learn about the clustering methods			
CLR-5 :	Know the techniques to compare and assess the learning algorithms			
CLR-6 :	Apply deep learning techniques in biomedical field			

Course Learning Outcomes (CLO): *At the end of this course, learners will be able to:*

					Program Learning Outcomes (PLO)														
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
					Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	Explain what are the different types of learning algorithm	1, 2	80	70	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	Familiarize with different parametric models	1, 2	80	70	M	-	-	-	-	-	-	-	-	-	-	-	M	-	-
CLO-3 :	Describe the multivariate data analysis and the different techniques	2	80	70	-	M	-	-	-	-	-	-	-	-	-	-	M		-
CLO-4 :	Give a detailed account on clustering techniques	1	80	70	-	-	H	-	-	-	-	-	-	-	-	M	-	M	-
CLO-5 :	Compare the performance of different algorithms	1	80	70	-	-	-	-	-	-	-	-	-	-	-	M	-	-	-
CLO-6 :	Apply the machine and deep learning algorithms for concept related to image analysis	1,2	80	70	-	-	-	-	-	-	-	-	-	-	-	L	-	-	-

Duration (hour)		Machine Learning - Introduction	Parametric models and Multivariate Methods	Unsupervised learning	Machine learning Experiments	Deep learning Application
		9	9	9	9	9
S-1	SLO-1	Bayesian decision theory , Classification	Parametric Methods	Clustering	Design and Analysis of Machine Learning Experiments	Regularization, Normalizing inputs
	SLO-2	Bias and Variance	Maximum Likelihood Estimation	Mixture Densities	cost-sensitive learning	Weight Initialization for Deep Networks
S-2	SLO-1	Bayes' Estimator	Bernoulli Density	k-Means Clustering	Experiment	Numerical approximation of gradients
	SLO-2	Losses and risks	Multinomial Density	vector quantization	strategies of experimentation	Gradient checking, Gradient Checking Implementation
S-3	SLO-1	Discriminant Functions	Parametric Classification-Regression	leader cluster algorithm	factorial design	Mini-batch gradient descent
	SLO-2	Utility Theory	Bias/Variance	leader cluster algorithm	Response Surface Design	Exponentially weighted averages
S-4	SLO-1	Value of information	Model Selection Procedures	Expectation-Maximization Algorithm	Randomization, replication, blocking, pairing	Classical Supervised Tasks with Deep Learning
	SLO-2	Bayesian networks	Validation techniques , Minimum lengthdescription, Bayesian model selection	Mixtures of Latent Variable Models	Guidelines for Machine Learning Experiments	Brain MRI Age Classification
S-5	SLO-1	Influence Diagrams	Multivariate Data	Supervised Learning after Clustering	Choice of Factors and Levels	Image Denoising
	SLO-2	Association Rules	Parameter Estimation	Hierarchical Clustering	Choice of Experimental Design, Performingthe Experiment	Image Denoising

S-6	**SLO-1**	*Machine learning applications-learning associations,*	*Estimation of Missing Values*	*Choosing the Number of Clusters*	*Statistical Analysis of the Data*	*Analysis of medical images*
	SLO-2	*classification, regression,*	*Multivariate Normal Distribution*	*Nonparametric Methods*	*Cross-Validation and Resampling Methods*	*Analysis of medical images*
S-7	SLO-1	*unsupervised learning, reinforcement learning*	*Multivariate Methods- Multivariate Data*	*Instance-based memory-based learning*	*K-Fold Cross-Validation*	*Automatic Interpretation of Carotid Thickness*
	SLO-2	*Supervised learning-examples*	*Parameter Estimation*	*Nonparametric Density Estimation*	*5×2 Cross-Validation*	*Automatic Interpretation of Carotid Thickness*
S-8	SLO-1	*Regression, Noise, learning multiple classes*	*Principal Components Analysis*	*Kernel Estimator*	*Bootstrapping*	*3-D Brain Tumor Segmentation*
	SLO-2	*Probably Approximately Correct (PAC) learning*	*Eigen faces and Eigen digits*	*k-Nearest Neighbor Estimator*	*Measuring Classifier Performance*	*3-D Brain Tumor Segmentation*
S-9	SLO-1	*Vapnik–Chervonenkis (VC) dimension*	*reconstruction error, Karhunen-Lève expansion*	*Generalization to Multivariate Data*	*Interval Estimation*	*Convolutional NN for Real time 2D/3DRegistration*
	SLO-2	*Exercises*	*Multidimensional scaling, Linear discriminant Analysis*	*Nonparametric Classification*	*Comparing Multiple Algorithms*	*Convolutional NN for Real time 2D/3DRegistration*

Learning Resources	*1. Tony J. Cleophas and Aeilko H. Zwinderman, "Machine Learning in Medicine - a Complete Overview", Springer,2015* *2. Sunila Gollapudi, S. , "Practical Machine Learning", Packt Publishing Ltd.2016* *3. Applied Deep Learning: A Case-Based Approach to Understanding Deep Neural Networks, By Umberto Michelucci, Delaware corporation, 2018*	*4. Deep Learning for Medical Image Analysis, edited by S. Kevin Zhou, Hayit Greenspan, Dinggang Shen , Academia Press, 2017* *5. Deep Learning, An MIT Press book, Ian Goodfellow and Yoshua Bengio and Aaron Courville http://www.deeplearningbook.org* *6. Introduction to Deep Learning: From Logical Calculus to Artificial Intelligence, By Sandro Skansi, Springer, 2018*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*40 %*	-	*40 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*20 %*	-	*20 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

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Course Code	18BME472T	Course Name	VIRTUAL REALITY IN HEALTH CARE	Course Category	E	Professional Elective	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:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	Understand the sensors in virtual reality systems			
CLR-2 :	Understand the techniques in image creation			
CLR-3 :	Understand the techniques in image manipulation and viewing			
CLR-4 :	Gain knowledge in techniques involved in haptics			
CLR-5 :	Gain knowledge in auditory aspects in VR			
CLR-6 :	Understand the various input sensors, visual and auditory aspects of virtual reality systems			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)															
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	Explain the terms and the various input sensors used in VR	1,2	80%	70%	M	-	-	-	-	-	-	-	-	-	-	-	M		
CLO-2 :	Analyze the visual aspects of VR systems	2	80%	70%	M	-	-	-	-	-	-	-	-	-	-	-	M		
CLO-3 :	Demonstrate the various techniques for image creation and manipulation	2	80%	70%	M	-	-	-	-	-	-	-	-	-	-	-		L	
CLO-4 :	Explain the various haptic sensors and techniques used in VR	2	80%	70%	M	-	-	-	-	-	-	-	-	-	-	-	M		
CLO-5 :	Explore the various auditory aspects related to VR	2	80%	70%	M	-	-	-	-	-	-	-	-	-	-	-	M		
CLO-6 :	Describe and explain the various components of Virtuality reality systems	2	80%	70%		L	-	-	-	-	-	-	-	-	-	-	M		

		Input Periphery	Visual Aspects- I	Visual Aspects - II	Haptic Aspects	Auditory Aspects and applications
Duration (hour)		9	9	9	9	9
S-1	SLO-1	Definition of Virtual Reality (VR)	Computer graphics, building blocks	Light Sources and Reflection	Haptic sense and perception	Auditory Sense and Perception
	SLO-2	Presence and Immersion, Need for training in medicine	Visual sense and perception	Point light, directional light, spot light	Tactile receptors,	interaural level differences
S-2	SLO-1	Principles of VR, Main components	Human eye, photoreceptors, color vision	Ambient light, diffuse reflection, specular reflection,	Kinesthetic receptors,	Design of Auditory Displays
	SLO-2	Problems in VR	RGB color space, liquid crystal display	Viewing projections	Psychophysics	Headphones
S-3	SLO-1	Human Actuators , Input Modalities	color spaces, subtractive model	Image projection in the thin lens cameramodel	Haptic Display Technology	Mono, Stereo, and Surround Loudspeaker Systems
	SLO-2	Position and movement recording	HSV color space	Depth of field in thin lens camera model	Kinematic principles, serial and parallel	Auditory Rendering
S-4	SLO-1	Resistive sensors, Capacitive sensors	Depth Perception, monocular cues	Projection in pinhole camera	Actuation principles	Olfactory and Gustatory Aspects
	SLO-2	Inductive sensors, Ultrasound and opticalmethods	Oculomotor cues,	Early depiction of a CameraObscura	Shape memory alloys	wearable olfactory display devices
S-5	SLO-1	Position and movement measuring systems	binocular cues	Perspective projection	Electroactive Polymers	Gustatory Sense and Perception
	SLO-2	Desktop systems, body mounted systems	Visual Display technology	2D mapping in the yz-plane	Piezoelectric Actuators	Virtual Reality for Rehabilitation
S-6	SLO-1	Contact free and remote systems	Stereoscopic rendering	Orthographic projection	Control Principles of Haptic Displays	Virtual Reality Supported Physiotherapy
	SLO-2	Eye tracking systems	Display hardware	Orthographic projection onto image plane	Terminology	Gait Rehabilitation,

S-7	**SLO-1**	*Force and torque recording*	*Virtual reality displays*	*Surface Shading*	*Admittance and Impedance Control Architectures*	*Robot-Assisted Gait Training*
	SLO-2	*Sound and speech recording*	*Cave Automatic Virtual Environment*	*Flat Shading*	*Stability, Passivity and safety of Haptic Displays*	*Motivation for Robot Aided Arm Therapy*
S-8	**SLO-1**	*Physiological data recording*	*Head mounted displays*	*Gouraud Shading*	*Ground- and Wall-Mounted Systems*	*Virtual Reality Applications with ARMin*
	SLO-2	*Bioelectrical signal*	*Rendering in computer graphics*	*Phong Shading*	*Tactile and Portable systems*	*Wheelchair Mobility and Functional ADLTraining*
S-9	**SLO-1**	*Blood pressure measurements, pulse oximetry, skin conductance*	*Object representations*	*Advanced Rendering Techniques, RayTracing*	*Haptic Rendering*	*VR Based surgical simulator and itscomponents*
	SLO-2	*Respiratory measurements*	*Geometry transformations (basics)*	*Radiosity, Visual Displays in Medical VR*	*Penalty method, Haptic Displays in MedicalVR*	*VR for Surgical planning*

Learning Resources	*1. Robert Riener, Matthias Harders, "Virutal Reality in Healthcare"Springer, 2012.* *2. Wadee Alhalabi "Virtual Reality Implementation in Healthcare Settings", Medical Information Science Reference, 2017*	*3. Lynne Edgar, "Virtual Reality: Future of Health Care" ,iUniverse, 2003.* *4. James Roland, "Virtual Reality and Medicine", ReferencePoint Press, Incorporated, 2018.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*40 %*	-	*40 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*20 %*	-	*20 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

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