ACADEMIC CURRICULA

UNDERGRADUATE/ INTEGRATED POST GRADUATE DEGREE PROGRAMME

(With exit option of Diploma)

(Choice Based Flexible Credit System)

Regulations 2021

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

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

Kattankulathur, Chengalpattu District 603203,

Tamil Nadu, India

11. (e) Program Structure: B.Tech. in Biomedical Engineering

Humanities & Social Sciences including Management Courses (H)

Course Code	Course Title	Hours/Week L	T	P	C
21LEH101T	Communicative English	2	1	0	3
21LEH102T	Chinese	2	1	0	3
21LEH103T	French				
21LEH104T	German				
21LEH105T	Japanese				
21LEH106T	Korean				
21LEH107T	Spanish				
21GNH101J	Philosophy of Engineering	1	0	2	2
21PDH201T	Social Engineering	2	0	0	2
21GNH401T	Behavioral Psychology	2	1	0	3
	Total Credits				**13**

Engineering Science Courses (S)

Course Code	Course Title	Hours/Week L	T	P	C
21CSS101J	Programming for Problem Solving	3	0	2	4
21MES101L	Basic civil and Mechanical Workshop	0	0	4	2
21MES102L	Engineering Graphics and Design	0	0	4	2
21EES101T	Electrical and Electronics Engineering	3	1	0	4
21DCS201P	Design Thinking and Methodology	1	0	4	3
21PYS202T	Medical Physics	3	0	0	3
21CSS303T	Data science	1	1	0	2
	Total Credits				**20**

Professional Elective Courses (E)
(Any 6 Courses)

Course Code	Course Title	Hours/Week L	T	P	C
21BME261T	Biophotonics and Bioimaging	3	0	0	3
21BME262T	Home Medicare Technology	3	0	0	3
21BME263T	Biomedical Laser Instruments	3	0	0	3
21BME264T	Artificial Organs and Tissue engineering	3	0	0	3
21BME265T	Biomedical Nano Technology	3	0	0	3
21BME266T	Biometrics	3	0	0	3
21BME361T	BioMEMS	3	0	0	3
21BME362T	Human Electrophysiology	3	0	0	3
21BME363T	Biomedical device design Fundamentals	3	0	0	3
21BME364T	Innovation, Translation and Entrepreneurship	3	0	0	3
21BME365T	Hospital Management system	3	0	0	3
21BME366T	Trouble shooting of Medical Devices	3	0	0	3
21BME367T	Quality Assurance and regulatory aspects for medical devices	3	0	0	3
21BME368T	Neuroengineering	3	0	0	3
21BME369T	IOT and Telehealth Technology	3	0	0	3
21BME370T	Micro fluidics	3	0	0	3
21BME371T	Medical Ethics and Intellectual property rights	3	0	0	3
21BME372T	Virtual Instrumentation for Biomedical Engineers	3	0	0	3
21BME373T	Health Care Data Analytics	3	0	0	3
21BME461T	Biomedical Informatics	3	0	0	3
21BME462T	Physiological Modeling	3	0	0	3
21BME463T	Biomimetics	3	0	0	3
21BME464T	Neural Networks and Genetic Algorithms	3	0	0	3
21BME465T	Wearable Systems and Mobile Health Care	3	0	0	3
21BME466T	Artificial Intelligence in Health care	3	0	0	3
21BME467T	Bio inspired Robotics	3	0	0	3
21BME468T	Computational tools in Bioengineering and Biomedicine	3	0	0	3
21BME469T	Neuro Rehabilitation and Human Machine Interface	3	0	0	3
21BME470T	Assistive and Augmentative Technologies	3	0	0	3
21BME471T	Machine Learning and Deep learning techniques in medicine	3	0	0	3
21BME472T	Virtual Reality in Health Care	3	0	0	3
21BME473T	Requirement Engineering and Medical Device Regulations	3	0	0	3
	Total Credits				**18**

Basic Science Courses (B)

Course Code	Course Title	Hours/Week L	T	P	C
21MAB101T	Calculus and Linear Algebra	3	1	0	4
21CYB101J	Chemistry	3	1	2	5
21BTB104T	Biology -Human Physiology and anatomy	2	0	0	2
21MAB102T	Advanced Calculus and Complex Analysis	3	1	0	4
21PYB101J	Physics: Electromagnetic Theory, Quantum Mechanics, Waves and Optics	3	1	2	5
21MAB201T	Transforms and Boundary Value Problems	3	1	0	4
21MAB202T	Numerical Methods	3	1	0	4
21MAB301T	Probability and Statistics	3	1	0	4
	Total Credits				**32**

Professional Core Courses I

Course Code	Course Title	Hours/Week L	T	P	C
21BMC101J	Biomedical Sensors	2	0	2	3
21BMC202T	Biomedical Signals and Systems	3	0	0	3
21BMC203J	Electric and Electronic Circuits	3	0	2	4
21BMC204J	Digital Logic for Medical Systems	2	0	2	3
21BMC205J	Integrated Circuit Design for Bioinstrumentation	2	0	2	3
21BMC206J	Biomedical Instrumentation	3	0	2	4
21BMC207J	Biomaterials and Tissue Interaction	2	0	2	3
21BMC301J	Biomedical Signal Processing	3	0	2	4
21BMC302J	Microcontrollers and its Application in Medicine	3	0	2	4
21BMC303T	Principles of Medical Imaging	3	0	0	3
21BMC304J	Medical Image Processing	2	0	2	3
21BMC305T	Biocontrol Systems	3	0	0	3
21BMC401T	Biomechanics	2	0	2	3
21BMC402T	Biomedical Equipments for Clinical Applications	2	0	2	3
	Total Credits				**46**

Open Elective Courses (O) *(Any 5 Courses)*

Course Code	Course Title	Hours/Week L	T	P	C
21BMO121T	Fundamentals of Biomedical Engineering	3	0	0	3
21BMO122T	Health Information Systems	3	0	0	3
21BMO123T	Basics of Medical Imaging	3	0	0	3
21BMO124T	Rehabilitation Engineering	3	0	0	3
21BMO125T	Quality control for biomedical devices	3	0	0	3
21BMO126T	Biomechanics of Human Movement	3	0	0	3
21BMO127T	Digital healthcare Technology	3	0	0	3
	Total Credits				**15**

Project Work, Seminar, Internship In Industry / Higher Technical Institutions (P)

Course Code	Course Title	Hours/Week L	T	P	C
21GNP301L	Community Connect	0	0	2	1
21BMP302L	MOOC	3	0	0	3
21BMP303T	Project	0	0	6	
21BMP401L	Major Project	0	0	30	15
21BMP402L	Internship				
	Total Credits				**19**

Mandatory Courses (M)

Course Code	Course Title	Hours/Week L	T	P	C
21PDM101L	Professional Skills and Practices*	0	0	2	0
21CYM101T	Environmental Science*	1	0	0	0
21PDM102L	General Aptitude*	0	0	2	0
21LEM201T	Professional Ethics*	1	0	0	0
21PDM201L	Verbal Reasoning*	0	0	2	0
21PDM202L	Critical and Creative Thinking Skills*	0	0	2	0
21PDM301L	Analytical and Logical Thinking Skills*	0	0	2	0
21PDM302L	Employability Skills and Practices*	0	0	2	0
21LEM101T	Constitution of India	1	0	0	0
21LEM202T	Universal Human Values	1	0	0	0
21LEM301T	Indian Art Form	1	0	0	0
21LEM302T	Indian Traditional Knowledge	1	0	0	0
21GNM101L	Physical and Mental Health using Yoga	0	0	2	0
21GNM102L	NSS	0	0	2	0
21GNM103L	NCC	0	0	2	0
21GNM104L	NSO	0	0	2	0
	Total Credits				0

11. (f) Implementation Plan: B.Tech. in Biomedical Engineering

Semester – I

Code	Course Title	Hours/ Week			C
		L	T	P	
21LEH101T	Communicative English	2	1	0	3
21MAB101T	Calculus and Linear Algebra	3	1	0	4
21PYB101J	Physics: Electromagnetic Theory, Quantum Mechanics, Waves and Optics	3	1	2	5
21MES102L	Engineering Graphics and Design	0	0	4	2
21EES101T	Electrical and Electronics Engineering	3	1	0	4
21BMC101J	Biomedical sensors	2	0	2	3
21CYM101T	Environmental Science*	1	0	0	0
21PDM101L	Professional Skills and Practices	0	0	2	0
21LEM101T	Constitution of India	1	0	0	0
	Total Credits				**21**

Semester – II

Code	Course Title	Hours/ Week			C
		L	T	P	
21LEH102T	Chinese	2	1	0	3
21LEH103T	French				
21LEH104T	German				
21LEH105T	Japanese				
21LEH106T	Korean				
21LEH107T	Spanish				
21GNH101J	Philosophy of Engineering	1	0	2	2
21MAB102T	Advanced Calculus and Complex Analysis	3	1	0	4
21CYB101J	Chemistry	3	1	2	5
21CSS101J	Programming for Problem Solving	3	0	2	4
21BTB104T	Biology-Human Physiology and anatomy	2	0	0	2
21MES101L	Basic Civil and Mechanical Workshop	0	0	4	2
21PDM102L	General Aptitude*	0	0	2	0
21GNM101L	Physical and Mental Health using Yoga	0	0	2	0
21GNM102L	NSS				
21GNM103L	NCC				
21GNM104L	NSO				
	Total Credits				**22**

Semester – III

Code	Course Title	Hours/ Week			C
		L	T	P	
21MAB201T	Transforms and Boundary Value Problems	3	1	0	4
21BMC202T	Biomedical Signals and Systems	3	0	0	3
21BMC203J	Electric and Electronic circuits	3	0	2	4
21BMC204J	Digital Logic for Medical Systems	2	0	2	3
21DCS201P	Design Thinking and Methodology	1	0	4	3
21PYS202T	Medical Physics	3	0	0	3
21LEM201T	Professional Ethics*	1	0	0	0
21PDM201L	Verbal Reasoning*	0	0	2	0
	Total Credits				**20**

Semester – IV

Code	Course Title	Hours/ Week			C
		L	T	P	
21MAB202T	Numerical Methods	3	1	0	4
21CSE206T	Artificial Intelligence	2	1	0	3
21BMC205J	Integrated Circuit Design for Bioinstrumentation	2	0	2	3
21BMC206J	Biomedical Instrumentation	3	0	2	4
21BMC207J	Biomaterials and Tissue Interaction	2	0	2	3
E	Professional Elective – I	3	0	0	3
21PDH201T	Social Engineering	2	0	0	2
21PDM202L	Critical and Creative Thinking Skills*	0	0	2	0
21LEM202T	Universal Human Values	1	0	0	0
	Total Credits				**22**

Semester – V

Code	Course Title	Hours/ Week			C
		L	T	P	
21MAB301T	Probability and Statistics	3	1	0	4
21BMC301J	Biomedical Signal Processing	3	0	2	4
21BMC302J	Microcontrollers and its Application in Medicine	3	0	2	4
21BMC303T	Principles of Medical Imaging	3	0	0	3
E	Professional Elective – II	3	0	0	3
O	Open Elective – I	3	0	0	3
21PDM301L	Analytical and Logical Thinking Skills*	0	0	2	0
21LEM301T	Indian Art Form	1	0	0	0
21GNP301L	Community Connect	0	0	2	1
	Total Credits				**22**

Semester – VI

Code	Course Title	Hours/ Week			C
		L	T	P	
21CSS303T	Data Science	1	1	0	2
21BMC304J	Medical Image Processing	2	0	2	3
21BMC305T	Biocontrol Systems	3	0	0	3
E	Professional Elective – III	3	0	0	3
E	Professional Elective – IV	3	0	0	3
21BMP303T	MOOC	3	0	0	3
21BMP302L	Project	0	0	6	
O	Open Elective – II	3	0	0	3
21PDM302L	Employability Skills and Practices*	0	0	2	0
21LEM302T	Indian Traditional Knowledge	1	0	0	0
	Total Credits				**20**

Semester – VII

Code	Course Title	Hours/ Week			C
		L	T	P	
21GNH401T	Behavioral Psychology	2	0	2	3
E	Professional Elective – V	3	0	0	3
E	Professional Elective – VI	3	0	0	3
21BMC401T	Biomechanics	2	0	2	3
21BMC402T	Biomedical Equipments for Clinical Applications	2	0	2	3
O	Open Elective – III	3	0	0	3
	Total Credits				**18**

Semester – VIII

Code	Course Title	Hours/ Week			C
		L	T	P	
21BMP401L	Major Project	0	0	30	15
21BMP402L	Internship				
	Total Credits				**15**

ACADEMIC CURRICULA

UNDERGRADUATE/ INTEGRATED POST GRADUATE DEGREE PROGRAMMES

(With exit option of Diploma)

(Choice Based Flexible Credit System)

Regulations 2021

Volume – 9
(Syllabi for Biomedical Engineering Programme Courses)

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

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

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

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ACADEMIC CURRICULA

Engineering Science Course

Regulations 2021

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

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

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

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

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

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

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

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

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

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

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

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

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

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

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

Learning Assessment

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

Course Designers

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

ACADEMIC CURRICULA

Professional Core Courses

Regulations 2021

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

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Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

Course Code	21BMC202T	Course Name	BIOMEDICAL SIGNALS AND SYSTEMS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*classify the continuous time signals and systems and discrete-time signals and systems*
CLR-2:	*illustrate the concepts of Continuous Time Signals and System*
CLR-3:	*compute the Convolution and Correlation in bio signals*
CLR-4:	*execute z-transform and discrete Fourier transform*
CLR-5:	*analyze the discrete time IIR and FIR systems by using suitable structures and apply in biomedical applications*

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

Unit-1 - Basics of Discrete Time and Continuous Time Signals and Systems	***9 Hour***
Representation of discrete time signals- continuous time signals- standard discrete time signals,- standard continuous time signals- Classification of signals: Continuous time(CT)- Tutorials- Classification of Discrete time (DT) signals- Tutorials- Mathematical operations on CTS- DTS- Classification of systems: static and dynamic systems- time invariant and time variant- linear and nonlinear systems- causal and non-causal systems,- stable and unstable systems	
Unit-2 - Analysis of Continuous Time Signals and System	***9 Hour***
Fourier transform analysis- Properties- Laplace transform analysis—properties- Poles and zeros - Analysis of differential equation- impulse response-- Transfer function- Analysis of differential equation-frequency response Bio signal measurements	
Unit-3 - : Convolution and Correlation of Discrete Time Signals	***9 Hour***
linear convolution- Circular convolution- linear convolution via circular convolution- Sectioned convolution-overlap add method- Overlap save method- Inverse system- deconvolution- Correlation- autocorrelation-cross correlation- Correlation of Bio signals- ECG,EMG	
Unit-4 - Transforms of Discrete Time Signals and Systems	***9 Hour***
Z transform- properties- region of convergence- representation of poles and zeros in z transform- Inverse z transform- residue method-Partial fraction method-Discrete time Fourier transform-properties-Relation between Z transform and DTFT Introduction to discrete Fourier transform-DFT-properties	

Unit-5 - Realization and Bio Signal Applications	***9 Hour***
Introduction to discrete time Infinite impulse response (IIR)-finite impulse response (FIR) systems-Structure for realization of IIR systems-direct form-I direct form-II -Cascade form-parallel form of IIR system-Structure for realization of FIR systems-direct form -cascade and linear phase realization of FIR systems--Neural Firing rate analysis-Nerve action potentials Linearized model and system equations for immune response	

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

Learning Assessment

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

Course Designers

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

Course Code	21BMC203J	Course Name	ELECTRIC AND ELECTRONIC CIRCUITS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

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

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*analyze real-time circuits using mesh and nodal analysis and network reduction*
CLR-2:	*implement various Network theorems for analyzing electrical circuits*
CLR-3:	*apply the principles of network theorems in simplifying electrical circuits*
CLR-4:	*summarize the basis for understanding semiconductor material, how a pn junction is formed and its principle ofoperation*
CLR-5:	*explain the importance of diode in electronic circuits by presenting appropriate diode applications*

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

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

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

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

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

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

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

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

ion Theorem-Practice problems-Substitution Theorem-Practice problems -Reciprocity theorem-Practice problems

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

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

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

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

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

Learning Resources		
	1. *David A. Bell, Electronic Devices and Circuits, 5th ed., Oxford University Press, 2015*	4. *William H. Hayt, Jack E. Kemmerly, Steven M. Durbin, Engineering circuit analysis, 8th ed., McGraw Hill,2012*
	2. *Jegatheesan R, Analysis of Electric Circuits, McGraw Hill, 2014.*	5. *Mahmood Nahvi & Joseph Edminister, "Schaum's Outline of Electric circuits", McGraw-Hill Education, 5thedition 2011.*
	3. *Robert L. Boylestad, Louis Nashelsky, Electronic Devices and Circuit Theory, 11th ed., Pearson Education, 2013*	

Learning Assessment

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

Course Designers

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

Course Code	21BMC204J	Course Name	DIGITAL LOGIC FOR MEDICAL SYSTEMS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							2	0	2	3

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

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*explain and understand the numerical conventions in digital electronics*
CLR-2:	*understand the mathematical concepts of combinatorial logics*
CLR-3:	*design and execute synchronous sequential logic circuits*
CLR-4:	*design and execute asynchronous sequential logic circuits*
CLR-5:	*explain and develop programmable logic circuits*

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

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

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

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

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

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

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

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

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

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

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

Learning Resources	1. *M. Morris Mano and Michael D. Ciletti, 'Digital Design', Pearson, 5th Edition, 2013.* 2. *Charles H. Roth, Jr, 'Fundamentals of Logic Design', Jaico Books, 4thEdition, 2002.* 3. *William I. Fletcher, "An Engineering Approach to Digital Design",Prentice- Hall of India, 1980.*	4. *Floyd T.L., "Digital Fundamentals", Charles E. Merril publishing company, 1982.* 5. *John. F. Wakerly, "Digital Design Principles and Practices", Pearson Education, 4 thEdition, 2007.*

Learning Assessment

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

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Anbuselvan T,General Manager – Sales, Wipro GEHealthcare Pvt. Ltd., Tamil Nadu, Srilanka & Maldives*	1. *Dr. S. Poonguzhali, Professor, Centre for Medical Electronics, Anna University*	1. *Dr. D. Kanchana, SRMIST*

Course Code	21BMC205J	Course Name	INTEGRATED CIRCUIT DESIGN FOR BIOINSTRUMENTATION	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							2	0	2	3

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1:	explain the operation and analysis of op-amp oscillators, single chip oscillators and frequency generators
CLR-2:	identify the active filter types, filter response characteristics, filter parameters and IC voltage regulators
CLR-3:	illustrate the concepts of data converter terminology, its performance parameters, and various circuit arrangements for A/D and D/A conversions
CLR-4:	familiarize the mathematical operations of combinational systems
CLR-5:	design simple combinational logics using basic gates, MSI circuits, flip-flops, registers, counters and their usage, and able to design and analyze sequential logic circuits and Finite State Machines

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Learning Assessment

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

Course Designers

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

Course Code	21BMC206J	Course Name	BIOMEDICAL INSTRUMENTATION	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

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

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*Enumerate the basic function of physiological systems and bio-potential electrodes for picking up biological signals*
CLR-2:	*Describe various biological signals acquired from physiological systems using various instruments*
CLR-3:	*Identify the various blood pressure and blood flow measurement techniques*
CLR-4:	*Explain the various techniques used for measurements in the respiratory system*
CLR-5:	*Classify the various instruments used for therapeutic and patient safety*

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

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

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

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

Unit-2 - Biosignal Acquisition From Physiological System ***15 Hour***

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

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

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

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

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

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

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

Learning Assessment

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

Course Designers

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

Course Code	21BMC207J	Course Name	BIOMATERIALS AND TISSUE INTERACTION	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							2	0	2	3

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

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*Attain the knowledge on basics properties of biomaterials*
CLR-2:	*Study the phenomena various metals used in implant applications*
CLR-3:	*Acquire knowledge importance of ceramics and polymer used biomedical diagnostics*
CLR-4:	*Familiarize with biological system, prosthetic and medical implants*
CLR-5:	*Obtain the concept of different types biomaterials applied in-vitro and in-vivo biomedical implant application*

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

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

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

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

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

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

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

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

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

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

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

Learning Resources	1. *Joon park, R.S Lakes, "Biomaterials An Introduction "Springer, 2007* 2. *Sujata V. Bhat "Biomaterials" springer 2002*	3. *Larry L. Hench and Julian R. Jones, Biomaterials, artificial organs and tissue engineering, CRC Press 2010* 4. *P Ducheyne (Editor), Comprehensive Biomaterials, 1st Edition, Elsevier, 2013*

Learning Assessment

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

Course Designers

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

Course Code	21BMC301J	Course Name	BIOMEDICAL SIGNAL PROCESSING	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Learning Resources		
	1. *Ramesh Babu," Digital signal processing" Laxmi Publications, 2005.* 2. *Rangaraj.M.Rangayyan, "Biomedical signal processing ' ,Wiley-IEEE press, 2nd edition,2015*	3. *Reddy D.C, "Biomedical signal processing: Principles and Techniques", Tata McGraw-Hill, New Delhi, 2nd edition, 2005*

Learning Assessment

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

Course Designers

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

Course Code	21BMC302J	Course Name	MICROCONTROLLERS AND ITS APPLICATION IN MEDICINE	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

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

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*Explain the fundamental concepts of 8086 microprocessors*
CLR-2:	*Interpret the basic concepts of 8051 microcontroller*
CLR-3:	*Illustrate the concepts of interfacing devices*
CLR-4:	*Describe the instruction set of Microcontroller*
CLR-5:	*Implement the ARM microcontroller in Biomedical applications*

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

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

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

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

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

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

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

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

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

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

Unit-4 - Arm Microcontroller ***15 Hour***

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

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

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

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

Learning Assessment

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

Course Designers

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

Course Code	21BMC303T	Course Name	PRINCIPLES OF MEDICAL IMAGING	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*Narrate the physics of X –ray production and image intensifier system*
CLR-2:	*Demonstrate the working of different components of Computed tomography and its different generations*
CLR-3:	*Describe the working principle of PET and SPECT imaging*
CLR-4:	*Explain the basic physics behind MRI imaging and reconstruction algorithms for MRI Images*
CLR-5:	*Illustrate the working principles of different types of scanners – A, B & M mode and Duplex ultrasound scanners*

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

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

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

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

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

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

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

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

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

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

Learning Resources	1. *R.S.Khandpur., 'Handbook of Biomedical instrumentation', Tata McGraw Hill Publishing Co Ltd., 3rd edition, 2014.* 2. *Jerrold T. Bushberg, John M. Boone., "The essential physics of medical imaging", Lippincott Williams & Wilkins, 3rd edition, 2011.* 3. *M. A. Flower (Editor). "Webb's Physics of medical imaging, Second Edition", CRC Press, Taylor& Francis Group, ISBN: 978-0-7503-0573-0, 2nd edition, 2016.*	3. *Nadine Barrie Smith, Andrew Webb, "Introduction to medical imaging: Physics, Engineering and clinical applications", Cambridge University Press, 1st edition, 2010.* 4. *K. Kirk Shung, Michael Smith, Benjamin M.W. Tsui., "Principles of medical imaging", AcademicPress, 1st edition, 2012.*

Learning Assessment

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

Course Designers

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

Course Code	21BMC304J	Course Name	MEDICAL IMAGE PROCESSING	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							2	0	2	3

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

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*Explain the basic image operations and image transforms*
CLR-2:	*Apply various image enhancement techniques in medical images*
CLR-3:	*Illustrate the concepts of Image restoration and reconstruction techniques*
CLR-4:	*Analyze the various types of image segmentation algorithms*
CLR-5:	*Describe various Image compression and fusion methods*

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

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

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

Experiments:

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

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

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

Experiments:

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

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

Learning Resources	1. *Rafael C., Gonzalez and Richard E. Woods,"Digital Image Processing", Pearson Education Asia,Third Edition, 2007* 2. *Anil.k.Jain, "Fundamentals of Digital image processing", Prentice Hall of India, 2nd edition 1997.*	3. *Joseph V.Hajnal, Derek L.G.Hill, David J Hawkes, "Medical image registration", Biomedical Engineering series, CRC press,2001.*

Learning Assessment

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

Course Designers

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

Course Code	21BMC305T	Course Name	BIOCONTROL SYSTEMS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*Explain about mathematical modeling of mechanical and electrical systems*
CLR-2:	*Analyze the transient and steady state error and its analysis*
CLR-3:	*Identify and analyze stability of a system in time domain using root locus technique*
CLR-4:	*Explain the different frequency domain analytical techniques*
CLR-5:	*Illustrate the controllers used in control systems*

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

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

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

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

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

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

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

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

Learning Resources	1. *Nagrath.J and Gopal, "Control System Engineering", 5th Edition, New Age, 2007.* 2. *Benjamin C Kuo, "Automatic Control System", 9th edition, John Wiley & Sons, 2010.*	3. *Gopal.M, "Control System Principles and Design", 2nd Edition, TMH, 2002.* 4. *Michael C K Khoo, "Physiological Control Systems: Analysis, Simulation and Estimation", John Wiley & Sons, 2000.*

Learning Assessment

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

Course Designers

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

Course Code	21BMC401J	Course Name	BIOMECHANICS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							2	0	2	3

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

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*Define the concepts of kinematics and kinetics of human motion*
CLR-2:	*Express the basic mechanics of skeletal and muscular movements*
CLR-3:	*Apply the basic mechanics in various movements and loads on shoulder, elbow and wrist*
CLR-4:	*Analyze the movements and loads applied on hip, knee, ankle and foot*
CLR-5:	*Implement the analysis of gait and study the movement characteristics of spine*

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

Unit-1 - Kinematic and Kinetic Concepts of Human Motion	***12 Hour***
Forms of Motion-Standard Reference Terminology-Joint Movement Terminology -Qualitative analysis of human movement-Basic concepts related to kinetics and kinematics-Mechanical loads on the human body - Effectsof loading-Tools for Measuring Kinetic and kinematic quantities. ***Experiments:*** *Analysis of mechanical stress and strain, Projectile motion analysis, Measurement of bone mineral density*	
Unit-2 - Characteristics of Bone	***12 Hour***
Mechanical properties of body tissues-Structural Analysis -Biomechanical Characteristics of Bone-Bone tissue function- Composition of bone tissue-Bone Modeling and Remodeling-Mechanical properties of bone-Maxwell and Voight model. ***Experiments:*** *Study of Mechanical properties of bone, Preprocessing and post processing analysis, Deflection analysis*	
Unit-3 - Functional Anatomy of Upper Extremity	***12 Hour***
Shoulder complex- Functional Characteristics of the Joints of the Shoulder-Loads on the shoulder-Elbow and Radio ulnar joints- Functional Characteristics of the Joints of the Elbow-Loads on the elbow-Functional Characteristics of the joints Of the Wrist and Hand -Common injuries of upper extremity. ***Experiments:*** *Study of upper extremity joints, Segmentation of radius and ulna, 3D modeling of radius and ulna*	
Unit-4 - Functional Anatomy of Lower Extremity	***12 Hour***
Structure of Hip joint-Loads on the Hip- Structure of Knee joint- Movement Characteristics of the Knee- Loads on the knee-Structure of Ankle and Foot-Combined movements of Ankle and Foot-Common injuries of lower extremity. ***Experiments:*** *Study of lower extremity joints, Segmentation and modeling of femur bone, Segmentation and modeling of fibula and tibia*	

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

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

Learning Assessment

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

Course Designers

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

Course Code	21BMC402J	Course Name	BIOMEDICAL EQUIPMENTS FOR CLINICAL APPLICATIONS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							2	0	2	3

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

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*Explain the fundamentals of diagnostic and therapeutic equipments*
CLR-2:	*Summarize the functioning of different types of physiotherapy and electrotherapy equipments*
CLR-3:	*Illustrate the concepts of the instruments dealing with bone*
CLR-4:	*Construct the respiratory care equipments*
CLR-5:	*Describe the diagnosis procedure of hearing problems and Hearing aids and working principle of therapeutic equipments*

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

Unit-1 - Coronary Care Equipments ***12 Hour***

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

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

Unit-2 - Physiotherapy, Electrotherapy and Phototherapy Equipments ***12 Hour***

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

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

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

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

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

Unit-4 - Sensory Diagnosis and Hearing Aid Equipments ***12 Hour***

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

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

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

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

Learning Assessment

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

Course Designers

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

ACADEMIC CURRICULA

Professional Elective Courses

Regulations 2021

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

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

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

Course Code	21BME261T	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:*
CLR-1:	*Compile the concepts of spectroscopy*
CLR-2:	*Summarise the concepts and applications of various biosensors*
CLR-3:	*Describe the concepts of various microscopes used in medicine*
CLR-4:	*Assess the treatment mechanism of Phototherapy*
CLR-5:	*Recognize the special techniques like optical holography*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*Compile the concepts of spectroscopy*	*1*	-	*2*	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*Summarise the concepts of various biosensors*	*1*	-	-	*3*	-	-	-	-	-	-	-	-	*2*	-	-
CO-3:	*Describe the concepts of various microscopes used in medicine*	*1*	-		*3*	-	-	-	-	-	-	-	-	-	*2*	-
CO-4:	*Assess the treatment mechanism of Phototherapy*	*1*	-	-	*3*	-	-	-	-	-	-	-	-	-	-	-
CO-5:	*Recognize the special techniques like optical holography*	*1*	-	-	*3*	-	-	-	-	-	-	-	-	-	-	-

Unit-1 - Light - Matter Interaction and Principle of Optics ***9 Hour***

Concepts of Light matter interaction - Interactions Between Light and a Molecule - Interaction of light with bulk matter - Spectroscopy: Principles - System description - Types of spectroscopy - Conventional Spectrometers Fourier Transform Spectrometers - Michelson interferometer - Electronic absorption spectroscopy - Types of Electronic Transitions - Electronic luminescence spectroscopy - - Vibrational spectroscopy - Fluorescence spectroscopy

Unit-2 - Optical Biosensors ***9 Hour***

Biosensors: Definition - Block diagram & description - Principles of Optical Bio sensing - Bio recognition- Optical Transduction - Fluorescence Sensing, Fluorescence Energy Transfer Sensors - Optical Geometries of Bio sensing - Immobilization of bio-recognition elements - Fiber optic Biosensors - Operating principles of Fiber optic – Biosensors - Types of optical biosensor: Fiber optic Biosensor - Planar waveguide Biosensor - Evanescent Wave Biosensors - Principle of Evanescent Wave Biosensors - Interferometric biosensor - Surface plasmon resonance Biosensor - Applications of optical Biosensors in medicine - Advantages and Disadvantages

Unit-3 - Bio-Imaging ***9 Hour***

Introduction of optical imaging - Needs of optical imaging - Microscopy: Principles - Types of microscopy: Transmission microscopy - Fluorescence microscopy - Scanning microscopy - Inverted and Upright Microscopes Confocal Microscopy - Multi-photon- microscopy - Optical Coherence Tomography - Total Internal Reflection Fluorescence Microscopy - Near-Field Optical Microscopy - Advantages and disadvantages of optical imaging - Applications of Bio imaging, Fluorophores - as Bio imaging Probes - Green Fluorescent Protein, Cellular Imaging - Tissue Imaging, In Vivo Imaging

Unit-4 - Photodynamic Therapy	***9 Hour***
Basics of radiation therapy - Basic principles - Mechanism of Photodynamic Photo oxidation - Photosensitizers For Photodynamic Therapy- Mechanism of photodynamic action - Three Principal - Mechanisms of Photodynamic Therapy - Light Irradiation For Photodynamic Therapy - Light sources - Laser dosimetry - Light delivery - Two-Photon Photodynamic Therapy - PUVA technique - Applications of PDT - Advantages and disadvantages	
Unit-5 - Optical Holography	***9 Hour***
Fundamentals – Object wave – Photography – Holography - Interference during recording - Diffraction during reconstruction - Imaging techniques –In line hologram - Off axis hologram, Fourier hologram - Fraunhofer hologram, Reflection hologram - Optical properties of holographic imaging - Hologram of an object - Image equation, Angular magnification - longitudinal magnification, Image aberrations - Properties of light source - spectral bandwidth - Image plane holograms - Image luminance - - Without pupil - With pupil, Image plane holograms - Speckles- diffuser - 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 Publishers Inc., 1975.*	3. *Tuan VO Dirh, Biomedical Photonics – Handbook, CRC Press, Bocaraton, 2003.* 4. *Paras N, Prasad, "Introduction to Biophotonics", John Wiley &Sons, First Edition, 2003.* 5. *Gerhard K. Ackermann, Jürgen Eichler, "Holography: A Practical Approach", WILEY-VCH Verlag GmbH &Co, first edition, 2008.*

Learning Assessment

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

Course Designers

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

Course Code	21BME262T	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:***
CLR-1:	*Describe home health nursing practice*
CLR-2:	*Discriminate home care working with different clients*
CLR-3:	*Analyze the various medical devices used at home*
CLR-4:	*Identify the advancement in medical technologies*
CLR-5:	*Analyze the use of wireless technology in healthcare*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*Organize home health nursing practice*	*1*	-	-	-	-	-	-	-	-	-	-	-	*1*	-	*1*
CO-2:	*Demonstrate working with client*	*1*	-	-	-	-	-	-	-	-	-	-	-	*1*	-	*1*
CO-3:	*Analyze the various medical devices used at home*	*2*	-	*2*	-	-	-	-	-	-	-	-	-	*1*	-	*1*
CO-4:	*Predict the advancement in health technologies*	*2*	-	*1*	-	-	-	-	-	-	-	-	-	*1*	-	*1*
CO-5:	*Discover various types of wireless technology on healthcare*	*2*	-	*2*	-	-	-	-	-	-	-	-	-	*1*	-	*1*

Unit-1 - Introduction to Home Health Nursing	***9 Hour***
Home health care – purpose - Organization of homecare system - Historical development of home care - Environmental influences of home care - Home care Organization - Legal and ethical issues in home care - Case management and leadership - strategies - Organization of home care system - Home care organization - Role of home care nurse and orientation strategies - Environmental influences on home care - Infection control in home - Patient education in home	
Unit-2 - Working with Clients	***9 Hour***
Basic human needs - Communication and interpersonal skills - Caregiver observation - Recording and reporting, confidentiality - Working with elderly – aging and body systems - Working with children - Need for home care- Mobility transfers and ambulation - Range of motion exercises - Skin care and comfort measures	
Unit-3 - Medical Devices at Home	***9 Hour***
Medical devices at home - ECG monitors - ECG monitors - Smart watch - Wireless infant monitoring system - PCG monitors- Medical alert services - Activity monitors - Automatic wireless healthcare monitoring system The ventilator dependent patient - Device for patient with congestive heart failure - Device for Patient with chronic Obstructive pulmonary disease - Device for patient with Diabetic Mellitus	
Unit-4 - Advancement in Medical Technologies	***9 Hour***
Advances and trends in health care technologies - Driver impacting the growth of medical Technologies - Impact of Moore"s law of medical imaging - E-health and personal healthcare - Defining the future of health Technology - Future of Nano fabrication molecular scale devices - Future of telemedicine - Future of medical computing	
Unit-5 - Wireless Technology	***9 Hour***
Wireless communication basics - Types of wireless network - Body area network - Emergency rescue - Remote recovery - Personalized ambient monitoring - Future trends in healthcare technology - Multi model interaction and technologies for care at home - Cost of home healthcare - Direction for emerging technology	

Learning Resources	1. *Robyn Rice, "Home care nursing practice: Concepts and Application", 4th edition, Elsevier, 2006.* 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 (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*10%*	-	*10%*	-
Level 2	*Understand*	*20%*	-	*10%*	-	*10%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	*10%*	-
Level 6	*Create*	-	-	*10%*	-	*10%*	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

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

Course Code	21BME263T	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:***
CLR-1:	*Recall the functioning of a laser system*
CLR-2:	*Explain the working principle of laser*
CLR-3:	*Examine the optical characteristics of tissue*
CLR-4:	*Summarise the applications of laser in Urology, Gynecology and dentistry*
CLR-5:	*Describe the non- thermal applications of laser in medicine*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*Recall the functioning of a laser system*	*1*	-	*2*	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-2:	*Explain the working principle of laser*	*1*	-	*2*	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*Examine the optical characteristics of tissue*	*1*	-	-	*3*	-	-	-	-	-	-	-	-	2	-	-
CO-4:	*Summarise the applications of laser in Urology, Gynecology and dentistry*	*1*	-	*2*	-	-	-	-	-	-	-	-	-	-	2	-
CO-5:	*Describe the non- thermal applications of laser in medicine*	*1*	-	*2*	-	-	-	-	-	-	-	-	-	-	-	-

Unit-1 - Laser System	***9 Hour***
Absorption and Emission of Radiation by atoms - Ions and Molecules - Laser – Definition - Properties of laser - Characteristics of Laser- Pumping mechanism - Optical pumping - Electrical pumping - Laser pumping, Levels of laser – Resonators - Q-switching - Methods of Q-switching - Gain switching - Mode locking and its types - Cavity damping	
Unit-2 - Types of Laser	***9 Hour***
Classification of Laser - Solid state Laser Construction - Atomic laser Construction - Molecular Laser Construction - Dye Laser Construction - - Semiconductor Laser Construction - Gas Laser Construction - Chemical Laser Construction - - Metal-vapor lasers construction - Free-electron laser - construction and working	
Unit-3 - Mechanism of Laser Tissue Interaction	***9 Hour***
Photochemical interaction - Bio stimulation - Thermal interaction - Heat generation - Heat transport - Heat effects - LASER induced interstitial thermotherapy - (LITT) – Photo ablation - Model, cytotoxicity of UV radiation Plasma induced ablation - Model, analysis of plasma parameters - Photo distribution - Plasma formation - Shock wave generation – Cavitation - Jet formation	
Unit-4 - Laser Applications	***9 Hour***
Disorders in Eye - Diagnostic and Therapeutic Applications of - laser in ophthalmology - Dermatological disorders - Applications of Lasers in dermatology - Diagnostic Applications of Lasers in cardiology - Therapeutic Applications of Lasers in cardiology - Lasers in Surgery - Tissue welding and Soldering - Lasers in urology- Lithotripsy - Therapeutic applications of Lasers in urology - Laparoscopy- System description - Applications of laser in Gynecology - laryngeal surgery - Otology - neurology - dentistry – Orthopedics	
Unit-5 - Non Thermal Applications of Laser and Laser Safety Management	***9 Hour***
Optical coherence tomography - System description - Applications of Optical coherence tomography - Laser Induced Fluorescence (LIF)-Imaging - FLIM Raman Spectroscopy and Imaging - FLIM – Holographic and speckle - Laser hazards - Laser hazards classification - Laser hazards to eye and skin - Viewing laser radiation - Non beam hazards - Laser safety control - Laser signage - Laser risk management - Good laser safety practices	

Learning Resources	1. *Leon Goldman, M.D., & R.James Rockwell, Jr., Lasers in Medicine, Gordonand Breach Science Publishers Inc., 1975.* 2. *Abraham Katzir, Lasers and Optical Fibers in Medicine, Academic PressEdition, 1998.* 3. *Markolf H.Niemz, _Laser Tissue Interaction-Fundamentals andApplications",Springer,3rd ed 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 (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*10%*	-	*10%*	-
Level 2	*Understand*	*20%*	-	*10%*	-	*10%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	*10%*	-
Level 6	*Create*	-	-	*10%*	-	*10%*	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

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

Course Code	21BME264T	Course Name	ARTIFICIAL ORGANS AND TISSUE ENGINEERING	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1:	learn the fundamentals of various organs
CLR-2:	Study the different biomaterials used in artificial organs
CLR-3:	Acquire basic knowledge of various types of artificial organs
CLR-4:	Familiarize with basic biological system in human system
CLR-5:	Have an Gain the knowledge about technology transfer and ethical problem

Course Outcomes (CO):	At the end of this course, learners will be able to:	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	State the basic Knowledge of artificial organs	1	-	-	-	-	-	-	-	-	-	-	1	-	-	-
CO-2:	Analyze various types of materials used in implant applications.	2	-	-	-	-	-	-	-	-	-	-	2	-	1	2
CO-3:	Explain the process of importance of Tissue organization	1	-	-	-	-	-	-	1	-	-	-	-	-	-	-
CO-4:	Select appropriate class of polymers using scaffold applications	2	-	-	-	-	-	-	1	-	-	-	-	2	-	-
CO-5:	Apply the various biomaterials used in implants and artificial organs	1	-	1	-	-	-	-	-	-	-	-	1	2	2	2

Unit-1 - Basics of Artificial Organ — **9 Hour**

Introduction -artificial organ - Immunological considerations - Blood transfusion - Artificial kidney - Cardiovascular organ - Vascular organ - Cardiac pacemakers - Introduction to Kidney organ - Artificial Kidney - Artificial Lung - Liver implant - Artificial Pancreas - Skin and Hair organ - Artificial ear - Artificial Nose - Regeneration and Potential Future Uses for Stem Cells - Ethical consideration

Unit-2 - Types of Artificial Organs — **9 Hour**

Introduction to Biomaterials in Ophthalmology - Anatomy of eye - Viscoelastic solution - Contact lenses - Optical implants - Scleral buckling materials for retinal detachment - Artificial exchange systems: Blood viscosity Effects of shear on blood cells - Blood–air interactions - Blood flow in artificial devices – Exchangers – Hemodialysis - Soft Tissue Applications - Bulk space fillers -Maxillofacial implants - Fluid transfer implants - Functional load-carrying and supporting implants - Microencapsulation of live animal cells

Unit-3 - Basics Concepts of Tissue Engineering — **9 Hour**

Introduction to Tissue engineering - Cell source - Types of cell Sources - Three-dimensional interactions - Cells as therapeutic Agents with examples, Cell numbers and growth rates - Tissue organization - Tissue Components - Tissue types, Functional subunits - Tissue Dynamics, Dynamic states of tissues - Homeostasis in highly prolific tissues and Tissue repair. Angiogenesis - Measurement of cell characteristics - cell morphology - Cell number and viability - Cell-fate processes, cell motility - Cell function - Cell-extracellular matrix interactions - Binding to the ECM, Modifying the ECM - Malfunctions in ECM signaling - Direct Cell-Cell contact - Cell junctions in tissues, malfunctions in direct cell-cell contact Signaling.

Unit-4 - Types And Application of Tissue Engineering — **9 Hour**

Scaffolds for tissue engineering - Classes of potential scaffold materials - The criteria for an ideal scaffold - Polymer scaffolds - Polymer scaffolds applications – Electro spinning method -Bioactive ceramic scaffolds - Bioactive ceramic scaffolds and its applications - Substrate Scaffold Materials - Nano composites - Control of architecture - A guide to basic cell culture and - applications in biomaterials and tissue engineering - sterilization of scaffolds - Sterilization methods - Cell culture protocols - Basic techniques for assessment of cell viability - culture environment - maintenance of cells in vitro, cryopreservation - Regeneration stimulated electrically

Unit-5 - Recent Advancement of Tissue Engineering	***9 Hour***
Immunochemical techniques in tissue engineering and biomaterial science - Basic immunological principles - Common immunochemical techniques used in biomaterials - Immunochemical applications in biomaterial science and tissue engineering research - Clinical applications of tissue engineering - Cell source, Stable 3D constructs – Cartilage - Tendons, ligaments and bone - Regeneration in the cardiovascular system - 3D printing techniques in cardiac stent - Regulatory classification of biomaterials and medical devices - Classification of medical devices - Ethical issues, The ethical problem and Moral uncertainties - 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 (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*10%*	*-*	*10%*	*-*
Level 2	*Understand*	*20%*	*-*	*10%*	*-*	*10%*	*-*
Level 3	*Apply*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*10%*	*-*	*10%*	*-*
Level 6	*Create*	*-*	*-*	*10%*	*-*	*10%*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

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

Course Code	21BME265T	Course Name	BIOMEDICAL NANO 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:	*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 importance of nanotechnology based biomedical diagnostics*
CLR-4:	*Familiarize with biological system, prosthetic and medical implants in nanotechnology*
CLR-5:	*Have an Gain the knowledge about nano material used in biomedical application*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*Explain the basics concepts synthesis method of nano materials in medical applications*	*1*	-	-	-	-	-	-	-	-	-	-	*1*	*1*	-	-
CO-2:	*Analyze the phenomena taking various characterization techniques used in Nano material method*	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-	*2*	*1*
CO-3:	*Describe the process of importance of nanotechnology based biomedical diagnostics*	*1*	-	-	-	-	-	-	-	-	-	-	*1*	-	-	-
CO-4:	*Select appropriate class of Nano materials using knowledge of, prosthetic and medical implants in nanotechnology*	*2*	-	-	-	-	-	-	-	-	-	-	*1*	-	*2*	-
CO-5:	*Write the concepts of biomedical application of different organic particles*	*1*	-	-	-	-	-	-	-	-	-	-	*1*	*2*	-	*1*

Unit-1 - Nano Materials Preparation Techniques	***9 Hour***
Introduction - synthesis Nanomaterial - Types of bulk synthesis Material - Top Town approaches - Bottom up approaches - - Types of Physical Vapour deposition Method - Sputtering Techniques - Chemical evaporation techniques - Laser ablation method - Pulsed laser deposition - Introduction to chemical synthesis - Sol gel process and micro emulsion method-Hydrothermal process and wet chemical - Spray pyrolysis Techniques - Spin coating methods	
Unit-2 - Characterization Techniques of Nano Material	***9 Hour***
Introduction to Nano scale phenomena - Nano particle determination - Introduction to characterization techniques - X-Ray diffraction method - Particles size determination - Principle of Scanning electron microscopy - Construction and working of SEM - Application of SEM - Energy dispersive X-ray spectroscopy - EDS Using elemental analysis - Principle and working of Transmission electron microscope - Application of TEM - Principle and working of atomic force microscope - Application of AFM - Fourier transform infrared (FTIR) spectroscopy and its application	
Unit-3 - Nanotubes and its Applications	***9 Hour***
Introduction to carbon Nano tube and its types - Carbon Nano tube for biomedical application - Introduction to Improved diagnosis by in vivo imaging - Types of In vivo imaging and its application - Detection of tumors for Nano materials-Nano particle using drug delivery system - Different types in drug delivery system - Nano particle using genetic defect diagnostics - Introduction to Nano robotic medical devices - Application of Nano robotic medical devices - Introduction to Nano material in medical imaging - Magnetic resonance imaging based contrast reagent used in Nano particles - Organic Nano particles and Its applications - Nanoprobes for CT imaging - Different types of nanoprobe in CT image - PET based contrast reagent used as a Nano particle	

Unit-4 - Biomedical Implants in Nanotechnology	***9 Hour***
Introduction to prosthesis and implants - Nano materials used in Neural implant - Recent and advancement in Neural implant - Nano materials and coating used in HIP implant - Recent and advancement in Hip implant - Knee implant coating in Nano technology - Recent advancement in Knee implant - Nano materials and coating used in Dental implant - Recent advancement in Dental implant - Nano Technology in ocular implant - Recent advancement in Ocular implant - Nano Technology in ear implant - Recent advancement in ear implant - Tissue engineering in nanotechnology - Nano fiber scaffold technology - Nano fiber scaffold technology in Biomedical application	
Unit-5 - Organic - Inorganic Nanoparticles and is Applications	***9 Hour***
Introduction -Nano Biodegradable material - Nano Biodegradable material for biomedical application - synthesis methods of Magnetic nanoparticles - Magnetic nanoparticles for biomedical application - Multi-functional inorganic Nano particles - Multi-functional inorganic Nano particles for biomedical application - Carbon nano tube (CNT) based inorganic Nano particles - Biomedical application of CNT based inorganic Nano particles Introduction to Nano biosensor - Nano Biosensor: Fabrication methods - Nano Materials based breath gas sensor - Fabrication of breath gas sensor - Glucose Nano sensor for Diabetic diagnostics -Nano oxygen sensor and its biomedical 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*	3. *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* 4. *David Wild; "The Immunoassay Handbook", Elsevier, 4thedition, 2013.*

Learning Assessment

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

Course Designers

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

Course Code	21BME266T	Course Name	BIOMETRICS	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:	*Explain the basics of biometric systems*
CLR-2:	*Illustrate the finger print and hand geometry recognition*
CLR-3:	*describe the characteristics of face recognition system*
CLR-4:	*Identify the applications of biometrics in gait recognition.*
CLR-5:	*Analyze the concepts of voice biometrics*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*Analyze the performance and characteristics of biometric systems*	*2*	-	-	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-2:	*Explain the image processing techniques used in finger print technology*	*2*	-	-	*2*	-	-	-	-	-	-	-	-	-	*2*	-
CO-3:	*Illustrate the concepts of face recognition system in 2D and 3D imaging*	*2*	-	-	*2*	-	-	-	-	-	-	-	-	-	-	*2*
CO-4:	*Implement the gait algorithm in gait recognition process and perform on line signature verification using image processing techniques*	*2*	-	*2*	-	-	-	-	-	-	-	-	-	-	-	*2*
CO-5:	*Evaluate the application of voice biometrics technology*	*2*	-	-	*2*	-	-	-	-	*1*	-	-	-	-	-	*2*

Unit-1 - Fundamentals of Biometrics	***9 Hour***
Introduction to biometrics - Definition and Evolution - Operation of biometric systems - Block diagram description - Biometric functionalities - Verification vs. identification - Performance of biometric systems - Biometric system errors-failure to acquire - Failure to enroll - Benefits of biometrics - Parameters of good biometrics - Application of biometrics-Forensics - Government, commercial - Characteristics of biometrics - Accuracy in biometric systems - Legal consideration in use of biometric systems	
Unit-2 - Finger Print and Hand Geometry Recognition	***9 Hour***
Introduction to finger print technology - General description - Finger print sensing-optical sensors - Solid state sensor and ultrasound sensors - Feature extraction-segmentation - Enhancement, minutiae extraction - Finger print matching-correlation based methods - Rigid feature based techniques - Performance evaluation-finger print verification competition - Finger print vendor technology evaluation - Synthetic finger print generation - Securing finger print based biometric systems - Hand geometry: Historical perspective - Modern hand reader - Processing steps –hand capture, processing - Classification, template adaptation - Performance metrics – Standardization	
Unit-3 - Face Recognition	***9 Hour***
Face recognition –Introduction - Techniques-Eigen faces, Linear discriminant analysis - Independent component analysis - Local feature analysis - Face recognition databases-FRGC,FERET - PIE, AR,Yale face database - Advanced correlation filters - Kernel class dependent analysis - Support vector machine for classification –Algorithm - Tensor faces method-multilinear analysis of training images , testing images - 3D sensor and data for face recognition - 3D Face image processing-smoothing - Local feature extraction - Representation and features for 3d face recognition- Global and local set point model - Deformation model	
Unit-4 - Gait Recognition and Palm Print Identification	***9 Hour***
Gait –Introduction - Human ID gait challenge problem - Base line gait Algorithm - Recognition Approaches-Temporal alignment - Shape based approach - Palm print identification system-block diagram - Image preprocessing techniques - Feature extraction - Feature matching - Online signature verification – Architecture - Data acquisition and preprocessing - Feature extraction and enrolment - Similarity computation – Matching - Resources for online signature verification systems-Reference systems - On-line signature databases	

Unit-5 - Voice Biometrics	***9 Hour***
Voice biometrics-Technology - Identity information in the speech signal - Language generation and speech production - Feature extraction and Tokenization-short term analysis – parameterization - Phonetic and word Tokenization - Prosodic Tokenization - Text dependent speaker recognition- classification - Databases and benchmarks - Text –independent speaker recognition-short term spectral systems - Idiolectal systems - Phonotactic systems - Prosodic systems - Applications of voice biometrics-voice authentication - Speaker detection - Strength of voice biometrics - 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, 20*

Learning Assessment

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

Course Designers

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

Course Code	21BME361T	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:	*Define the fundamental principles of microsensors and micro actuators*
CLR-2:	*Comprehend about the materials used in MEMS and its fabrication processes*
CLR-3:	*Acquire an idea about the micromachining*
CLR-4:	*Analyze about the biomedical application of MEMS in POCT*
CLR-5:	*Demonstrate the different biomedical application of MEMS*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*Define the working principle of MEMS & Microsystems in healthcare domain*	*2*	-	-	*1*	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*Explain the micro system fabrication processes and materials used for MEMS*	*2*	-	-	-	*1*	-	-	-	-	-	-	-	*2*	-	-
CO-3:	*illustrate the various Micromanufacturing techniques*	-	-	*1*	-	*2*	-	-	-	-	-	-	-	*2*	-	-
CO-4:	*Apply the concepts of BioMEMS in POCT*	-	-	*1*	*1*	*2*	-	-	-	-	-	-	-	-	*2*	-
CO-5:	*Summarize the research areas in the field of BioMEMS*	-	-	*1*	*1*	*2*	-	-	-	-	-	-	-	-	-	-

Unit-1 - Mems and Microsystem	***9 Hour***
MEMS and microsystems- Introduction - Typical MEMS and microsystem products - Difference between MEMS and Microsystems - Application of Microsystems in healthcare industry - Working Principles for Microsensor Types of Biomedical Sensors & Biosensor Chemical Sensors - Optical Sensors - - Pressure Sensors - Thermal Sensor - Acoustic Wave Sensors – MEMS with Microactuator - Working Principle for Microactuator - Micropumps – Microvalves- Application of Microactuations	
Unit-2 - Mems Materials and Fabrication Processes	***9 Hour***
Substrates and wafers - Silicon as a substrate material – Types of Silicon compounds, Silicon piezoresistor - Gallium arsenide, Quartz - Piezoelectric crystals, Polymers - Packaging materials – Photolithography– Oxidation - Chemical vapor deposition (CVD) - Types of CVD - Physical vapor deposition (PVD)– Epitaxy - Types of Epitaxy – Etching – Chemical Etching	
Unit-3 - Overview of Micro-Manufacturing	***9 Hour***
Micro-Machining- Introduction - Micromachining Techniques - Bulk Micromanufacturing (BM) - Steps in Bulk Micromanufacturing - Construction of a Microcantilever using BM - Types of Etching process in bulk micromanufacturing - Types of Etching process in bulk micromanufacturing - Surface Micromachining (SM) - Construction of a Microcantilever using SM - Steps in Surface Micromachining - LIGA – Fabrication Steps in LIGA process - Difference between LIGA, SM, BM - Applications of LIGA - Applications of Surface Micromachining - Applications of Bulk Micromachining	
Unit-4 - Biomems-1	***9 Hour***
Introduction to BioMEMS - Home Pregnancy Test - Lab on a Chip - Lab on a cellphone - Mobile Point of Care Monitors - DNA Sensors - Drug Delivery- Insulin Delivery - Artificial Retinal Prosthesis - Endoscopic Wireless Pill - Medtronic Reveal - Microsystem Approaches to PCR - Implantable Microelectrodes - Microfabricated Cochlear Implants - Microelectrodes for Visual Prostheses	
Unit-5 - Biomems-2	***9 Hour***
Microcantilever BioMEMS - Basic Principles of Sensing Biomechanical Interactions - Detection Modes of Biomechanical Interactions- Static Mode - Detection Modes of Biomechanical Interactions- Dynamic Mode - Fabrication and Functionalization of Microcantilevers - Tissue scaffold fabrication using MEMS approaches - Applications of MEMS -fabricated tissue scaffold - Paper-Based Microfluidic Devices - Lens-Based Glucose Sensor - Catheter based sensors - Microneedles - Types of Microneedles	

Learning Resources	1. *Tai-Ran Hsu, "MEMS & Microsystems- Design, Manufacture and Nanoscale Engineering JohnWiley & Sons, 2nd Edition, 2008* 2. *Nitaigour PremchandMahalik, "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.* 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 (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*10%*	-	*10%*	-
Level 2	*Understand*	*20%*	-	*10%*	-	*10%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	*10%*	-
Level 6	*Create*	-	-	*10%*	-	*10%*	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

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

Course Code	21BME362T	Course Name	HUMAN ELECTROPHYSIOLOGY	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:	*Explain in detail about the cell electrophysiology*
CLR-2:	*Describe the neuronal communication*
CLR-3:	*Elaborate about electrophysiology at neuromuscular junctions*
CLR-4:	*Illustrate the concepts of cardiac electrophysiology*
CLR-5:	*Explore the latest technologies with Electrophysiology studies*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*Outline the physiology of cellular communication*	-	-	-	*1*	-	-	*1*	-	-	-	-	-	*1*	-	-
CO-2:	*Explain how neuron communicate and about perception*	-	*1*	-	*1*	-	-	-	-	-	-	-	-	*1*	-	-
CO-3:	*Illustrate how skeletal muscles work with neural system*	-	*1*	-	*2*	-	-	-	-	-	-	-	-	*1*	-	-
CO-4:	*Relate how human systems are controlled by the electrical signals from brain*	-	*2*	-	*2*	-	-	-	-	-	-	-	-	*1*	-	-
CO-5:	*Summarize the cardiac electrophysiology and electrophysiological studies using EEG and other signals.*	*2*	*1*	*2*	*2*	*3*	-	-	-	-	-	-	-	*1*	*1*	*2*

Unit-1 - Cell Electrophysiology	***9 Hour***
Physiology- levels of organization in the body - Concept of homeostasis - Homeostasis control systems - Cell structure overview - Plasma membrane structure - Plasma membrane functions - Membrane transport overview Assisted, unassisted transports –Electrical properties of organs- Membrane potential - Membrane potential causes - Neural communication- Graded potentials - Action potential - Action potential-generation and - Propagation - All or none law – Myelination - Myelination challenges	
Unit-2 - Neural Communication and Perception	***9 Hour***
Synapse - Process involved in synapse - Intracellular communication - Signal transduction - Organization of nervous system - Overview - Brain review - Spinal cord review - Peripheral nervous system - Receptor physiology – Pain - Pain perception - Nerve conduction in pathological states (Demyelination, entrapment) -Eye revisited - Visual perception - Ear and hearing - Ear and equilibrium - Chemical sensing - Taste and Smell	
Unit-3 - Neuromuscular Physiology	***9 Hour***
Autonomic nervous system - Somatic nervous system - Neuromuscular junction - Chemical linkage - Skeletal muscles structure and functions - Skeletal muscle mechanics - Shortening of skeletal muscles - Fiber types - Nervous control of motor movements - Smooth muscle - Phasic contraction - Cardiac muscles - Blend with smooth and skeletal muscles	
Unit-4 - Electrophysiology of Human Systems	***9 Hour***
Heart anatomy review - Electrical and Mechanical events of cardiac cycle - Pacemaker activity - Refractory periods - ECG- Spread of electrical activity - Cardiac output - Cardiac output and its control - Blood pressure (BP) - Reflexes responsible for BP - Respiratory mechanics - Adjustments in ventilation - Nervous control of respiration - Nervous control of digestive system -Defecation reflex - Nervous control of excretory system - Micturition reflex	
Unit-5 - Electrophysiology Studies	***9 Hour***
Electrophysiology studies (EPS) - Facts – Need for EPS - Risks involved - Procedure involved - Pacing Maneuvers - Pace mapping - Vagal Maneuvers (VM) - Indications of VM - Technologies for VM - Special considerations - Supra ventricular tachycardia (SVT) - Causes, types SVT - Symptoms of SVT - Treatments for SVT - Latest trends in EPS - 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 (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*10%*	-	*10%*	-
Level 2	*Understand*	*20%*	-	*10%*	-	*10%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	*10%*	-
Level 6	*Create*	-	-	*10%*	-	*10%*	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

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

Course Code	21BME363T	Course Name	BIOMEDICAL DEVICE DESIGN FUNDAMENTALS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*Analyze the basic concepts of design issues in medical devices*
CLR-2:	*Enumerate information about the forming applications in the design of medical devices*
CLR-3:	*Apply knowledge about the laser processing applications*
CLR-4:	*Summarize the relation between different advanced fabrication techniques of medical implants*
CLR-5:	*Identify the machinability of biocompatible metal alloys*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*Identify the challenges in the Medical Device Industry*	*3*	-	-	*1*	-	-	-	-	-	-	-	-	*1*	-	-
CO-2:	*Explain the process of fabricating implantable devices*	*2*	-	-	*1*	-	-	-	-	-	-	-	-	*2*	-	-
CO-3:	*Summarize the basics of microscale medical device applications*	*1*	-	-	*1*	-	-	-	-	-	-	-	-	*1*		-
CO-4:	*Analyze the importance of different biomaterials used in device design*	*3*	-		-	-	-	-	-	-	-	-	*2*	-	*1*	-
CO-5:	*Apply the knowledge of machining-based fabrication for medical devices*	*1*	-	-	-	-	-	-	-	-	-	-	*1*	-	-	*1*

Unit-1 - Design Issues in Medical Devices ***9 Hour***

Introduction - Need for Medical Devices - Technology Contribution to Medical Devices - Subtractive Technologies - Net-Shape Technologies - Additive Technologies - Challenges in the Medical Device Industry - Medical Device Development - Biomedical Product Life Cycle - Medical Device Development Process - Medical Devices' Design Process - Manufacturing a Prototype

Unit-2 - Forming Applications on Implantable Devices ***9 Hour***

Forming Applications – Forming - Typical Process Parameters - Temperature– Strain - Strain Rate - Tribology and Micro-Tribology - Manufacturing Process Chain - Manufacture of Alloys and Raw Materials – Forming - Machining and Finishing – Coating - Packaging and Sterilization - Implantable Devices - Bone Implants

Unit-3 - Laser Processing Applications on Medical Devices ***9 Hour***

Laser Processing procedures - Microscale Medical Device Applications - Processing Methods for Medical Device Fabrication - Biomaterials Used in Medical Devices - Microjoining of Similar and Dissimilar Materials - Laser Micromachining for Microfluidics

Unit-4 - Machining Applications and Advanced Techniques on Medical Implants ***9 Hour***

Machinability of Biocompatible Metal Alloys - Surfaces Engineering of Metal Implants - Wear and Failure of Metal Implants - Micromilling-Based Fabrication of Metallic Microchannels for Medical Devices - Machining-Based Fabrication of Polymeric - Microneedle Devices - Degenerative Disc Disease - Intervertebral Spinal Spacers - Inkjet Technology - Medical Applications of Inkjet Technology

Unit-5 - Regulation and Protection of Medical Devices ***9 Hour***

Minimisation of exposure to radiation - Medical devices intended to emit radiation - additional requirements - Safety dependent on internal power supply - Safety dependent on external power supply - Protection against electrical risks associated with mechanical, vibration, electrical, heat and noise - IEC standards: - IEC 60601-2-44: Computed tomography - IEC 60601-2-43: Interventional procedures - IEC 60601-2-45: Mammographic X-ray equipment

Learning Resources	1. *Claudio Becchetti,Alessandro Neri , "Medical Instrument Design and Development: FromRequirements to Market Placements",Wiley; 1st edition, 2013.* 2. *Andreoni, Giuseppe, Barbieri, Massimo, Colombo, Barbara,"Developing BiomedicalDevices Design, Innovation and Protection", Springer, 2014.* 3. *Tugrul Özel, Paolo Jorge Bártolo, Elisabetta Ceretti, Joaquim De Ciurana Gay, Ciro AngelRodriguez, Jorge Vicente Lopes Da Silva, "Biomedical Devices: Design, Prototyping, andManufacturing", 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 (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	20%	-	10%	-	10%	-
Level 2	Understand	20%	-	10%	-	10%	-
Level 3	Apply	30%	-	30%	-	30%	-
Level 4	Analyze	30%	-	30%	-	30%	-
Level 5	Evaluate	-	-	10%	-	10%	-
Level 6	Create	-	-	10%	-	10%	-
	Total	100 %		100 %		100 %	

Course Designers

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

Course Code	21BME364T	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:***
CLR-1:	*Utilize range of creative thinking tool and apply these to the innovation and entrepreneurial process.*
CLR-2:	*Explain the business environment and idea generation*
CLR-3:	*Construct Marketing feasibility and feasibility plan*
CLR-4:	*Define about Entrepreneurship and implement it*
CLR-5:	*Familiarizing with the nuances of Intellectual Property Rights*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*Interpret creative thinking, learning techniques and correlate to innovation*	*2*	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*Develop idea generation in the business environment*	*2*	-	-	-	-	-	*1*	-	-	-	-	-	-	-	-
CO-3:	*Apply knowledge of Marketing feasibility and feasibility plan*	-	-	*2*	-	*2*	-	-	-	-	-	-	-	*2*	-	*1*
CO-4:	*Correlate Knowledge about entrepreneurship and new opportunities*	-	-	-	-	*2*	-	-	-	*1*	-	-	-	-	-	-
CO-5:	*Evaluate current scenario on entrepreneurship and create innovative business plan*	*2*	-	-	2	-	-	-	-	-	-	-	-	2	-	*1*

Unit-1 - Innovation & Creative Thinking	***9 Hour***
Introduction to Creativity & Innovation - Need for Creativity & Innovation - The process of Technological Innovation - Sources of Innovative - opportunity : Process Need - Industry - and market structures – demographics changes - in perception - Organization and personal factors to promote creativity - Creativity and analytical skill - Difference between Creativity and Analytical skill - Creativity and Problem Solving - Different Techniques for Creative Intelligence - Brain storming technique	
Unit-2 - Business Plan / Idea	***9 Hour***
Scanning of Environment - Understanding factors - Sensing Opportunities - Identify and evaluate factors - harnessing different - sources of knowledge and information - Generation of Ideas - Methods for Generating ideas - Product Planning - Writing a Business Plan - Using and - Implementing the Business Plan - Difference between 'Basic Ideas' and post scanning ideas - Self-Assessment of idea - Reasons for Business Plans Failure	
Unit-3 - Marketing Feasibility and Planning	***9 Hour***
Market survey & Assessment - Demand and Supply - Nature of Competition - Fixing cost and price of product - Project Innovation and Changes - Identification of applicable - Entrepreneurial Opportunities - Data collection for setting up small ventures - Financial, Economic Feasibilities - Technical Feasibilities - Legal Feasibilities - Locational and Other Feasibilities - Preliminary screening in market - Preparation of detailed feasibility plan - Key features of detailed feasibility plan	
Unit-4 - Entrepreneurship	***9 Hour***
Understanding the Meaning of "Entrepreneur" - Universal definitions - Characteristics of an Entrepreneur - Classification of Entrepreneurs - The Entrepreneurial Scene in India - Factors Influencing Entrepreneurship - Entrepreneurial Growth - Problems of Entrepreneurs - HEIs Strategies & Governance for Promoting Innovation & Entrepreneurship - National Innovation and Startup Policy (NISP) - for Higher Educational Institutions (HEIs) - Creating Innovation Pipeline and Pathways for Entrepreneurs - Collaboration Co-creation and Business Relationship and Knowledge - Exchange	

Unit-5 - Intellectual Properties and Responsibilities	***9 Hour***
Product Strategies - Distribution Strategies - Promotional Strategies - Concept of Intellectual Property Rights (IPR) - Patents, Trademarks - Copyright, Industrial Designs Registrations - Geographical Indications, Trade Secrets - Territoriality of IPR - Concept and procedures of obtaining rights and ownership for creative works in India - Environment protection - importance of Business Ethics and Values in Business - Role of entrepreneur in economic growth	

Learning Resources	1. *Peter Drucker, "Innovation and Entrepreneurship", Routledge Classics 2015 Carolina Machado, J. Paulo Davim, "Entrepreneurship and Organizational Innovation", Springer 2020* 2. *Norman M. Scarborough , "Essentials of Entrepreneurship and Small Business Management" (6th Edition) by (Paperback - Jan 13, 2010)* 3. *Dr.Jayashree suresh –Entrepreneurship Development.-Margham Publication-2012* 4. *Ganguli Prabuddha "Intellectual Property Rights--Unleashing the Knowledge Economy", Tata McGrawHill (2001)*	5. *S.S.Khanka, Entrepreneurial Development, S.Chand and Company Limited, New Delhi. 2013* 6. *Gupta C.B. & Khanka. S.S, ―Entrepreneurship and small business management‖, 5th edition , sultan chand & sons, 2014* 7. *Jayshree Suresh, ―Entrepreneurial Development‖, Margham Publishers, Chennai, 2011.* 8. *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 (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*10%*	-	*10%*	-
Level 2	*Understand*	*20%*	-	*10%*	-	*10%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	*10%*	-
Level 6	*Create*	-	-	*10%*	-	*10%*	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

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

Course Code	21BME365T	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:*
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*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*Describe performance improve methods*	*1*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*Identify the project management in healthcare*	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-	-	-
CO-3:	*Apply the process redesign and data analytics in population health*	*1*	-	-	-	-	-	-	-	-	-	-	*1*	*2*	-	*1*
CO-4:	*State the knowledge of health care organizations*	*1*	-	-	-	-	-	-	-	-	-	-	*1*	-	-	-
CO-5:	*Analyzes the population health management*	*2*	-	-	-	-	-	-	-	-	-	-	-	*2*	-	*1*

Unit-1 - Quality and Performance Improve Methods ***9 Hour***

Introduction to Quality management system - Quality Management - Core components of Quality managements - Planning, Improvement and control - Need for health improvement - Performance improvement - Introduction to performance management - Performance management - Health care strategy - Performance frame work - Change versus improvement - Performance based planning – Benchmarking - Identifying problem and gap - Research and Prepare benchmarking visit - Guideline for performance management - Bio-Medical Waste Management

Unit-2 - Performance Management Methods and Project Management ***9 Hour***

Introduction to Quality Measures - Process and outcome Measures - Plan do check act - Six sigma and Lean - Theory of constraints and process modeling - Others Tools and Techniques - Introduction to developing new quality teams - Building a new Quality - Managing performance improvement - Measure the project status - Recommendation of Building capacity - Recommendation of Building capacity to all - Introduction to project management in health care - Project initiation and design - Project risk - Project Execution and Control - Change Management

Unit-3 - Process Redesign, Data Analytics and Population Health ***9 Hour***

Introduction to process redesign - Importance of Process Improvement in system implementation - Basic process Improvement Approach - Lean Six Sigma - Documenting the process - Communication Planning - Solidifying the process - Improvement Approach - Creating Future State - Identify metrics and Information capture points - Gap Analysis definition - Introduction to Big data analysis - Decision Model - Predictive Modeling Define the objects and data collection Applying algorithm - Apply Prediction to decisions - Information sharing beyond the Organizational walls

Unit-4- Analytics In Healthcare Organizations and Population Health Management ***9 Hour***

Introduction to healthcare organizations - Analytical challenges - The values of analytics in health care - Types of data in health care organizations - Understanding managing data (Analytical tool and data) - Statistical analysis in health analytics and performance improvement - Introduction to population health management - Measure of population health status - Interaction with community Public health service Provider - Factors influencing population health status - Impact of health disparities and inequities - Healthcare delivery systems - Continuum of care - Care of co-ordination - Network Affiliation Strategies -Medical Audit – Hazard and Safety in a hospital Setup.

Unit-5 - Strategically Hospital Management System	***9 Hour***
Strategic, Tactical, and Operational Information Management - Information Management - Strategic Information Management - Operational Information Management - Organizational Structures for Information Management Typical Organizational Structures for Strategic Information Management - Typical Organizational Structures for Tactical and Operational Information Management - Examples: Organizational Structures for Information	

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," InformationSystems for Healthcare Management", Health Administration Press, 2014* 5. *G.D.Kunders, "Hospitals – Facilities Planning and Management", TMH, NewDelhi – hedition Reprint 2007.*

Learning Assessment

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

Course Designers

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

Course Code	21BME366T	Course Name	TROUBLESHOOTING OF MEDICAL DEVICES	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*Compile the fundamental troubleshooting procedures and testing of basic electronic components*
CLR-2:	*Comprehend the methods to ensure electrical safety*
CLR-3:	*Demonstrate techniques of fault diagnosis in analog and digital ICs.*
CLR-4:	*Adopt the methods of troubleshooting Diagnostic Equipment*
CLR-5:	*Develop methods to troubleshoot therapeutic and surgical Equipment*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*Identify and rectify issues associated with electronic components in an electronic circuit*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-2:	*Ensure safety in all aspects on medical systems*	*3*	*1*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*Perform fault diagnosis in all medical circuits constructed with analog and digital ICs.*	*2*	-	-	*2*	-	-	-	-	-	-	-	-	-	-	-
CO-4:	*Service and repair a faulty Diagnostic medical Equipment*	*1*	-	-	*2*	-	-	-	-	-	-	-	-	-	-	-
CO-5:	*Perform maintenance operations on therapeutic and surgical Equipment*	*1*	-	-	*2*	-	-	-	-	-	-	-	-	-	*1*	-

Unit-1 - Basic Troubleshooting Techniques & Procedures ***9 Hour***

Making of an electronic equipment – PCB - types - Causes of Equipment Failure - Types of Equipment Failure - Functional block diagram of a troubleshooting system –- Troubleshooting Process - Fault finding Aids – Troubleshooting techniques: Split half method - Application of Split half method in circuit troubleshooting - Systematic Troubleshooting - Correction action

Unit-2 - Grounding Systems ***9 Hour***

Electrical Hazards – Causes - Types of electrical shock - Threshold levels of electrical shock - Electrical grounding - Need for grounding - Grounding Systems in Electronic Equipment – Methods - Temperature Sensitive Intermittent Problems - Methods to rectify - Correction Action to repair the Equipment - Correction Action to repair the Equipment - Tools & Aids for Servicing & Maintenance - Situations where repair not to be attempted Situations where repair not to be attempted - Types of power supply - World power supply types

Unit-3 - Troubleshooting Active and Passive Components ***9 Hour***

Testing of passive components: Fixed Resistors - Testing of passive components: variable Resistors - Testing of passive components: Capacitors - Testing of passive components: variable Capacitors - Testing of passive components: Inductors -Testing of passive components: variable Inductors - Testing of PN Diodes - Testing of Zener Diodes - Testing of NPN transistor - Methods - Testing of PNP transistor – Methods - Testing of FET Methods - Typical op-amp based medical circuits - Fault diagnosis in op-amp circuits - Digital IC Troubleshooter:, Logic clip, Logic probe - Logic pulser, Logic current tracer

Unit-4 - Troubleshooting of Diagnostic Equipments ***9 Hour***

Parts of an ECG Machine - Sources of ECG artifacts - Troubleshooting- ECG Machine - Preventive maintenance of ECG system - Parts of an EEG Machine - Sources of EEG artifacts - Troubleshooting- EEG Machine - Preventive maintenance of EEG system - X ray System - Sources of errors - Troubleshooting- X-ray Machine - Preventive maintenance of X-ray system - Endoscopy: Sources of artifacts - Troubleshooting of endoscope & its preventive maintenance - Ultrasound: Sources of artifacts - Troubleshooting of Ultrasound system & its preventive maintenance - Troubleshooting of Pulse oximeter - Troubleshooting of Sphygmomanometers

Unit-5 - Troubleshooting of Therapeutic & Surgical Equipments	***9 Hour***
Troubleshooting of Defibrillator - Preventive maintenance of Defibrillator - Troubleshooting of Electrosurgical unit - Preventive maintenance of Electrosurgical unit - Troubleshooting of Incubator - Preventive maintenance of Incubator unit -Troubleshooting of Suction apparatus - Preventive maintenance of Suction apparatus - Troubleshooting of Anaesthesia Machine - Preventive maintenance of Anaesthesia Machine - Troubleshooting of Nebulizer Machine - Preventive maintenance of Nebulizer Machine - Oxygen cylinders - Preventive maintenance of Oxygen cylinders - Radiation Monitors-trouble shooting - Radiation Monitors-calibration - Troubleshooting of Autoclaves & sterilizers - 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", Springer Wien NewYork, 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 (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*10%*	-	*10%*	-
Level 2	*Understand*	*20%*	-	*10%*	-	*10%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	*10%*	-
Level 6	*Create*	-	-	*10%*	-	*10%*	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

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

Course Code	21BME367T	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	*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:	*Comprehend the fundamental concepts of Quality management*
CLR-2:	*Describe the principles of quality management*
CLR-3:	*Demonstrate the various process control tools in statistical analysis*
CLR-4:	*Explain the process of benchmarking and Quality Function Deployment*
CLR-5:	*Understand the regulatory strategy of medical devices and biomedical products*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*Understand the basic concepts of quality management*	-	-	-	-	-	-	-	-	-	-	*1*	-	-	-	-
CO-2:	*Explain the principles of Quality management and performance measurement*	*1*	*2*	-	*2*	*2*	-	-	-	-	-	*2*	-	*1*	-	-
CO-3:	*Demonstrate the various tools used for statistical process control*	*1*	*2*	*2*	*2*	*2*	-	-	-	-	-	*2*	-	*1*	-	-
CO-4:	*Apply the knowledge of benchmarking and Quality Function Deployment techniques*	-	*2*	*3*	-	*3*	-	-	-	-	-	*2*	*2*	-	-	-
CO-5:	*Summarize the regulatory strategies of medical devices and biomedical products*	*1*	-	-	-	-	-	*1*	*2*	-	-	-	*2*	-	*2*	-

Unit-1 - Fundamentals of Quality Management	***9 Hour***
Definition of Quality - Dimensions of Quality - Quality Planning - Quality costs. - Analysis Techniques of quality Cost - Basic concepts of Total Quality Management - Historical Review - Principles of TQM – Leadership - Role of Senior Management - Quality Council - Quality Statements - Strategic Planning - Deming Philosophy - Barriers to TQM Implementation	
Unit-2 - Quality Management Principles	***9 Hour***
Customer satisfaction - Customer Perception of Quality - Customer Complaints - Service Quality - Customer Retention - Employee Involvement- Motivation – Empowerment – Teams - Recognition and Reward - Performance appraisal -Continuous process improvement - Juran Trilogy - PDSA Cycle – PDCA Cycle - 5S – Kaizen –Quality Control; Quality Assurance. Performance Measures-Basic concepts – Strategy - Performance measurement	
Unit-3 - Statistical Process Control Tools	***9 Hour***
The seven tools of quality: Flow chart - Check list – Histograms - Pareto Diagram - Cause and Effect diagram - Scatter diagram - Control Charts for variables - Control Charts for attributes – CUSUM charts and multivariate charts. New seven Management tools: Affinity diagram - Relationship diagram - Tree diagram - Matrix Diagram - Matrix data analysis diagram - Process decision program chart - Arrow diagram	
Unit-4 - Quality Management Techniques	***9 Hour***
Benchmarking – Reasons to Benchmark - Benchmarking Process - Quality Function Deployment (QFD) - House of Quality - QFD Process - Taguchi Quality Loss Function - Total Productive Maintenance (TPM - Six sigma– FMEA - Types of FMEA - Benefits of FMEA – FMECA	
Unit-5 - Regulatory Strategy	***9 Hour***
Purpose of regulation - Principles of regulation - Legal frame work for regulation - Basic regulatory strategy —General regulations of Medical Devices, FDA, ISO, - Joint Commission - Regulatory Bodies of India-Medical Council of India –BIS, Importance of regulatory system - Market Overview - Overview of Regulatory Environment - Details of Key Regulator - Organization Chart — CDSCO, Regulatory requirements, Regulations of design, development, testing and production of biomedical products.	

Learning Resources	1. *Charantimath PM. "Total quality management". Pearson Education India; 2017.* 2. *A.Mitra, Fundamentals of Quality Control and Improvement, Pearson Education, 2nd ed. 2005* 3. *H.M.Wadsworth, K.S.Stephens and A.B.Godfrey, Modern Methods forQuality Control andImprovement, John Wiley & Sons.2004*	4. *J.R.Evans and W.M.Lindsay, the Management and Control of Quality, Thomson.2005.* 5. *Ramakrishna S, Tian L, Wang C, Liao S, Teo WE. "Medical devices: regulations, standards and practices",Woodhead Publishing; 2015*

Learning Assessment

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

Course Designers

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

Course Code	21BME368T	Course Name	NEUROENGINEERING	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*Describe the basic principles of brain anatomy and nervous system*
CLR-2:	*Explain about the principles of neurotransmission and neurotransmitters*
CLR-3:	*Enumerate the concepts of BCI and neurophysiologic recording and imaging technologies*
CLR-4:	*Discuss the basics of neuro prosthetic devices*
CLR-5:	*Associate the concepts of various neural stimulators and neural modeling techniques*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*Explain the anatomy of brain and its functions*	2	-	-	*1*	-	-	-	-	-	-	-	-	2	-	-
CO-2:	*Summarize the nervous system and neurotransmission*	2	-	-	*1*	-	-	-	-	-	-	-		2	-	-
CO-3:	*Associate the BCI system and neuro imaging techniques*	2	-	-	*1*	-	-	-	-	-	-	-		-	2	-
CO-4:	*Infer the various neuro prosthetic devices*	2	-	-	-	*1*	-	-	-	-	-	-		-	-	2
CO-5:	*Demonstrate the concepts of neural stimulation and modeling techniques for various applications*	2	-	-	-	*1*	-	-	-	-	-	-		-	-	2

Unit-1 - Introduction to Neurons and Nervous Systems	***9 Hour***
Brain anatomy - Structure of neurons - Function of neurons - Types of neurons – Neuroglia - Myelinated and unmyelinated nerve fibers - Properties of nerve fibres , Transport of materials and impulse in neurons – Synapse Myelination - Neuronal differentiation - Characterization of neuronal cells - Blood Brain barrier - Meninges-Cerebrospinal fluid	
Unit-2 - Neuro-Transmission and Neuro- Transmitters	***9 Hour***
Nervous system - Central nervous system - Peripheral nervous system – Neurotransmission - Stages in neurotransmission - Synaptic transmission - Chemical synaptic transmission -Electrical synaptic transmission - Neurotransmitters and their release - Types of neurotransmitters - Fast and slow neurotransmission	
Unit-3 - Neural Imaging Techniques	***9 Hour***
Brain Computer Interface - History - Components of a BCI System - Feedback - Signal Acquisition - Invasive Techniques - Noninvasive Techniques - Feature Extraction and Translation Techniques - Types of BCI Signals Training of BCI signals - Signal Processing and Feature Extraction - BCI development - Electroencephalography (EEG) - Principle and working of EEG - Computerized axial tomography (CAT) scans in brain imaging - Functional Magnetic Resonance Imaging (fMRI)	
Unit-4 - : Neuro-Prosthetics	***9 Hour***
Sensory prosthetics - Retinal prosthetics - Visual prosthetics - Bionic eye - Auditory prosthetics - Cochlear implant - Bionic ear - Spinal cord stimulator - Motor prosthetics - Bladder control implant- Sacral anterior root stimulator - Prosthetics for conscious control of movements	
Unit-5 - Neural Stimulation and Neural Modeling	***9 Hour***
Deep brain stimulation - Spinal cord stimulation - Cortical stimulation -Transcranial direct current stimulation - Single neuron model - Hodgkin Huxley neuron model - Fitzhugh Nagumo models - Morris lecar model - 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 (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	20%	-	10%	-	10%	-
Level 2	Understand	20%	-	10%	-	10%	-
Level 3	Apply	30%	-	30%	-	30%	-
Level 4	Analyze	30%	-	30%	-	30%	-
Level 5	Evaluate	-	-	10%	-	10%	-
Level 6	Create	-	-	10%	-	10%	-
	Total	100 %		100 %		100 %	

Course Designers

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

Course Code	21BME369T	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:	*Explain the building blocks of IoT*
CLR-2:	*Describe the technologies in IoT*
CLR-3:	*Implement system management in wearable devices*
CLR-4:	*Apply the architecture of smart healthcare systems*
CLR-5:	*Write the basics of tele-health technology and architecture involved*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*List the various models and protocols in IoT*	*3*	*-*	*2*	*1*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*2*	*-*	*-*
CO-2:	*Summarize the various technologies for building IoT*	*3*	*2*	*1*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*2*	*-*	*-*
CO-3:	*Describe the IoT system management and its applications*	*3*	*-*	*2*	*1*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*2*	*-*	*-*
CO-4:	*Apply the techniques in Realtime healthcare applications*	*3*	*-*	*2*	*1*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*2*	*-*	*-*
CO-5:	*Illustrate the architecture in tele health technology*	*3*	*-*	*2*	*1*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*2*	*-*	*-*

Unit-1 - Building Blocks of IoT	***9 Hour***
Characteristics of IoT - Physical design of IoT - IoT protocols - IoT devices - Network/internet layer - Transport layer, - Application layer - Layer protocols - Logical design of IoT - IoT functional blocks - Communication models - Request response model - Publish subscribe model - Push pull model, Exclusive pair model - IoT communication APIs - Rest based communication APIs - Request response model used by REST - WebSocketbased communication APIs	
Unit-2 - IoT Enabling Technologies	***9 Hour***
Wireless sensor network - Cloud computing - Big data analytics - Communication protocols - Embedded systems - Key components - IoT levels and deployment templates - System components - IoT level – 1 - IoT level– 2 - IoT level – 3-Applications - IoT Level – 4 - IoT Level – 5 - IoT Level – 6 – Applications - Wellness monitoring and diagnosis - Wearable electronics	
Unit-3 - Machine-to-Machine and System Management	***9 Hour***
Smart healthcare - Distributed Analytics and Edge Intelligence - Smart Healthcare Use Cases and Applications - Healthcare Monitoring - Wearable Devices - architecture of wearable devices in health care - Pulse Rate Monitoring System - Smart Glove for Paralyzed Patients - Automatic Medicine Dispenser - Smart Healthcare Applications - and Real-Time Analytics Through Edge Computing q - Comparison cloud, fog and edge computing - Edge Computing and Healthcare Systems - Edge Computing General Framework - Edge Computing Use Cases - Edge Computing for Real-Time Analysis - Serverless Framework for Real-Time –Analysis -Real-Time Map-Reduce Framework Using Edge - Challenges for IoT-based Edge computing and deployment	
Unit-4 - Smart Healthcare Applications	***9 Hour***
Real time smart healthcare model using IoT - Sensor modules - Model Architecture - Wearable smart health management clothing - Data acquiring - Training and testing, accuracy prediction - Fog based Real time analytics - IoT analytics - Data gathering and Consumptions - Protocols used for IoT platform - Real-Time Stream Processing - Fog Computing - Fog computing architecture - Characteristics of fog computing - Comparison of fog, cloud, and edge - Role of Fog Computing in Healthcare - Deployment of Healthcare Applications - Case Study: A Real-Time Fog Healthcare Scenario, Patient monitoring system	

Unit-5 - Telehealth Technology	***9 Hour***
Mobile application for medical diagnosis - Architecture of the program, design of the modules - Telecardiology to detect cardiac abnormalities - Telecommunications, Wearable device for ECG monitoring - Virtual clinic –a telemedicine framework - System model - Research methodology - Proposed clinical decision support systems - Personalized Telehealth care - Categories based tele-based services – Telediagnosis - Machine learning approach for telediagnosis - Architecture of Mobile Telemedicine System using MMS for telediagnosis - Teleconsultation, Teletreatment and Telerehabilitation	

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 Things Use 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, Mobile and Remote Applications for Global Healthcare", Academic Press, 2019*

Learning Assessment

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

Course Designers

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

Course Code	21BME370T	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:***
CLR-1:	*Describe the basic concepts of the microfluidic and nanofluidic*
CLR-2:	*Illustrate about the Interfaces in Microfluidic and Nanofluidic Systems*
CLR-3:	*Acquire an idea about the materials and various fabrication methods and techniques*
CLR-4:	*Demonstrate the fluidic control methods and detection methods*
CLR-5:	*Explain the application of various microfluidic and nanofluidic in a biological system*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*Comprehend the fundamental of the microfluidic and nanofluidic*	*2*	*-*	*-*	*1*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
CO-2:	*Illustrate the various interfaces with surface and devices*	*2*	*-*	*1*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*2*	*-*	*-*
CO-3:	*Apply the techniques and methods with materials used for fabrication of microfluidic and nanofluidic structures*	*2*	*2*	*-*	*2*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*2*	*-*	*-*
CO-4:	*Interpret a problem for control and detection 's of fluid interaction and techniques used for solving*	*2*	*1*	*3*	*2*	*1*	*-*	*-*	*-*	*-*	*-*	*-*	*2*	*-*	*2*	*-*
CO-5:	*Explain the various Microdevice Technologies and their applications*	*2*	*1*	*2*	*2*	*1*	*-*	*-*	*-*	*-*	*-*	*-*	*2*	*-*	*-*	*-*

Unit-1 - Basic Microfluidic Concepts	***9 Hour***
Introduction to Microfluidics -Microfluidics - Fluidics and Transport Fundamentals: - Laminar flow - - Diffusion in microfluidic systems - Mixing in microfluidic systems - Surface forces and droplets - Pumps and valves - Pumps and valves(contd.) – Electrokinetics – Working Principle of Electrokinetics - Electro-osmosis - Working Principle of Electroosmosis– Electrophoresis – Principle and Working of Electrophoresis	
Unit-2 - Materials and Fabrication Processes for Microfluidic	***9 Hour***
Materials for Microfluidic Devices - Silicon Based Materials - Glass Based Materials - Polymers Based Material - Fabrication of Microfluidics devices - Photolithography & its techniques - Additive Techniques - Subtractive Techniques - Silicon microfabrication - (Dry Reactive Ion Etching) DRIE - Surface micromachining - Glass Microfabrication – wet isotropic etching - Wafer Bonding – Fusion, Anionic and Adhesive - Polymer microfabrication Injection molding and Hot embossing - Casting & Lithography - Fabrication of microfluidic channels in SU-8 - Microfluidic networks created in biodegradable materials	
Unit-3 - Fluidic Control Methods and Detection Methods	***9 Hour***
Fluid Control :Basic theory - Pressure –Driven Flow - Shear driven Flow - Electrokinetically –driven flow - Single Molecule Detection Methods - Optical detection methods -Case Study - Electrochemical method – Case Study - Measurement of Fluidic Properties: Nonintrusive flow measurement techniques - Streaming potential/current measurement in pressure-driven flows - Current monitoring in electroosmotic flow - Optical flow imaging techniques using a tracer : Properties of flow tracers - Scalar image velocimetry - Laser-induced fluorescence photo - bleaching anemometer - with stimulated emission depletion	
Unit-4 - Microdevice Technologies	***9 Hour***
Actuators for micropumps - Actuators for Microvalves - Flow sensors – Microarrays – Microreactors – Pipettes and Dispensers -Microanalytical Chips - Microanalytical Chips - Electrochemical microfluidics devices - - Paper Microfluidics devices - 3D Printed Microfluidic Devices - Case Study	
Unit-5 - Applications to Biological System	***9 Hour***
Electrophoresis:DNA separation - Case study :DNA separation - Shear-driven flow: Biomolecular separation - Case study : Biomolecular separation - Ion Transport with case study - Concentration with case study - Bioanalysis:Immunoassay - DNA analysis - On-chip separations and combinations - Sample injection and separation - Micro-gas chromatography: - Micro gas sensors for micro GC - Case study for a micro GC - Micro- scale impedance measurements – Biosensor - Biosensors: Case study 1 - Nano- Biosensors - 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, andApplications", 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 (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	*20%*	-	*10%*	-	*10%*	-
Level 2	*Understand*	*20%*	-	*10%*	-	*10%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	*10%*	-
Level 6	*Create*	-	-	*10%*	-	*10%*	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

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

Course Code	21BME371T	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:***
CLR-1:	*Explain the fundamentals and codes of medical ethics*
CLR-2:	*Describe about intellectual property rights*
CLR-3:	*Describe about patents*
CLR-4:	*Explain about copyrights*
CLR-5:	*Summarize an overall idea about trademarks and geographical indicators*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*Identify the importance of medical ethics and codes*	*1*	-	-	-	-	*2*	-	*3*	-	-	-	*1*	-	*1*	-
CO-2:	*Infer about intellectual property rights*	-	-	-	-	-	*2*	-	-	-	-	-	*1*	*1*	-	-
CO-3:	*Interpret the importance of patents*	-	-	-	-	-	*2*	-	-	-	-	-	*1*	*1*	-	-
CO-4:	*Summarize the importance of copyrights*	-	-	-	-	-	*2*	-	-	-	-	-	*1*	-	*1*	-
CO-5:	*Describe the concept of trademarks and geographical indicators*	-	-	-	-	-	*2*	-	-	-	-	-	*1*	*1*	-	*1*

Unit-1 - Medical Ethics ***9 Hour***

Definition and historic evolution of bioethics - Codes and guidelines, universal principles - Medical ethics: some basic issues - Teaching and learning medical ethics - Code of ethics for biomedical engineers – Ethical Theories – Deontology and Utilitarianism, casuist theory, Virtue theory, The Right Theory. Role of ethics in Healthcare workplace - Codes of conduct - Rights of patients - Rights of life - Malpractice – Negligence – Care of the terminally ill - Distributive Justice in Health Care - Human experimentation - Clinical trials – Obligations of Engineering Profession and Moral Propriety

Unit-2 - Introduction To Intellectual Property Rights ***9 Hour***

Origin and development of IPR - History of IPR - Importance and need for protection of intellectual property - Rights to be given - Patentable subject matter - Emerging trends and issues in IPR - Creativity and Invention Theories on concept of property - Public Vs. Private - Tangible Vs. Intangible Industrial Vs. Intellectual - World Intellectual Property Organization(WIPO) - World Trade Organisation (WTO) - General Agreement on Tariffs and Trade (GATT) agreement - Major Conventions on IP - Berne Convention - Paris Convention - TRIPS agreement - Basic forms of intellectual property rights

Unit-3 - Patents ***9 Hour***

Definition of patents - Purpose of a patent - What sort of things can be patented, Patentable and non-patentable inventions - Conditions for an invention to be patentable - Invention vs Innovation - Process Patent - Product Patent - Types of patent applications - Precautions while patenting - Patent specification - Patent claims - Disclosures and non-disclosures - Patent rights and infringement - Rights of a patent owner - Patent cooperation treaty -Paris convention for the protection of industrial property - Importance, advantages and disadvantages of patents

Unit-4 - Copyrights ***9 Hour***

What is copyright - Why copyright - Literature and artistic works - Protection of copyright - Right of reproduction - Right of public performance - Right of broadcasting - Right of translation - Right of Adaptation - Transfer of copyright - Limitations of copyright - Enforcement of Rights - International conventions and treaties - Benefits from copyright protection - Works that are protected by copyright

Unit-5 - Trademarks And Geographical Indicators	***9 Hour***
Trademark and purpose of a trademark - Characteristics of trademark - Functions of trademarks - Guidelines for the registration of a trademark - Nontraditional trademarks - Major types of trademarks - Protection of a trademark - Purpose of a trademark - Madrid system for the International registration of trademarks - Industrial design - Purpose of industrial design - Protection of industrial design - The Hague agreement- Geographical indication - Appellation of origin - Protection of geographical indication(GI) - 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 (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*10%*	*-*	*10%*	*-*
Level 2	*Understand*	*20%*	*-*	*10%*	*-*	*10%*	*-*
Level 3	*Apply*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*10%*	*-*	*10%*	*-*
Level 6	*Create*	*-*	*-*	*10%*	*-*	*10%*	*-*
	Total	*100%*		*100%*		*100%*	

Course Designers

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

Course Code	21BME372T	Course Name	VIRTUAL INSTRUMENTATION FOR BIOMEDICAL ENGINEERS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*Describe the fundamental Virtual Instrumentation*
CLR-2:	*Detail about the software used in Virtual Instrumentation and function*
CLR-3:	*Acquire a concept about the VI programming*
CLR-4:	*Comprehend about the biomedical application of Virtual Instrument*
CLR-5:	*Gain knowledge on research and biomedical applications of virtual instrumentation*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*Define the concepts of Virtual instrumentation & LabVIEW with suitable examples*	*2*	*1*	-	-	-	-	-	-	-	-	-	-	*2*	*2*	*2*
CO-2:	*Differentiate the various Programming techniques*	*3*	*1*	*1*	-	-	-	-	-	-	-	-	-	*2*	*2*	-
CO-3:	*Illustrate the Virtual hardware instrument with common interfaces*	*3*	-	*1*	-	-	-	-	-	-	-	-	-	*2*	*2*	-
CO-4:	*Apply the concepts of LabVIEW in Real time experimental*	*3*	*2*	*1*	*2*	-	-	-	-	-	-	-	-	*2*	*2*	-
CO-5:	*Explain the uses of Virtual Instrument in research and healthcare*	*3*	*2*	*1*	*2*	-	-	-	-	-	-	-	-	*2*	*2*	-

Unit-1 - Virtual Instrumentation	***9 Hour***
Virtual Instrumentation - Conventional Instrumentation Vs Virtual Instrumentation - Architecture of VI - Conventional Virtual Instrumentation - Distributed Virtual Instrumentation - Advantages of VI - Evolution of LabVIEW- LabVIEW - Creating Virtual Instruments Using LabVIEW - Advantages of LabVIEW - Front Panel of Virtual Instruments - Block Diagram of Virtual Instruments - LabVIEW Environment and its Menus Palletes of LabVIEW	
Unit-2 - Programming Mode& Techniques	***9 Hour***
Data Flow Programming - G' Programming Concepts - Creating and Saving VIs, SubVIs - Wiring, Editing, and Debugging VI - Control Structures such as the For Loop and the While Loop - Shift Registers and Their function Selection Structures: Case and sequence structures - Formulae nodes, feedback nodes – Arrays – Cluster: Creating Cluster Controls and Indicator - Cluster functions - Waveform Chart and graph - XY Graph - Strings, Creating String Controls and Indicators - String Functions - Tables and List Boxes - File Input/Output Functions	
Unit-3 - Hardware Instrument	***9 Hour***
Digital I/O Techniques - Data Acquisition in LabVIEW - Hardware Installation and Configuration - Components of DAQ - DAQ Signal Accessory - DAQ Assistant: Create a MAX-Based Task - Create a Project-Based Task DAQ Hardware - DAQ Hardware - DAQ Software - 4–20mA Current Loop - 60 mA Current Loop	
Unit-4 - Common Instrument Interface	***9 Hour***
General Purpose Interface Bus(GPIB) - :IEEE 488.2 STANDARD - RS232 - RS485 - Virtual Instrument Software Architecture(VISA) – VXI – USB – PCI - PCI Express – PXI – PCMCIA – SCXI – LXI	
Unit-5 - Labviews Tools & Its Applications	***9 Hour***
Fourier transform - Power spectrum – Correlation – Windowing – Filters – Oscilloscope - Waveform generation - Multi-channel data acquisition - Vision and Motion tools- problems - Bio Bench - Biomedical work bench - ECG recording - EMG recording - EEG recording - EOG recording	

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 edition 2006.* 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 of America, 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 (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*10%*	-	*10%*	-
Level 2	*Understand*	*20%*	-	*10%*	-	*10%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	*10%*	-
Level 6	*Create*	-	-	*10%*	-	*10%*	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

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

Course Code	21BME373T	Course Name	HEALTH CARE DATA ANALYTICS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*Describe the basics of Health care data*
CLR-2:	*Explain the basics of data analysis*
CLR-3:	*Illustrate the complexity of health care data and information system*
CLR-4:	*Utilize the knowledge of data analytics to solve health problems*
CLR-5:	*Implement the data security and Ethics in Health care data*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*Explain the conceptual and practical difficulties in getting health care data*	*1*	*2*	*-*	*1*	*1*	*-*	*2*	*2*	*1*	*-*	*2*	*2*	*1*	*2*	*1*
CO-2:	*Execute suitable statistical methods for data analysis*	*2*	*2*	*-*	*1*	*1*	*-*	*2*	*2*	*1*	*-*	*2*	*2*	*1*	*2*	*1*
CO-3:	*Describe the information system design and technical skills to use data for decision making and business development*	*2*	*2*	*-*	*1*	*1*	*-*	*2*	*3*	*1*	*1*	*2*	*2*	*1*	*2*	*2*
CO-4:	*Elaborate the importance of Data standards, security and ethics in health care data*	*3*	*2*	*1*	*2*	*1*	*3*	*2*	*3*	*1*	*-*	*2*	*2*	*1*	*2*	*2*
CO-5:	*Implement the data analytics that can provide potential solutions to improve health outcomes.*	*3*	*2*	*1*	*3*	*3*	*3*	*2*	*2*	*1*	*1*	*2*	*2*	*1*	*2*	*3*

Unit-1 - Health Care Data	***9 Hour***
Introduction to health care data - Data analytics life cycle - Complexity of Health care data - Importance of Data in health care - Evidence based medicine - Data sources - Digital health initiatives - Concept of M health - M Health and data types - e-Health - e- health and data – Telemedicine - Telemedicine and its importance - Ways to manage the different data types	
Unit-2 - Data Management and Information System	***9 Hour***
Introduction to MIS - Management pyramid - Concept of Informatics - Components of information system - Data sources and Data tools - Management of databases - Management systems - Decision support system development - Ethical issues in health care data - Ethical issues in health care data - HIPAA standards - Standardization – ICD - Steps to Secure Big data - Steps to Secure Big data - Classifying data - Protecting big data - Intellectual property challenge	
Unit-3 - Pre Processing	***9 Hour***
Introduction to preprocessing - Concept of Outliers - Ways to Detect outliers - Ways to deal with outliers - Process of Dealing outliers - Missing Values - Concept of Missing values - Possible reasons for Missing values Types of missing values - Ways to deal with missing values - - Concept of Dimensionality - Importance of dimensionality reduction - Statistical methods for dimensionality reduction	
Unit-4 - Big Data Analytics	***9 Hour***
Introduction to big data analytics - Properties of Big data - Classification and Prediction - Data mining - Importance of data mining in Health care - Data mining Technique uses in Health care - Association rule mining using R - Introduction to Decision trees - Introduction to CART - Classification by decision tree induction	
Unit-5 - Predictive Modelling	***9 Hour***
Introduction to modeling - Regression models- Types of Regression models - Types of Link functions - Concept of Correlation - Auto correlation - Multicollinearity and its effects - Ways to detect multicollinearity - Multiple correlation - Concept of Validation - Types of validation - Cross validation - Internal validation - External Validation - Concept of over and under fitting - 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 (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*10%*	-	*10%*	-
Level 2	*Understand*	*20%*	-	*10%*	-	*10%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	*10%*	-
Level 6	*Create*	-	-	*10%*	-	*10%*	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Anbuselvan T, General Manager – Sales, Wipro GE Healthcare Pvt. Ltd., Tamil Nadu,Srilanka & Maldive*	1. *Prof M Bagawandas – Centre for statistics , SRM IST*	1. *.Dr.M Prakash , SRMIST*

Course Code	21BME461T	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:*
CLR-1:	*Illustrate what is medical informatics, The types of medical databases and various theft issues*
CLR-2:	*Implement the Hospital information system and clinical Information system and Apply the telemedicine technology*
CLR-3:	*Develop an automation of clinical laboratories*
CLR-4:	*Apply different decision making algorithms for computerized imaging techniques*
CLR-5:	*Create computer aids for handicapped and for critically ill patients*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*Describe applications of computers in health care and different types of medical databases*	*1*	-	-	-	-	*2*	-	-	-	-	-	-	-	-	-
CO-2:	*Develop packages for Hospital Information system and Clinical Information system and demonstrate the applications of telemedicine technology*	*1*	-	-	-	-	*1*	-	-	-	-	-	-	*1*	-	-
CO-3:	*Implement automation of clinical laboratories*	*2*	-	*1*	*1*	*1*	-	-	-	-	-	-	-	-	*2*	*1*
CO-4:	*Apply different decision making algorithm for imaging and diagnosis*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-	*1*
CO-5:	*Create various computer aids for handicapped and for care of critically ill patients*	*1*	-	*2*	-	-	-	-	-	-	-	-	-	-	-	-

Unit-1 - Medical Informatics and Computer Based Patient Record — ***9 Hour***

What is Medical Informatics? - Prospects of medical informatics - Historical review of the development of computers and informatics - Foundation ontology - What is computer based patient record - History taking by computer and Dialogue with the computer - Development tools Intranet - CPR in radiology - Types of databases: Bibliographic – databases - Non Bibliographic databases - Medical information retrieval techniques - Legal, Security and privacy issues in computers and internet - Types of threats –Cryptography - Digital Signature - User Authentication - Attacks from inside and outside the system

Unit-2 - Hospital Information System and Clinical Information System, Telemedicine — ***9 Hour***

Functional capabilities of computerized Hospital information system - Need for computerization of hospitals in India - Security of computer records - Cost effectiveness of information - processing by computer - Benefits of clinical information system - Sources of data for decision making - Modes of decision output to Physician - Registry of Computerized Medical record system - CIS in obstetrics – Gynecology - Fetal Monitoring - Telemedicine Introduction - Telemedicine technology - Types of data transfer - Mode of transmission - Internet and telemedicine - Telemedicine websites - Applications of telemedicine

Unit-3 - Computers in A Clinical Laboratory — ***9 Hour***

Microprocessor for automation - Database approach to laboratory - Automation of clinical laboratories - Automated methods in hematology - Chromosome analysis by computer - Computerized cytology and histology - Automated scanning for cervical scanner - Computer assisted semen analysis - Radio Immunoassays - Intelligent laboratory information system - Computer aided analysis of Echocardiograms - Computerized ECG and analysis of signals - Computerized EEG - Long term monitoring of EEG - Computerized EMG - Single fibre EMG -

Unit-4 - Computer Assisted Medical Decision Making — ***9 Hour***

General model of CMD - Various approaches in decision making - Computer assisted decision support systems - Algorithmic methods - Elements of a protocol - Probabilistic approaches to decision making - Sequential Bayes, Linear discriminant function - Multivariate analysis - Database comparisons and case based reasoning - Production rule systems - Cognitive models - Semantic networks - Decision analysis in clinical medicine - Computers in nuclear medicine - Data acquisition, manipulation and processing - Computer assisted medical imaging-CT - CT-Radiation therapy planning - Computer for MRI

Unit-5 - Computer Aids for the Handicapped & Computers In the Care of Critically Ill Patients	***9 Hour***
Mobility, EMG controlled limbs - Aids for Blind and visually handicapped - Braille system, bat cane - Portable reading aids - Artificial vision for the blind - Concept of artificial retina - Computer aids for the deaf - Computer speech generation and recognition - Robotics to assist the elderly infirm - Cognitive system engineering - Automated computer assisted Fluid and metabolic balance - Pulmonary function Evaluation - Computerized decision support for mechanical ventilation - Cardiovascular physiological evaluation - Computer assisted surgery - Robotics in surgery - Sensing system - Interactive modes	

Learning Resources	1. *Ramchandra Lele., "Computers in Medicine Progress in Medical Informatics", Tata McGraw-HillPublishing 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 Application Informatics in Health Care and Biomedicine", Springer, Third Edition, 2006.*

Learning Assessment

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

Course Designers

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

Course Code	21BME462T	Course Name	PHYSIOLOGICAL MODELING	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*Express the process of modeling to various physiological systems*
CLR-2:	*Implement the mathematical tools for static analysis of models*
CLR-3:	*Demonstrate time domain analysis of the physiological models*
CLR-4:	*Evaluate frequency domain analysis of the physiological models*
CLR-5:	*Apply techniques in system identification and parameter estimation*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*Describe the different techniques in designing physiological model*	*3*	-	*1*	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-2:	*Recall the tools for static analysis of physiological system*	-	*2*	*1*	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-3:	*Illustrate the techniques for time domain analysis of physiological model*	-	*2*	*1*	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-4:	*Demonstrate the techniques for frequency domain analysis of the physiological models*	-	*2*	*1*	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-5:	*Apply the various methods for system identification and parameter estimation*	-	*2*	*1*	-	-	-	-	-	-	-	-	-	*2*	-	-

Unit-1 - Linear Model	***9 Hour***
Introduction to modeling methodology, need for models, approaches to modeling - Model identification, model validation and Simulation - System analysis, fundamental concepts - Physiological control system an example Engineering control system versus physiological control system - Science of modeling - Generalized system properties - Models with combinations of system elements - Linear model of respiratory mechanics - Derivation of transfer function - Linear model of muscle mechanics - Derivation of transfer function - Distributed versus lumped parameter model - Linear system and superposition principle - Laplace transform and transfer function Impulse function analysis - Basics of Linear convolution	
Unit-2 - Static Analysis	***9 Hour***
Static analysis: Open loop versus closed loop - Loop gain calculation: Room temperature control - Steady state characteristics - Determination of steady state operating point for simple model of muscle stretch reflex - Human body Glucose – Insulin regulatory system - Steady state analysis of glucose –insulin model - Human body chemical regulation of ventilatory system - Mechanism of respiration - Gas exchanger mathematical modeling - Respiratory controller mathematical modeling - Closed loop analysis : lung and controller - Calculation of transfer function	
Unit-3 - Time Domain Analysis	***9 Hour***
Introduction to time domain analysis - Linearized respiratory mechanics transient response - Linearized respiratory mechanics first order model – impulse response for open loop - Linearized respiratory mechanics first order model – impulse response for closed loop - Transient response descriptors : Impulse response - Transient response descriptors : Step response - Concept of sliding theory - Neuromuscular reflex action - Mathematical model of neuromuscular reflex motion - Calculation of transfer function - Stability and transient response - Root locus and Routh-Hurwitz stability criterion - Stability analysis: root locus method – Introduction to Nyquist plot - Nyquist criterion for stability - Relative stability theory - Physiology: Pupillary reflex control - Stability analysis of pupillary reflex control	

Unit-4 - Frequency Domain Analysis	***9 Hour***
Frequency response: Open loop frequency response - Closed loop frequency response - Relation between transient and frequency response - Frequency domain specifications - Graphical representation of frequency response: Bode plot - Bode plot :Linearized lung mechanics - Graphical representation of frequency response: Nicholas chart, Linearized lung mechanics - Graphical representation of frequency response : Nyquist plot, Introduction : Circulatory system - Mathematical model of circulatory system - Frequency response of circulatory system - Graphical representation for frequency response of circulatory system - Frequency response of glucose – insulin model - Mathematical model and simulation of glucose – insulin model	
Unit-5 - System Identification	***9 Hour***
Identification of physiological control system - Basic problems in Physiological system analysis - Nonparametric and parametric identification methods - Numerical Deconvolution, Least square estimation - Estimation using correlation functions - Estimation in frequency domain, optimization techniques - Problems in parameter estimation - Input design - Identification of closed loop systems – "opening the loop" - Starling heart- lung preparation - Kao's cross – circulation experiment - Opening the Pupillary reflex loop - Read rebreathing technique - Adaptive control of Physiological variables - General adaptive control system - Multiple model adaptive control - Model reference adaptive control - Optimization in systems with negative feedback	

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. *Claudio Cobelli Ewart Carson, , "Introduction to Modeling in Physiology and Medicine", Academic press series, 1st edition, 2008.*	3. *V.Z. Marmarelis,"Advanced Methods of Physiological System Modeling", Vol.3, Springer Science and Business Media, 2013.* 4. *Johnny T. Ottesen, Mette S. Olufsen, Jesper K. Larsen, "Applied Mathematical Models in Human Physiology", Vol.9, SIAM, 2004.*

Learning Assessment

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

Course Designers

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

Course Code	21BME463T	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:	*Define the fundamentals of biomimetics and its applications*
CLR-2:	*Acquire an idea about the mechanism of cognition and open ended design automation*
CLR-3:	*Analyze the basic concepts of bio-inspired sensors and actuators*
CLR-4:	*Employ the skills about the biomimetics of human motion*
CLR-5:	*Incorporate all the advancement in Bio-inspired technologies*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*Describe the basic mechanism in biomimetic design in various applications*	*1*	*1*	-	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-2:	*Apply the mechanism of cognition and open ended design automation*	*2*	*1*	-	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-3:	*Analyze the importance bio-inspired sensors and biomimetic actuators*	-	*1*	*2*	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-4:	*Organize the biomechanics and rhythmic of motion*	*1*	-	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-5:	*Evaluate the application of biomimetic technologies*	*1*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	*2*

Unit-1 - Introduction to Biomimetics ***9 Hour***

Introduction : Biologically Inspired Mechanisms - Biologically Inspired Structures and Parts - Defense and Attack Mechanisms in Biology - Materials and Processes in Biology - Bio-Sensors - Robotics Emulating Biology Interfacing Biology and Machines - Muscle function - Muscle design - Muscle adaptation - Biomimetics of muscle design -

Unit-2 - Mechanism of Cognition and Open Ended Design Automation ***9 Hour***

Mechanized Cognition - Training and Education - Language Cognition - Sound Cognition - Visual Cognition - Machine Bodies and Brains: Evolving - Controllers and Some Aspects of the Morphology - Evolving Bodies and Brains - Morphology Representations: Tree representations - Developmental representations - Regulatory network representations - Evolving Machines in Physical Reality - Economy of Design Automation - Principles of Design - Research Methodology

Unit-3 - Bio-Inspired Sensors and Biomimetic Actuator ***9 Hour***

Biomimetic tactile sensing: Human sense of touch - Biomimetic artificial touch - Examples of bio-inspired tactile sensing - - Olfactory sensor system for the e-nose - Olfactory classification-data processing - Polymer network actuators - Biomimetic vision systems - Novel biomimetic materials :Introduction - Design of self-oscillating polymer gel - Control of self-Oscillating chemo mechanical behaviors - Design of biomimetic soft actuators

Unit-4 - Biomimetics of Motion ***9 Hour***

Biomechanics of motion: Control center - Passive external and internal actuation - Active external and internal actuation - Agonist Mechanism: Hygroscopic mechanism - Muscular actuation - Antagonist mechanism: Spring Antagonism - Muscular Antagonism - Mechanics of hydrostatic systems: Single compartment systems - Multiple compartment systems - Rhythmics of motion: Gait - Passive Locomotion - Passive locomotion - Limbless locomotion - Multiple limb locomotion

Unit-5 - Application of Biomimetic Technologies	***9 Hour***
Artificial intelligence through symbolic connectionism - Localist symbolic connectionism - Distributed symbolic connectionism - Symbolic connectionism in biological models Neuro fuzzy systems - Bio-Inspired adhesion technologies - Bio-Inspired locomotion mechanisms - Size and current technology constrains - Quadruped robot system: Mechanical components - Quadruped robot system: Mechanical components - Electrical components of quadruped robot - Biologically inspired antenna array design - Biologically inspired antenna beam pattern design	

Learning Resources	1. *Yoseph Bar-Cohen, "BIOMIMETICS Biologically Inspired Technologies", CRC Press, 1st Edition, 2006.* 2. *Trung Dung Ngo, "Biomimetic Technologies: Principles and Applications", Wood head Publishing Ltd, 1st Edition, 2015.*	3. *Sandra Persiani, "Biomimetics of Motion: Nature-Inspired Parameters and Schemes for Kinetic Design",Springer, 1st 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, 1st Edition, 2011*

Learning Assessment

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

Course Designers

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

Course Code	21BME464T	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*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*Explain the fundamental of Artificial Neural Network*
CLR-2:	*Describe about various ANN model and self-organizing map*
CLR-3:	*Illustrate basic concepts of Genetic algorithm*
CLR-4:	*Explore about the genetic algorithm operators*
CLR-5:	*Demonstrate the concepts of ANN for Biomedical Application*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*Apply the concepts of Artificial neural network*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*Implement the algorithm of various ANN*	*2*	-	-	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-3:	*Explain the concepts of Neural network based on competition*	-	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-4:	*Outline the concepts of genetic algorithm and operators*	*2*	-	*3*	-	-	-	-	-	-	-	-	*2*	-	*2*	-
CO-5:	*Analyze the concepts of ANN for Biomedical applications*	*2*	-	-	-	-	-	-	-	-	-	-	*1*	-	-	-

Unit-1 - Artificial Neural Network: an Overview	***9 Hour***
Basics of Artificial Neural network--Biological neuron, Properties-Artificial model-Network parameters: Weight, activation, threshold-Typical architecture: Single layer net, Multilayer net, competitive layer-Common activation function- - McCulloch Pitt's net: Architecture-Algorithm- Hebb net: Architecture- Hebb net: Algorithm- Error correction learning- Perceptron: Architecture-Perceptron: Algorithm-Delta rule	
Unit-2 - Artificial Neural Network Model	***9 Hour***
Feed forward networks - Back propagation network- structure-Algorithm, Applications- BPN -Associative memory: Heteroassociative memory : Architecture-Applications- Associative memory: Autoassociative Net: Architecture-Algorithm, Applications-Hopfield network:Architecture, Algorithm-Boltzman machine-Issue in network design-Radial Basis function	
Unit-3 - Neural Network Based on Competition	***9 Hour***
Kohonen SOM : Architecture-Algorithm-Learning vector Quantization(LVQ) : Architecture-Algorithm-Max net: Architecture-Application procedure-Mexican Hat: Architecture-Training algorithm-Hamming net : Architecture Application procedure-ART Fundamentals-ART: Basic architecture-Learning in ART-Visualization in U matrix-Basics of SVM	
Unit-4 - Introduction to Genetic Algorithm	***9 Hour***
Biological Background-Genetic algorithm world-Evolution and optimization-Gradient based local optimization method-Random search-Stochastic Hill climbing-Simulated annealing-Simple genetic algorithm--Comparison of Genetic algorithm with other optimization techniques-Genetic algorithm at work simulation by hands-Data structures-Application of Genetic algorithm-Advantages and limitation of Genetic algorithm	
Unit-5 - Ga Operators and Biomedical Applications	***9 Hour***
Genetic operators:-Reproduction, Crossover-Mutation, Replacement-Fitness form-Scaling-Population-Data structure-Encoding: Binary , Octal,-Encoding: Hexadecimal-Encoding: Permutation-Encoding: Value and Tree- Handwritten numerical recognition- ECG signal classification using neural network-EMG pattern recognition-Breast cancer detection	

Learning Resources	1. LaureneFausett, "Fundamentals of Neural Networks: Architectures, Algorithms, andApplications", 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 (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	20%	-	10%	-	10%	-
Level 2	Understand	20%	-	10%	-	10%	-
Level 3	Apply	30%	-	30%	-	30%	-
Level 4	Analyze	30%	-	30%	-	30%	-
Level 5	Evaluate	-	-	10%	-	10%	-
Level 6	Create	-	-	10%	-	10%	-
	Total	100 %		100 %		100 %	

Course Designers

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

Course Code	21BME465T	Course Name	WEARABLE SYSTEMS AND MOBILE HEALTH CARE	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*Understand technical information and challenges in WBAN.*
CLR-2:	*Recognize the hardware requirements of BAN*
CLR-3:	*Review the wearable sensors and standards for BAN*
CLR-4:	*Identify the mobile devices that is available for health care*
CLR-5:	*Appreciate the possible and latest applications of mobile and context-aware healthcare*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*Outline the BAN challenges*	-	*1*	*1*	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*Indicate the hardware necessary for BAN*	*1*	-	-	*2*	-	-	-	-	-	-	-	-	*1*	-	-
CO-3:	*Illustrate the various wearable sensors*	-	*1*	*2*	-	-	-	-	-	-	-	-	-	*1*	*1*	-
CO-4:	*Categorize the mobile devices available for healthcare*	*1*	-	-	-	*2*	-	-	-	-	-	-	-	-	-	*1*
CO-5:	*Interpret the latest applications and research opportunities with mobile and context-aware healthcare.*	1	-	-	*2*	*3*	*1*	-	-	-	-	-	-	-	*1*	*2*

Unit-1 - Basics of BAN **9 Hour**

Need for wireless monitoring, Body area network (BAN) -Definition-Terminologies used with BAN-Technical Challenges-Sensor design concepts-Types of sensors-Biocompatibility issues-Energy Requirements-Energy supply-Nodes-Optimal node placement in BAN-System security-System Reliability-BAN Standards-BAN with other standards-BAN Architecture-BAN and other technologies-BAN and Healthcare

Unit-2 - Hardware Requirement for BAN **9 Hour**

Processor in BAN-Low Power MCUs-Mobile Computing MCU-Integrated processor-Radio transceiver along with the processor-Antenna for BAN-Antenna Requirements-Antenna Considerations-antenna design for in body and on body applications- Types of antenna-Wire -Ceramic External antenna-Sensor Interface-Considerations on the interface-Power sources- Batteries-Fuel cells for sensor nodes.-Other novel power sources

Unit-3 - Wireless Communication with BAN **9 Hour**

RF communication in and around the body-Antennal Design-Antenna testing-Propagation issues-Base Station considerations-Network topology-Stand – Alone BAN-Wireless personal Area Network-Wireless personal Area Network Technologies-IEEE 802.15.1-IEEE P802.15.13-IEEE 702.15.14-Zigbee-BAN and Wireless BAN (WBAN) technologies-Limitations in use-Coexistence issues with BAN-Other practical considerations

Unit-4 - Application of WBAN **9 Hour**

Medical Diagnostics applications, Multi parameter monitoring, , Smart Fabrics Sensors for wearable system-Wearable system design for specific applications-Wearable system for ECG monitoring- EEG monitoring- - Gait analysis-Evaluation of general and night time - performance-Evaluation parameters-Latest health monitoring methods-Smart phone based health care monitoring system-Phone based fall risk prediction-Emergency alerts-RFID based personal mobile medical assistance-Infusing image processing capabilities-Secure medical sensor network - Diagnostic applications-Therapeutic applications

Unit-5 - WBAN Application in Healthcare **9 Hour**

Mobile health technologies-Mobile nutrition tracking-Accessing existing virtual electronic patient record-Mobile personal health records,-Monitoring hospital patients-Sensing vital signs-Transmission using wireless networks-Continuous monitoring-Patient Monitoring and wearable devices-Patient Monitoring in Diverse Environments-A framework for Capturing Patient Consent in Pervasive Healthcare Applications-M-health application-Context aware sensing-Technology Enablers for context-Aware-healthcare Applications-Multichannel neural recording system-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 Informationscience 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 andhealthcare", Secon International ICST conference, Mobihealth 2011, Springers 2011.* 7. *Ullah, Sana, Et at, " A review of wireless body area networks for medicalapplications", 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 (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	*20%*	-	*10%*	-	*10%*	-
Level 2	*Understand*	*20%*	-	*10%*	-	*10%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	*10%*	-
Level 6	*Create*	-	-	*10%*	-	*10%*	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

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

Course Code	21BME466T	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:***
CLR-1:	*Define the basics of Artificial Intelligence and its principles*
CLR-2:	*Write 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:	*Evaluate the role of artificial intelligence in healthcare applications*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*Describe the basic principles of AI towards problem solving*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*Express the various search techniques in problem solving*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*Implement the techniques in knowledge representation*	-	-	*2*		*2*	-	-	-	-	-	-	-	*2*		*1*
CO-4:	*Analyze the role of machine learning in healthcare applications*	-	-		*2*	*2*	-	-	-	-	-	-	-	-	-	-
CO-5:	*Construct the AI algorithms for various healthcare applications to solve problems*	*2*	-	*2*	-	*2*	-	-	-	-	-	-	-	*2*		*1*

Unit-1 - Principles of Artificial Intelligence ***9 Hour***

Artificial Intelligence -introduction and definition-Turing Test approach-Intelligent agents-Structure of intelligent agents, Agent programs, example-Simple reflex agents-Goal based agents-Utility based agents-Environment programs-Problem solving-problem solving agents-Formulating problems,-Well defined problems and solutions-Example-Toy problems, travelling salesman-problem-Searching solutions-Data structures for search trees-Search Strategies-breadth first, Uniform cost search-Depth first search-Iterative search-Bidirectional search

Unit-2 - Search Techniques ***9 Hour***

Informed search methods-Best first search-Greedy search-A search-behavior-Heuristic functions-Heuristics for constraint satisfaction problem-Iterative deepening A* search (IDA*)-Simplified Memory Bounded A* search-Hill-climbing search-Simulated annealing-Applications in constraint satisfaction problems-Knowledge and reasoning-Knowledge based agent-Representation reasoning and logic-Semantics, Inference-Propositional logic-Syntax, semantics-Validity and inference*

Unit-3 - Knowledge Representation ***9 Hour***

First order logic-syntax and semantics-Symbols, terms, sentences-Quantifiers, equality-Extensions-notational variations-Higher order logic, A-expression-Using first order logic-kinship domain-Axioms, definitions and theorems-Domain of sets-special notations for sets, lists and arithmetic-Logical agents for Wumpus world-Simple reflex agent-limitations-Representing change in the world-situation calculus-Frame problem and its relatives-Deducing hidden properties of the world- Knowledge engineering – introduction-Knowledge engineering and programing

Unit-4 - Machine Learning in Healthcare ***9 Hour***

Data Preparation, Feature Cleaning-Feature Engineering, Feature Transformation-Feature Extraction, Feature Selection-Machine learning models-Machine learning categories-Machine Learning Challenges-Machine Learning Tools-Patient centric Machine learning model-Pre-processing of data, Results and discussions-Machine Learning Models to Classify Healthcare Data-Exploratory Data Analysis-supervised and- unsupervised approaches-Types of Unsupervised Learning-Clustering-Clustering Algorithms-K-Means Algorithm-Density Based Clustering - Natural language Processing

Unit-5 - Machine Learning – Applications in Healthcare	**9 Hour**
Healthcare Survey Dataset with-Unsupervised Learning-Feature selection using the Particle swam optimization (PSO) -Disease Detection System (DDS) Using Machine Learning Technique-System Implementation and Disease Detection Methodology-Architecture of DDS-Use Case Diagram of DDS-Simulation for Result-Deep learning solutions for skin cancer detection-Convolution neural network, methods, dataset-Data augmentation,-Network architecture, performance metrics-Security of Healthcare Systems-with Smart Health Records Using Cloud Technology-Cloud Computing in Healthcare-Cloud Service Models-Deployment Models in Cloud Computing-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 (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*10%*	-	*10%*	-
Level 2	*Understand*	*20%*	-	*10%*	-	*10%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	*10%*	-
Level 6	*Create*	-	-	*10%*	-	*10%*	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

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

Course Code	21BME467T	Course Name	BIO INSPIRED ROBOTICS	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:	*Explain the basic about bio inspired robots*
CLR-2:	*Illustrates the concept of musculoskeletal movements*
CLR-3:	*Apply the basics of postural balances in home based rehabilitation*
CLR-4:	*Design the assistive and rehabilitation robotics*
CLR-5:	*Interpret about the biomechanical modeling and stability analysis*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1 Engineering Knowledge	2 Problem Analysis	3 Design/development of solutions	4 Conduct investigations of complex problems	5 Modern Tool Usage	6 The engineer and society	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*Apply the basic concepts of bio inspired robotics to choose sensors*	*2*	-	-	-	*1*	-	-	-	-	-	-	-	-	-	-
CO-2:	*Analyze the biomechanics and human robot interface*	*2*	-	-	-	*1*	-	-	-	-	-	-	-	*2*	-	-
CO-3:	*Identify the problems in Based postural balance rehabilitation and methods to be adapted*	*2*	*2*	-	-	-	-	-	-	-	-	-	-	*2*		-
CO-4:	*Outline the importance of noninvasive BMI*	*2*	-	*3*	-	-	-	-	-	-	-	-	*2*	-	*2*	-
CO-5:	*Describe the concept of physiological modeling associated with assistive robots*	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-	-	-

Unit-1 - Introduction to Bio Inspired Robots	***9 Hour***
Introduction to Bio-inspired Robotics--Principles of Biomechanics-Basic Features-What is a biologically Inspired Robotic System, and its advantages and disadvantages - Mobility systems Requirements-legs-swimming-flying system-Sensors-Characteristics of Sensors-tactile,-vision-electronic nose-Evolution of Bio Inspired Robot	
Unit-2 - A Review of Computational Musculoskeletal Analysis of Human Lower Extremities	***9 Hour***
Introduction to Musculoskeletal Analysis- Human walking Gait cycle-Biomechanics of Normal human walking-Quantitative Human Walking Models- Computational Musculoskeletal Analysis Interaction with articulated systems-EMG motion classification-Task modeling for human interfaces-An EMG –controlled Human Robot Interface using Task modelling-Modeling of joint stiffness	
Unit-3 - Personalized Modeling for Home –Based Postural Balance Rehabilitation	***9 Hour***
Introduction- Home Based postural balance rehabilitation-Body segment parameters-Estimating center of mass position for human subjects- Various Methods for balance rehabilitation-Dynamic Model-Dynamic Optimization-Body motion sensing- -Strain-Sensitive conductive polymers	
Unit-4 - Non Invasive Brain Machine Interfaces for Assistive and Rehabilitation Robotics	***9 Hour***
Introduction to brain machine interfaces-BMI for assistive robotics- BMI for rehabilitation robotics-Kalman Filter Implementation-Challenges in exoskeleton design-Biomechanical modeling-Development of HRI model-Design examples-Stability analysis	
Unit-5 - Psychological Modeling of Humans By Assistive Robots	***9 Hour***
Introduction- Dimensions of Human characterization-Constructing behavioral models for HRI-Economic decision-making models- Interfering psychological models-Haptic stability-Human operator Modeling-Haptic assist control-System validation and experimental evaluation	

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 Roboticsand Autonomous Agents series) by Dario Floreano*

Learning Assessment

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

Course Designers

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

Course Code	21BME468T	Course Name	COMPUTATIONAL TOOLS IN BIOENGINEERING AND BIOMEDICINE	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*Analyze the basic concepts of computational tools in bioengineering and biomedicine*
CLR-2:	*Enumerate information about the concept of aortic dissection*
CLR-3:	*Summarize the mechanistic approach to analysis antioxidant action*
CLR-4:	*Identify the idea about Radical adduct formation (RAF) mechanism*
CLR-5:	*Apply the knowledge about the coupling algorithms on cochlear mechanics*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*Identify the need for computational tools in the field of bioengineering and biomedicine*	*3*	-	-	-	-	-	-	-	-	-	-	*2*	-	-	*1*
CO-2:	*Explain thorough understanding of basic equations of fluid flow and solid motion*	*3*	-	-	-	-	-	-	-	-	-	-	*2*	*1*	-	-
CO-3:	*Analyze the basics of antiradical mechanisms in the presence of different free radicals*	-	-	-	*2*	-	-	-	-	-	-	-	*1*	*1*	-	-
CO-4:	*Indicate the importance of radical adduct formation mechanism*	*2*	-	-	-	-	-	-	-	-	-	-	*1*	-	*2*	-
CO-5:	*Apply the knowledge on the model of cochlea including feedforward and feedbackward forces*	-	-	-	*2*	-	-	-	-	-	-	-	*2*	-	-	*1*

Unit-1 - Need for Computational Tools	***9 Hour***
Elements of computational tools-Elements of mathematical modeling-Elements of physics-The rational continuum -mechanics approach to matter in motion-Balance laws in integral form-Balance laws in integral form- Balance laws in local form-Continuum approach for -multicomponent mixtures-Constitutive relations for fluids- Constitutive relations for solids-Constitutive relations for electromagnetism and electrodynamics	
Unit-2 - Computational Approach in Aortic Dissection	***9 Hour***
Diagnostic techniques of acute aortic dissection-Treatment of acute aortic dissection-Basic equations of fluid flow-Basic equations of solid motion-Solid fluid interaction-Concept of aortic dissection-Need for 3D reconstruction- -Need for geometric 3D modeling	
Unit-3 - Computational Approach in Antioxidative Mechanisms	***9 Hour***
Prevention of oxidative stress-Characteristics of good antioxidants-The proposed reaction mechanisms-Mechanistic approach-Thermodynamical parameters for quercetin and gallic acid-Antiradical mechanisms in the presence of-different free radicals-Mechanistic approach to analyze antioxidant action-Radical adduct formation (RAF) mechanism	
Unit-4 - Computational Approach in Cochlear Mechanics	***9 Hour***
Cochlear mechanics-Concepts of modeling-Solid model-Fluid model-Loose coupling algorithm--Strong coupling algorithm-Need for finite element modeling of cochlea-Basic criteria for finite element modeling of-cochlea- Concept of finite element modeling of cochlea-Finite element models of cochlea-Model of cochlea including feedforward and feedbackward forces	
Unit-5 - Advanced Computational Approach	***9 Hour***
Functional Spaces and Functional Inequalities-Metric Spaces-Complete Metric Spaces-Normed Spaces-Banach Spaces-Hilbert Spaces-Hilbert Spaces-The Nonlinear Differential Model System-Time Semidiscretization- Block Nonlinear Jacobi and Gauss–Seidel-Iterations-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 (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*10%*	-	*10%*	-
Level 2	*Understand*	*20%*	-	*10%*	-	*10%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	*10%*	-
Level 6	*Create*	-	-	*10%*	-	*10%*	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

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

Course Code	21BME469T	Course Name	NEURO REHABILITATION AND HUMAN MACHINE INTERFACE	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*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:	*Understanding the usage of Human machine Interface in translational research*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of	Modern Tool Usage	The engineer and	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*Explain cellular and molecular mechanisms of neural plasticity*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*Demonstrate Functional Plasticity in the Central Nervous System*	*2*	-	*1*	*1*	-	-	-	-	-	-	-	-	*2*	-	-
CO-3:	*Describe the Regeneration in the Injured Nervous System*	*3*	-	*2*	*2*	-	-	-	-	-	-	-	-	*2*	-	-
CO-4:	*Predict future perspective of human machine interface (HMI)*	*3*	-	*2*	*2*	-	-	-	-	-	-	-	*3*	-	*2*	-
CO-5:	*List out the application of Human machine interface in translational research*	*3*	-	*2*	*2-*	-	-	-	-	-	-	-	*2*	*2*	-	-

Unit-1 - Neural Plasticity: Cellular and Molecular Mechanisms	***9 Hour***
Learning and memory: basic principles and model systems -Cellular and molecular mechanisms of associative and nonassociative learning- -Degenerative changes and reactive growth responses of-neurons following denervation and axotomy-Contemporary issue and theories of motor control learning.-Limbic system influence over motor control and learning--Learning of damaged brain/spinal cord neuroplasticity- -Movement neuroscience foundation ofneurorehabilitation-Sensor-motor interaction and error Augmentation-Augmentation-Physiological aspect of adaptation and adjustment during various phase of neurological Disability	
Unit-2 - Functional Plasticity in The Central Nervous System	***9 Hour***
Plasticity of mature and developing somatosensory systems-Activity-dependent plasticity in the intact spinal cord-Plasticity of cerebral motor functions:-Implications for repair and rehabilitation- Plasticity in visual connection retinal ganglion cell axonal development and regeneration-Plasticity in auditory function cross model plasticity in visual system	
Unit-3 - Determination of Regeneration in The Injured Nervous System	***9 Hour***
Non-mammalian models of nerve regeneration-Myelin-associated axon growth inhibitors,-Inhibitors of axonal regeneration- Role of the inflammatory response in central nervous system-injury and regeneration--Sensor-motor interaction and error augmentation- Limbic system influence on motor control and learning-Normal and impaired cooperative hand movement role of neural coupling-Physiological aspect of adaptation and adjustment during various phase of neurological Disability-Multisystem neurorehabilitation in rodents with spinal cord injury	
Unit-4 - Ambient Intelligence and Ubiquitous Computing Scenario	***9 Hour***
The advanced human machine interface (HMI) framework-The advanced human machine interface (HMI) framework -Human machine interface systems – structure, protocols,- Human machine interface systems – applications- Human machine interface systems – applications- The next-generation advanced HMI 2-A future perspective for next-generation HMI: fNIRS-EEG- Multi-Modal HMI-Multi-Modal HMI.	

Unit-5 - Translational Research: Application in Human Machine Interface	***9 Hour***
Application uses in robotics -Robotics and wearable technology for measurement--Clinical application of robotics and technology in restoration of walking-Clinical application of robotics and technology in children undergoing neurorehablitation-Biomimetic design of neural prosthesis Brain responses to neural prosthesis-Intracranial human machine interfaces for communication and control-Understanding motor recovery and-compensation in neurorehabilitation	

Learning Resources	1 *Michael E. Seizer, Stephanie Clarke, Lenardo G. Cohen. GertKwakkel, Robert H. Miller., "Textbook of Neural repair and rehabilitation", Volume 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 *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*	6 *Surjo R. Soekadar, NielsBirbaumer, Marc W. Slutzky, Leonardo G. Cohen., "Brain-machine interfaces in neurorehabilitation of stroke', Neurobiology of disease, 2015.* 7 *F. Nijboer, "Technology transfer of brain-computer interfaces as assistive technology: Barriers and opportunities", Annals of physical and Rehabilitation Medicine, 2015.* 8 *U.Chaudhary, N. Birbaumer, M.R.Curado., "Brain-machine interface (BMI) inparalysis", Annals of physical and rehabilitation medicine, 2015.* 9 *D.D. Franks and J.H. Turner., "Handbook of Neurosociology", Springer, 1stedition, 2013.* 10 *Jose L Pons, Diego Torricelli, Marta Pajaro., "Converging clinical andengineering research on neurorehabilitation", Springer, 1stedition, 2013.*

Learning Assessment

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

Course Designers

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

Course Code	21BME470T	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:***
CLR-1:	*Use the universal principles and human factors for Augmentative and alternative communication and assistive technology*
CLR-2:	*Apply the assistive technology tools for deafness and hearing impairments*
CLR-3:	*Compile the assistive technology tools for visual and dual sensory impairments*
CLR-4:	*Utilize the idea about the low and high technology tools for various disabilities*
CLR-5:	*Write an overall idea about the various assistive technology tools for mobility, seating and daily living*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*Incorporate the basic principles and human factors for person with disabilities*	*2*	*2*	-	-	-	-	-	-	-	-	-	-	*1*	*1*	*2*
CO-2:	*Analyze the assistive technology tools and its usage in hearing impairments persons*	*2*	-	-	-	-	-	*1*	-	-	-	-	-	*1*	-	-
CO-3:	*Evaluate the assistive technology tools and its usage in visual and sensory impairments persons*	-	*2*	-	-	*1*	-	-	-	-	-	-	-	*1*	*1*	-
CO-4:	*Demonstrate the utilization of low and high technology tools in various disability conditions*	-	-	*2*	-	-	-	-	-	-	-	-	*2*	-	*1*	*2*
CO-5:	*Construct a basic assistive technology tools for activities of daily living and mobility*	-	-	*2*	-	-	-	-	-	-	-	-	*2*	-	*1*	*2*

Unit-1 - Universal Principles and Human Factors	***9 Hour***
Augmentative and alternative communication (AAC) and Assistive technology (AT) software-Evaluation of AAC and AT software-Technical and user considerations-Quality resources on AAC and AT-Universal principles in AAC and AT-Evidence based practice in AT-Human factors in evaluation of AT-Environmental and social factors-Psychological factors influencing the use of technology-Sensory and Motor factors-Low technology :Communication displays-Object communication displays, Communication Boards-Principles of high technology assistive devices-Picture exchange communication system-Issues and considerations for low and high tech tools	
Unit-2 - Assistive Technology for Communication, Deafness and Hearing Impairments	***9 Hour***
Hearing functional assessment-Surgical and non-surgical hearing aids-Devices to improve hearing-Implants: Cochlear implant-Bone anchored hearing aids-Assistive listening devices-Electronic communication aids-Analog and digital recorders-Assistive listening devices-Devices to improve communication Design constraints in designing Adapted mouse-Smart pen- technology-Keyboard variations for differently abled-Modifying existing technology-Voice recognition and word prediction software-Communication devices-Smart phones, Cell phones and videophones	
Unit-3 - Assistive Technology for Visual And Dual Sensory Impairments and Daily Living	***9 Hour***
Anatomy of eye, Image formations in eye-Categories of visual impairment-Artificial vision implants-Cortical and retinal implants-External visual devices-Low and High technology to improve mobility-Electronic Travel Aids(ETA)-Low and High technology for reading and writing-Auditory information display-AT for dual sensory impairments-AT for leisure and recreation-Activities of daily living (ADL)-Daily living aids-AT in Home-Alternative devices for safety-Orientation & navigation Aids-Alert systems	
Unit-4 - Augmentative Technology for Prosthetic and Orthopedics	***9 Hour***
Anatomy of upper & lower extremities-Classification of amputation types-Prosthesis prescription-Hand and arm replacement-Different types of models-externally powered limb prosthesis-Foot orthosis-Pediatric orthosis-Wrist-hand orthosis-feedback in orthotic system- Lower extremity- and upper extremity- orthosis - Components of upper limb prosthesis-Components of lower limb prosthesis-Intelligent prosthesis-functional electrical stimulation-Electric Electronic Stimulation-Fuzzy logic expert system for automatic tuning of myoelectric prostheses-Fuzzy logic expert system for automatic tuning of myoelectric prostheses	

Unit-5 - Technology For Mobility, Seating And Daily Living	***9 Hour***
Basic assessment and evaluation for mobility-Mobility devices-Wheel chair :seating assessment-Interventions in seating system-Biological aspects of tissue health-Support surface classification-Optimum seated posture-Types of wheelchairs : Manual wheel chairs-Power wheelchairs-Power assisted wheelchairs-Control systems, navigation in virtual space by wheelchairs-EOG based voice controlled wheelchair-BCI based wheelchair-Wheel chair standards & tests-Wheel chair transportation-Mobility device Accessories	

Learning Resources	1. *Oliver Wendt, Raymond W Quist, Lyle L Lloyd, "Assistive Technology: Principles andApplications for Communication Disorders and Special Education", Emerald group publishing Ltd, 1st Edition, 2011.* 2. *Albert Cook, Janice Polgar, "Assistive Technologies -Principles and Practice", Mosby, 4thEdition, 2015.* 3. *Rory A, Cooper, Hisaichi Ohnabe, Douglas A, Hodson, "An Introduction to RehabilitationEngineering", 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 (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*10%*	-	*10%*	-
Level 2	*Understand*	*20%*	-	*10%*	-	*10%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	*10%*	-
Level 6	*Create*	-	-	*10%*	-	*10%*	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

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

Course Code	21BME471T	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	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biomedical Engineering*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*Compile gist of the applications of machine learning and types of learning algorithms*
CLR-2:	*Explain about the parametric model of classification*
CLR-3:	*Express knowledge in multivariate data handling and clustering methods*
CLR-4:	*Demonstrate the techniques to compare and assess the learning algorithms*
CLR-5:	*Apply deep learning techniques in biomedical field*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*Implement various types of learning algorithm*	*2*	-	*1*	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*Incorporate learning in different parametric models*	*2*	-	*1*	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-3:	*Evaluate different techniques of multivariate data analysis and clustering techniques*	-	*2*	*2*	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-4:	*Analyze the performance of different machine learning algorithms*	-	-	*3*	-	-	-	-	-	-	-	-	*2*	-	*2*	-
CO-5:	*Apply the machine and deep learning algorithms for concept related to image analysis*	-	-	-	*2*	*1*	-	-	-	-	-	-	*2*	-	-	-

Unit-1 - Machine Learning – Introduction	***9 Hour***
Bayesian decision theory , Classification-Bias and Variance-Bayes' Estimator-Losses and risks-Discriminant Functions-Utility Theory-Value of information-Bayesian networks-Influence Diagrams-Association Rules-Machine learning applications-learning -associations,-classification, regression,-unsupervised learning, reinforcement learning-Supervised learning-examples-Regression, Noise, learning multiple classes-Probably Approximately Correct (PAC)-learning-Vapnik–Chervonenkis (VC) dimension Exercises	
Unit-2 - : Parametric Models and Multivariate Methods	***9 Hour***
Parametric Methods-Maximum Likelihood Estimation-Bernoulli Density-Multinomial Density-Parametric Classification-Regression-Bias/Variance-Model Selection Procedures-Validation techniques , Minimum length description, Bayesian model selection-Multivariate Data-Parameter Estimation-Estimation of Missing Values-Multivariate Methods- Multivariate Data-Parameter Estimation-Principal Components Analysis-Eigen faces and Eigen digits-reconstruction error-Karhunen-Loève expansion-Multidimensional scaling, Linear discriminant Analysis	
Unit-3 - Unsupervised Learning	***9 Hour***
Clustering-Mixture Densities-k-Means Clustering-vector quantization-leader cluster algorithm-Maximization Algorithm-Mixtures of Latent Variable Models-Supervised Learning after Clustering-Hierarchical Clustering-Choosing the Number of Clusters-Nonparametric Methods-Instance-based memory-based learning-Nonparametric Density Estimation-Kernel Estimator-k-Nearest Neighbor Estimator-Generalization to Multivariate Data-Nonparametric Classification	
Unit-4 - Machine Learning Experiments	***9 Hour***
Design and Analysis of Machine Learning Experiments-cost-sensitive learning- strategies of experimentation-factorial design-Response Surface Design-Randomization, replication, blocking, pairing-Guidelines for Machine Learning Experiments-Choice of Factors and Levels-Choice of Experimental Design, Performing the Experiment-Statistical Analysis of the Data-Cross-Validation and Resampling Methods-K-Fold Cross-Validation-5×2 Cross-Validation-Bootstrapping-Measuring Classifier –Performance-Interval Estimation-Comparing Multiple Algorithms	

Unit-5 - Deep Learning Application	***9 Hour***
Regularization, Normalizing inputs-Weight Initialization for Deep Networks-Numerical approximation of gradients-Gradient checking, Gradient Checking Implementation-Mini-batch gradient descent-Exponentially weighted averages-Classical Supervised -Tasks with Deep Learning-Brain MRI Age Classification-Image Denoising-Analysis of medical images-Automatic Interpretation of Carotid Thickness- -3-D Brain Tumor Segmentation-Convolutional NN for Real time 2D/3D Registration	

Learning Resources	1. *Tony J. Cleophas and Aeilko H. Zwinderman, "Machine Learning in Medicine - aComplete Overview", Springer,2015* 2. *Sunila Gollapudi, S. , "Practical Machine Learning", Packt Publishing Ltd.2016 Applied Deep Learning:* 3. *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 (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*10%*	-	*10%*	-
Level 2	*Understand*	*20%*	-	*10%*	-	*10%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	*10%*	-
Level 6	*Create*	-	-	*10%*	-	*10%*	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

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

Course Code	21BME472T	Course Name	VIRTUAL REALITY 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:***
CLR-1:	*Demonstrate the sensors in virtual reality systems*
CLR-2:	*Write the techniques in image creation*
CLR-3:	*Implement the techniques in image manipulation and viewing*
CLR-4:	*Compile knowledge in techniques involved in haptics*
CLR-5:	*Incorporate the various input sensors, visual and auditory aspects of virtual reality systems*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*State the terms related to and the various input sensors used in VR*	*3*	-	*1*	*2*	-	-	-	-	-	-	-	-	*2*	-	-
CO-2:	*Explain the visual aspects of VR systems*	*3*	-	*1*	*2*	-	-	-	-	-	-	-	-	*2*	-	-
CO-3:	*Demonstrate the various techniques for image creation and manipulation*	*3*	*1*	-	*2*	-	-	-	-	-	-	-	-	*2*	*1*	-
CO-4:	*Illustrate the various haptic sensors and techniques used in VR*	*3*	-	*1*	*2*	-	-	-	-	-	-	-	-	*2*	-	-
CO-5:	*Apply various components of Virtuality reality systems*	*1*	-	*3*	*2*	-	-	-	-	-	-	-	-	*2*	-	-

Unit-1 - Input Periphery	***9 Hour***
Definition of Virtual Reality (VR)-Presence and Immersion, Need for training in medicine-Principles of VR - Main components-Problems in VR-Human Actuators , Input Modalities-Position and movement recording-Resistive sensors, Capacitive sensors-Inductive sensors, Ultrasound and optical methods-Position and movement measuring systems-Desktop systems, body mounted –systems-Contact free and remote systems-Eye tracking systems- Force and torque recording-Sound and speech recording-Force and torque recording-Sound and speech recording	
Unit-2 - Visual Aspects- I	***9 Hour***
Computer graphics, building blocks-Visual sense and perception-Human eye, photoreceptors, color vision-RGB color space, liquid crystal display-color spaces, subtractive model-HSV color –space-Depth Perception, monocular cues-Oculomotor cues,-binocular cues-Visual Display technology-Stereoscopic rendering-Display hardware-Virtual reality displays-Cave Automatic Virtual –Environment-Head mounted displays-Rendering in computer graphics-Object representations-Geometry transformations (basics)	
Unit-3 - Visual Aspects – II	***9 Hour***
Light Sources and Reflection-Point light, directional light, spot light-Ambient light, diffuse reflection, specular-reflection,-Viewing projections-Image projection in the thin lens camera model-Depth of field in thin lens camera model-Projection in pinhole camera-Early depiction of a Camera Obscura-Perspective projection-2D mapping-in the yz-plane-Orthographic projection-Orthographic projection onto image plane-Surface Shading-Flat Shading-Gouraud Shading-Phong Shading-Advanced Rendering Techniques, Ray Tracing-Radiosity, Visual Displays in Medical VR	
Unit-4 - Haptic Aspects	***9 Hour***
Haptic sense and perception-Tactile receptors,-Kinesthetic receptors,-Psychophysics-Haptic Display Technology-Kinematic principles, serial and parallel-Actuation principles-Shape memory alloys-Electroactive Polymers- Piezoelectric Actuators-Control Principles of Haptic Displays-Terminology-Admittance and Impedance Control Architectures-Stability, Passivity and safety of Haptic Displays-Ground- and Wall-Mounted Systems-Tactile and Portable systems-Haptic Rendering-Penalty method, Haptic Displays in Medical VR	

Unit-5 - Auditory Aspects and Applications	***9 Hour***
Auditory Sense and Perception-interaural level differences-Design of Auditory Displays-Headphones-Mono, Stereo, and Surround Loudspeaker Systems-Auditory Rendering, Virtual Reality for Rehabilitation-Virtual Reality Supported Physiotherapy-Gait Rehabilitation,-Robot-Assisted Gait Training-Motivation for Robot Aided Arm Therapy, Virtual Reality Applications with ARM in-Wheelchair Mobility and Functional ADL Training-VR Based surgical simulator and its components-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 ScienceReference, 2017*	3. *Lynne Edgar, "Virtual Reality: Future of Health Care", iUniverse, 2003.* 4. *James Roland, "Virtual Reality and Medicine", Reference Point Press, Incorporated, 2018.*

Learning Assessment

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

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Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
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SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

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