B. Tech in Biomedical Engineering

2018 Regulations

Professional Core Courses (C)

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

Course Code	18BTC205J	Course Name	PATHOLOGY AND MICROBIOLOGY	Course Category	C	Professional Core	L	T	P	C
							3	0	2	4

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning			Program Learning Outcomes (PLO)														
CLR-1 :	Understand the structural and functional aspects of living organisms	1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-2 :	Understand the concept of cellular response during pathogenesis	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design,	Modern Tool Usage	Society & Culture	Environment &	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLR-3 :	Illustrate microbial infections and their lifecycle																		
CLR-4 :	Apply the classical and modern methods of diagnosing diseases																		
CLR-5 :	Analyze the various tissue processing techniques																		
CLR-6 :	Analyze the various antimicrobial drugs																		
Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:																		
CLO-1 :	Discuss on the basic concepts of cells and immune system	1, 2	80%	70%												H			
CLO-2 :	Describe cellular changes during pathogenesis	2	80%	70%				M								H			
CLO-3 :	Explain the lifecycle of various microbial pathogens	2	80%	70%												H	M		L
CLO-4 :	Explain the application of microscopes in diagnosing various microorganisms	3	80%	70%					M							H			
CLO-5 :	Discuss various methods and stains used in histopathological analysis	3	80%	70%					H							H	M		L
CLO-6 :	Discuss the methods of treatment in microbial infections	3	80%	70%				M								H			

		Celld and immunity of mammals	Cellular responses during pathogenesis	Clinical Microbiology	Diagnostic pathology	Infection control and prevention
Duration (hour)		15	15	15	15	15
S-1	SLO-1	Cell structure	Host pathogen interactions – Route of entry	Microbial pathogens – Types, Life cycle	Microscopy	General characters of antimicrobial drugs
	SLO-2	Cytoskeleton	Immune evasion by microbes	Gram positive bacterial pathogens	Light (Bright field & Dark field)	Determining the level of antimicrobial activity
S-2	SLO-1	Structure and function of Cell Membrane	Host damage	Gram negative bacterial pathogens	Phase contrast and Fluorescent microscopy	Antibacterial drugs
	SLO-2	Structure and function of endoplasmic reticulum	PAMS, MAMS	Mycobacterial infections	Electron microscopy	Anti fungal drugs
S-3	SLO-1	Structure and function of Ribosomes	Microbial secretory systems	Spirochetes	Histopathology	Anti protozoan drugs
	SLO-2	Structure and function of Lysosomes	PRR and signalling	Anaerobic infections	Autopsy pathology	Antiviral drugs
S-4	SLO-1	Lab1: Identification of instruments and culture media preparation	Lab4: Differential Leukocyte count	Lab 7: Differential staining (Spore, AFB)	Lab 10: Fungal pathogen detection by lactophenol cotton blue	Lab 13: antibiotic sensitivity test by Kirby-Bauer method
	SLO-2	Lab1: Identification of instruments and culture media preparation	Lab4: Differential Leukocyte count	Lab 7: Differential staining (Spore, AFB)	Lab 10: Fungal pathogen detection by lactophenol cotton blue	Lab 13: antibiotic sensitivity test by Kirby-Bauer method
S-5	SLO-1	Lab1: Identification of instruments and culture media preparation	Lab4: Differential Leukocyte count	Lab 7: Differential staining (Spore, AFB)	Lab 10: Fungal pathogen detection by lactophenol cotton blue	Lab 13: antibiotic sensitivity test by Kirby-Bauer method
	SLO-2	Lab1: Identification of instruments and culture media preparation	Lab4: Differential Leukocyte count	Lab 7: Differential staining (Spore, AFB)	Lab 10: Fungal pathogen detection by lactophenol cotton blue	Lab 13: antibiotic sensitivity test by Kirby-Bauer method
S-6	SLO-1	Structure and function of mitochondria	Cellular responses to stress - Hypertrophy	Obligate intracellular bacteria	Surgical pathology	Increase the immune system of host
	SLO-2	Structure and function of nucleus	Metaplasia, Neoplasia	Fungal infections	Enzyme histochemistry	Vaccines – preparation & dosage
S-7	SLO-1	Cell –cell interactions	Hypersensitivity reactions	Yeast infections	Histokinates	Live vaccines
	SLO-2	Gap junctions	Hypersensitivity reactions	Diseases caused by molds	Block making	Attenuated vaccines
S-8	SLO-1	Tight junctions, Desmosomes	Cell injury and death	Dimorphic fungi	Microtomes & Knives	Whole cell vaccines
	SLO-2	Extra cellular matrix	Inflammation (Acute & Chronic)	Parasitic infections	Cryostat	Subunit vaccines

S-9	SLO-1	*Lab2: Microscopic observation of prokaryotes and eukaryotes*	*Lab5: Peripheral blood smear test*	*Lab 8: Diagnosis of aerobic bacteria by RPR test*	*Lab 11: Detection of Candida albicans*	*Lab 14: Demonstration of ELISA based detection of pathogens*
	SLO-2	*Lab2: Microscopic observation of prokaryotes and eukaryotes*	*Lab5: Peripheral blood smear test*	*Lab 8: Diagnosis of aerobic bacteria by RPR test*	*Lab 11: Detection of Candida albicans*	*Lab 14: Demonstration of ELISA based detection of pathogens*
S-10	SLO-1	*Lab2: Microscopic observation of prokaryotes and eukaryotes*	*Lab5: Peripheral blood smear test*	*Lab 8: Diagnosis of aerobic bacteria by RPR test*	*Lab 11: Detection of Candida albicans*	*Lab 14: Demonstration of ELISA based detection of pathogens*
	SLO-2	*Lab2: Microscopic observation of prokaryotes and eukaryotes*	*Lab5: Peripheral blood smear test*	*Lab 8: Diagnosis of aerobic bacteria by RPR test*	*Lab 11: Detection of Candida albicans*	*Lab 14: Demonstration of ELISA based detection of pathogens*
S-11	SLO-1	*Cell signaling pathways*	*Apoptosis*	*Protozoan diseases*	*Staining*	*Peptide based therapies*
	SLO-2	*GPCR and Tyrosine kinase pathway*	*Causes and biochemical changes of apoptosis*	*Protozoan diseases*	*Fat, iron & FAS stains*	*Antimicrobial peptides*
S-12	SLO-1	*Signal Transduction*	*Autophagy*	*Metazoan diseases*	*ELISA*	*Types and therapeutic potential of AMPs*
	SLO-2	*Cell growth factors – EGF*	*Intracellular accumulations of autophagy*	*Metazoan diseases*	*Western blotting*	*Prevention of infections*
S-13	SLO-1	*Hepatocyte growth factors*	*Immunodeficiency syndrome*	*DNA virus*	*PCR*	*Maintaining the hygiene*
	SLO-2	*VEGF, PDGF*	*Immunodeficiency syndrome*	*RNA virus*	*Sensor based detection*	*Isolation for the prevention of infection*
S-14	SLO-1	*Lab 3: Total WBC count*	*Lab 6: Simple staining and Gram staining*	*Lab 9: Detection of salmonella infection by WIDAL test*	*Lab12: Polymerase chain reaction*	*Lab15:Demonstration of antigen and antibody purification by using FPLC*
	SLO-2	*Lab 3: Total WBC count*	*Lab 6: Simple staining and Gram staining*	*Lab 9: Detection of salmonella infection by WIDAL test*	*Lab12: Polymerase chain reaction*	*Lab15:Demonstration of antigen and antibody purification by using FPLC*
S-15	SLO-1	*Lab 3: Total WBC count*	*Lab 6: Simple staining and Gram staining*	*Lab 9: Detection of salmonella infection by WIDAL test*	*Lab12: Polymerase chain reaction*	*Lab15:Demonstration of antigen and antibody purification by using FPLC*
	SLO-2	*Lab 3: Total WBC count*	*Lab 6: Simple staining and Gram staining*	*Lab 9: Detection of salmonella infection by WIDAL test*	*Lab12: Polymerase chain reaction*	*Lab15:Demonstration of antigen and antibody purification by using FPLC*

Learning Resources	1. *Robbins and Cotran," Pathologic Basis of Disease" Elsevier Saunders, 9 th edition, 2015.* 2. *Harsh Mohan, "Textbook of Pathology ' ,Jaypee publications, 6 th edition,2010.*	3. *Prescott, Harley and Klein's , "Microbiology", Tata McGraw-Hill, New Delhi, 7th edition, 2008*

Learning Assessment

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

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

Course Designers

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

Course Code	18BMC201J	Course Name	BIOMEDICAL SENSORS	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:	Learning			Program Learning Outcomes (PLO)														
CLR-1 :	Know the basics of measurement system	1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-2 :	Learn the working principles of temperature transducers	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLR-3 :	Know the operating principles of pressure transducers																		
CLR-4 :	Familiarise the principles of optical transducers																		
CLR-5 :	Learn the working of bridges Circuits																		
CLR-6 :	Learn the concepts of smart sensors																		
Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:																		
CLO-1 :	Explain the concepts of measurement system	1, 2	80%	70%	M														
CLO-2 :	Implement temperature sensors	2	80%	70%	M														
CLO-3 :	Implement pressure sensors	2	80%	70%			M		M								M		L
CLO-4 :	Demonstrate the optical transducers	3	80%	70%					M										
CLO-5 :	Describe the operation of bridges circuits	3	80%	70%	M												M		L
CLO-6 :	know the concepts of smart sensors	3	80%	70%	M														

		Measurement System	Temperature Transducers	Pressure And Magnetic Transducers	Optical Transducers And BridgeCircuits	Advances In Sensing Technologies
Duration (hour)		15	15		15	15
S-1	SLO-1	Measurement system	Transducers	Strain Gauge: Principles	photodiodes	Biosensors: Definition
	SLO-2	Block diagram	Block diagram	Types	Working principles	Block diagram
S-2	SLO-1	Measurement terminologies	Types	Inductive transducer: Principles	phototransistor	Classification of biosensors
	SLO-2	Measurement terminologies	Selection Characteristics	Construction and Working	Working principles	Immobilization of Bio receptor
S-3	SLO-1	Types of Instruments	RTD	Load cell	LDR	Biocatalysts based biosensor: Introduction
	SLO-2	types of Instruments	Construction and operating principles	Construction and Working	Working principles	Principle
S-4	SLO-1	Lab1: Study of static characteristics	Lab4: Characteristics of RTD	Lab7: Characteristics of strain gauge	Lab10: Characteristics of optoelectronictransducer	Lab13: Study on Immobilisation techniques
	SLO-2	Lab1: Study of static characteristics	Lab4: Characteristics of RTD	Lab7: Characteristics of strain gauge	Lab10: Characteristics of optoelectronictransducer	Lab13: Study on Immobilisation techniques
S-5	SLO-1	Lab1: Study of static characteristics	Lab4: Characteristics of RTD	Lab7: Characteristics of strain gauge	Lab10: Characteristics of optoelectronictransducer	Lab13: Study on Immobilisation techniques
	SLO-2	Lab1: Study of static characteristics	Lab4: Characteristics of RTD	Lab7: Characteristics of strain gauge	Lab10: Characteristics of optoelectronic transducer	Lab13: Study on Immobilisation techniques
S-6	SLO-1	Static characteristics	Characteristics of RTD	LVDT	Optocouplers	Glucose Biosensor: Principle
	SLO-2	Static characteristics	Applications of RTD	Construction and Working	Working principles	Construction and operation
S-7	SLO-1	Dynamic characteristics	Thermistor	Capacitive transducer	Photovoltaic cell	Bio affinity based biosensor: Principle
	SLO-2	Dynamic characteristics	Construction and operating principles	Principles	Working principles	Construction and operation
S-8	SLO-1	Errors: Sources and types	Characteristics	Modes of operation	wheat stone bridge	Microbe Biosensor
	SLO-2	Methods of minimizing errors	Applications	Modes of operation	Balance equation	Construction and operation
S-9	SLO-1	Lab2: Computation of measurement errors	Lab5: Characteristics of thermistor	Lab8: Characteristics of LVDT	Lab11: Computation of unknown resistance using Bridge circuit	Lab14: Measurement of blood glucose

	SLO-2	*Lab2: Computation of measurement errors*	*Lab5: Characteristics of thermistor*	*Lab8: Characteristics of LVDT*	*Lab11: Computation of unknown resistance using Bridge circuit*	*Lab14: Measurement of blood glucose*
S-10	**SLO-1**	*Lab2: Computation of measurement errors*	*Lab5: Characteristics of thermistor*	*Lab8: Characteristics of LVDT*	*Lab11: Computation of unknown resistance using Bridge circuit*	*Lab14: Measurement of blood glucose*
	SLO-2	*Lab2: Computation of measurement errors*	*Lab5: Characteristics of thermistor*	*Lab8: Characteristics of LVDT*	*Lab11: Computation of unknown resistance using Bridge circuit*	*Lab14: Measurement of blood glucose*
S-11	**SLO-1**	*Transducer Selection Criterion*	*Thermocouple*	*Piezoelectric active transducer*	*Kelvin Bridge*	Electrochemical Biosensor: Principle
	SLO-2	*Transducer Selection Criterion*	*Construction and operating principles*	*Construction and Working*	*Balance equation*	Construction and operation
S-12	**SLO-1**	*Measurement standards*	*Characteristics*	*Hall effect*	*Maxwell Bridge*	Smart Sensors: Introduction
	SLO-2	*Types of standards*	*Applications*	*Principles of hall effect sensors*	*Balance equation*	Salient features
S-13	**SLO-1**	*Calibration*	*Semiconductor based temperature sensors*	*Applications of hall effect sensors*	*Schering Bridge*	Architecture
	SLO-2	*Types*	*Semiconductor based temperature sensors*	*Applications of hall effect sensors*	*Balance equation*	Applications
S-14	**SLO-1**	*Lab3: Calibration of measuring devices*	*Lab6: Characteristics of thermocouple*	*Lab9: Characteristics of Piezoelectric transducer*	*Lab12: Computation of unknown Inductance and capacitance using Bridge circuit*	*Lab15: Minor Project*
	SLO-2	*Lab3: Calibration of measuring devices*	*Lab6: Characteristics of thermocouple*	*Lab9: Characteristics of Piezoelectric transducer*	*Lab12: Computation of unknown Inductance and capacitance using Bridge circuit*	*Lab15: Minor Project*
S-15	**SLO-1**	*Lab3: Calibration of measuring devices*	*Lab6: Characteristics of thermocouple*	*Lab9: Characteristics of Piezoelectric transducer*	*Lab12: Computation of unknown Inductance and capacitance using Bridge circuit*	*Lab15: Minor Project*
	SLO-2	*Lab3: Calibration of measuring devices*	*Lab6: Characteristics of thermocouple*	*Lab9: Characteristics of Piezoelectric transducer*	*Lab12: Computation of unknown Inductance and capacitance using Bridge circuit*	*Lab15: Minor Project*

Learning Resources	1. *Sawhney A.K, "A Course in electrical and electronic measurements and instrumentation", Dhanpat Rai & Co (P) Ltd, Educational and Technical Publishers, 19th Revised edition 2011, Reprint 2014.* 2. *Patranabis D, "Sensors and transducers", PHI, 2nd edition, 2004*	3. *Murty DVS, "Transducer and instrumentation", PHI, 2nd edition, 2010.* 4. *U.A. Bakshi, A.V. Bakshi, "Measurements and instrumentation", Technical Publications, 3rd revised edition, 2010.* 5. *Paras N, Prasad, "Introduction to biophotonics", John Wiley & Sons, 1st edition, 2003*

Learning Assessment

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

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

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18BMC202T	Course Name	BIOMEDICAL SIGNALS AND SYSTEMS	Course Category	C	Professional core	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning		
		1	2	3
		Level of Thinking(Bloom)	Expected Proficiency(%)	Expected Attainment(%)
CLR-1 :	Understand the Classification of the continuous time signals and systems and discrete-time signals and systems			
CLR-2 :	Acquire the knowledge about the Continuous Time Signals and System			
CLR-3 :	Utilize the knowledge of Convolution and Correlation in biosignals			
CLR-4 :	Understand the concepts of z-transform and discrete Fourier transform			
CLR-5 :	Analyze the discrete time IIR and FIR systems by using suitable structures			
CLR-6 :	Acquire knowledge in biosignal applications			
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*			
CLO-1 :	Analyze the **Discrete time signals and systems**	3	80	75
CLO-2 :	Analyze the Continuous Time Signals and System	3	80	70
CLO-3 :	Illustrate the concepts of convolution and correlation in biosignals	3	75	70
CLO-4 :	Analyze the transforms of Discrete Time Signals and Systems	3	80	75
CLO-5 :	Analyze the concept of realization using suitable filter structures	3	80	70
CLO-6:	Explain the application of biomedical signals	3	80	70

Program Learning Outcomes (PLO)															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
EngineeringKnowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & TeamWork	Communication	Project Mgt. &Finance	Life Long Learning	PSO – 1: Professional Achievement	PSO – 2: Project ManagementTechniques	PSO – 3: Analyze & Reseach
M	-	-	-	-	-	-	-	-	-	-	-	M	-	-
M	-	-	-	-	-	-	-	-	-	-	-	-	M	-
M	-	-	-	-	-	-	-	-	-	-	-	-	-	M
-	-	M	-	-	-	-	-	-	-	-	-	-	-	M
-	-	-	M	-	-	-	-	-	-	-	-	-	-	M
-	-	-	M	-	-	-	-	-	-	-	-	-	-	M

		Basics OF Discrete time and continuous time signals and systems	Analysis of Continuous Time Signals and System	Convolution and Correlation of Discrete Time Signals	Transforms of Discrete Time Signals and Systems	Realization and Biosignal Applications
Duration (hour)		9	9	9	9	9
S-1	SLO-1	representation of discrete time signals	Fourier transform analysis	linear convolution	Z transform	Introduction to discrete time Infinite impulse response (IIR)
	SLO-2	continuous time signals	Properties	Tutorials	-properties	finite impulse response (FIR) systems
S-2	SLO-1	standard discrete time signals,	Tutorials	Circular convolution-	region of convergence	Structure for realization of IIR systems-direct form-I
	SLO-2	standard continuous time signals	Tutorials	Tutorials	Tutorials	Tutorials
S-3	SLO-1	Classification of signals: Continuous time(CT)	Laplace transform analysis	linear convolution via circular convolution	representation of poles and zeros in z transform	direct form-II
	SLO-2	Tutorials	properties	Tutorials	Tutorials	Tutorials
S-4	SLO-1	Classification of Discrete time (DT) signals	Tutorials	Sectioned convolution-overlap add method	Inverse z transform- residue method	Cascade form
	SLO-2	Tutorials	Tutorials	Tutorials	Tutorials	Tutorials
S-5	SLO-1	Mathematical operations on CTS- scaling, folding	Poles and zeros	Overlap save method	Partial fraction method	parallel form of IIR system
	SLO-2	time shifting, addition and multiplication	Poles and zeros	Tutorials	Tutorials	Tutorials
S-6	SLO-1	Mathematical operations on DTS- scaling, folding	Analysis of differential equation- impulse response	Inverse system	Discrete time fourier transform-	Structure for realization of FIR systems-direct form
	SLO-2	time shifting, addition and multiplication	Transfer function	deconvolution	properties	Tutorials
S-7	SLO-1	Classification of systems: static and dynamic systems	Tutorials	Correlation- autocorrelation	Tutorials	cascade and linear phase realization of FIR systems
	SLO-2	time invariant and time variant	Tutorials	Tutorials	Tutorials	Tutorials
S-8	SLO-1	linear and nonlinear systems,	Analysis of differential equation-frequency response	cross correlation	Relation between Z transform and DTFT	Neural Firing rate analysis
	SLO-2	causal and non-causal systems,	Tutorials	Tutorials	Introduction to discrete fourier transform	Nerve action potentials

S-9	SLO-1	*stable and unstable systems*	*Biosignal measurements*	*Correlation of Biosignals*	*DFT-properties*	*Linearized model and system equations for immune response*
	SLO-2	*Tutorials*	*Biosignal measurements*	*ECG,EMG*	*Tutorials*	*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 (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

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

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

Course Code	18BMC203J	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:	Learning		
		1	2	3
CLR-1 :	Analyze real-time circuits using mesh and nodal analysis and network reduction	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-2 :	To learn various Network theorems for analyzing electrical circuits			
CLR-3 :	To learn the principles of network theorems in simplifying electrical circuits			
CLR-4 :	Provide a basis for understanding semiconductor material, how a pn junction is formed and its principle of operation			
CLR-5 :	Explain the importance of diode in electronic circuits by presenting appropriate diode applications			
CLR-6 :	Describe the basic structure, operation and characteristics of BJT, and discuss its use as a switch and an amplifier			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Program Learning Outcomes (PLO)														
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
					Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	Apply the concepts of mesh and nodal analysis in solving electric circuits	1	80	70	H	H	-	-	-	-	-	-	M	-	-	-	M	M	-
CLO-2 :	Implement the concepts of network theorems in simplifying electric circuits	1, 2	80	70	H	H	M	-	-	-	-	-	M	-	-	-	M	M	-
CLO-3 :	Evaluate solutions of network theorems for electric circuits	1,2	80	70	H	H	M	-	-	-	-	-	M	-	-	-	M	M	-
CLO-4 :	Understand the operation, characteristics, parameters and specifications of semiconductor diodes	1	80	70	H	H	M	-	-	-	-	-	M	-	-	-	M	M	-
CLO-5 :	Review bipolar transistor construction, operation, characteristics and parameters, as well as its application in amplification and switching.	1	80	70	H	H	-	M	-	-	-	-	M	-	-	-	M	M	-
CLO-6 :	Build a circuit, then make functional measurements to understand the operating characteristics of the circuit	1	80	70	H	H	M	-	-	-	-	-	M	-	-	-	M	M	-

Duration (hour)		METHODS OF ANALYSING CIRCUITS	NETWORK THEOREMS	NETWORK THEOREMS	SEMICONDUCTOR DIODES AND DIODE CIRCUITS	BIPOLAR JUNCTION TRANSISTORS
		15	15	15	15	15
S-1	SLO-1	Introduction – Circuit Variables and Circuit Elements	Thevenin's Theorem	Superposition Theorem	Basic semiconductor theory: Intrinsic & extrinsic semiconductors	Device operation of Bipolar junction transistor (BJT)
	SLO-2	Basic Circuits Laws : Kirchoff's Voltage Law (KVL)	Practice problems	Practice problems	Current flow in semiconductors	Device operation of Bipolar junction transistor (BJT)
S-2	SLO-1	Kirchoff's Current Law (KCL)	Practice problems	Practice problems	PN junction theory	Common (CE) configuration
	SLO-2	Practice problems	Practice problems	Practice problems	Forward biased PN junction	CE configuration
S-3	SLO-1	Mesh analysis	Norton's Theorem	Compensation Theorem	Reverse biased PN junction	Current-Voltage characteristics of CE BJT configuration
	SLO-2	Mesh analysis	Practice problems	Practice problems	Relation between Current and Voltage	Current-Voltage characteristics of CE BJT configuration
S-4	SLO-1	Lab1: Verification of KVL	Lab 4: Verification of Thevenin's theorem	Lab 7: Verification of Superposition Theorem	Lab 10: PN Junction Diode Characteristics	Lab 13: CE Input and output characteristics

	SLO-2	*Lab1: Verification of KVL*	*Lab 4: Verification of Thevenin's theorem*	*Lab 7: Verification of Superposition Theorem*	*Lab 10: PN Junction Diode Characteristics*	*Lab 13: CE configurations – Input and output characteristics*
S-5	**SLO-1**	*Lab1: Verification of KVL*	*Lab 4: Verification of Thevenin's theorem*	*Lab 7: Verification of Superposition Theorem*	*Lab 10: PN Junction Diode Characteristics*	*Lab 13: CE configurations – Input and output characteristics*
	SLO-2	*Lab1: Verification of KVL*	*Lab 4: Verification of Thevenin's theorem*	*Lab 7: Verification of Superposition Theorem*	*Lab 10: PN Junction Diode Characteristics*	*Lab 13: CE configurations – Input and output characteristics*
S-6	**SLO-1**	*Mesh analysis*	*Practice problems*	*Practice problems*	*Problem Solving*	*Common Base (CB) configuration*
	SLO-2	*Practice problems*	*Practice problems*	*Practice problems*	*Zener diode theory*	*Current-Voltage characteristics of CB BJT configuration*
S-7	**SLO-1**	*Practice problems*	*Maximum Power Transfer Theorem*	*Reciprocity theorem*	*Forward biased Zener diode junction*	*Current-Voltage characteristics of CB BJT configuration*
	SLO-2	*Practice problems*	*Practice problems*	*Practice problems*	*Reverse biased Zener diode junction*	*Current-Voltage characteristics of CB BJT configuration*
S-8	**SLO-1**	*Nodal Analysis*	*Practice problems*	*Practice problems*	*Relation between Current and Voltage*	*Common collector (CC) configuration*
	SLO-2	*Nodal Analysis*	*Practice problems*	*Practice problems*	*Problems*	*Current-Voltage characteristics of CC BJT configuration*
S-9	**SLO-1**	*Lab 2: Verification of KCL*	*Lab 5: Verification of Norton's theorem*	*Lab 8: Verification of Reciprocity Theorem*	*Lab 11: Zener diode characteristics*	*Lab 14: CC and CB configurations – Input and output characteristics*
	SLO-2	*Lab 2: Verification of KCL*	*Lab 5: Verification of Norton's theorem*	*Lab 8: Verification of Reciprocity Theorem*	*Lab 11: Zener diode characteristics*	*Lab 14: CC and CB configurations – Input and output characteristics*
S-10	**SLO-1**	*Lab 2: Verification of KCL*	*Lab 5: Verification of Norton's theorem*	*Lab 8: Verification of Reciprocity Theorem*	*Lab 11: Zener diode characteristics*	*Lab 14: CC and CB configurations – Input and output characteristics*
	SLO-2	*Lab 2: Verification of KCL*	*Lab 5: Verification of Norton's theorem*	*Lab 8: Verification of Reciprocity Theorem*	*Lab 11: Zener diode characteristics*	*Lab 14: CC and CB configurations – Input and output characteristics*
S-11	**SLO-1**	*Nodal Analysis*	*Millman's theorem*	*Substitution theorem*	*Half wave rectifier operation*	*BJT as an amplifier*
	SLO-2	*Practice problems*	*Practice problems*	*Practice problems*	*Efficiency and ripple factor*	*BJT as an amplifier*
S-12	**SLO-1**	*Source Transformation Technique*	*Tellegen's theorem*	*Practice problems*	*Full wave rectifier operation*	*BJT as a switch*
	SLO-2	*Source Transformation Technique : Practice problems*	*Practice problems*	*Practice problems*	*Efficiency and ripple factor*	*BJT as à switch*
S-13	**SLO-1**	*Star-Delta Transformation*	*Duals and Duality*	*Practice problems*	*Bridge rectifier operation*	*Practice problems*
	SLO-2	*Star-Delta Transformation: Practice problems*	*Practice problems*	*Practice problems*	*Efficiency and ripple factor*	*Practice problems*
S-14	**SLO-1**	*Lab 3: Mesh Analysis*	*Lab 6: Verification of Maximum Power Transfer Theorem*	*Lab 9: Verification of Substitution theorem*	*Lab 12: Diode circuits*	*Lab 15: Miniproject*
	SLO-2	*Lab 3: Mesh Analysis*	*Lab 6: Verification of Maximum Power Transfer Theorem*	*Lab 9: Verification of Substitution theorem*	*Lab 12: Diode circuits*	*Lab 15: Miniproject*
S-15	**SLO-1**	*Lab 3: Mesh Analysis*	*Lab 6: Verification of Maximum Power Transfer Theorem*	*Lab 9: Verification of Substitution Theorem*	*Lab 12: Diode circuits*	*Lab 15: Miniproject*
	SLO-2	*Lab 3: Mesh Analysis*	*Lab 6: Verification of Maximum Power Transfer Theorem*	*Lab 9: Verification of Substitution Theorem*	*Lab 12: Diode circuits*	*Lab 15: Miniproject*

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

Learning Assessment

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

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

Course Designers

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

Course Code	18BMC204T	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:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLR-1 :	Understand the physics of X –ray production																		
CLR-2 :	Learn the components of Computed tomography and different generations																		
CLR-3 :	Gain knowledge in PET and SPECT imaging																		
CLR-4 :	Understand the physics of MRI imaging																		
CLR-5 :	Gain knowledge about the reconstruction of images in MRI																		
CLR-6 :	Learn about different types of scanners – A, B & M mode and Duplex ultrasound scanners																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*																		
CLO-1 :	Describe the production of X ray and the working principle of X –ray machine	1, 2	80%	70%	M														
CLO-2 :	Differentiate the generations of CT	2	80%	70%	M														
CLO-3 :	Illustrate the working principle of PET and SPECT scanner	2	80%	70%			M		M								M		L
CLO-4 :	Differentiate and analyze the various image compression and registration algorithms	3	80%	70%					M										
CLO-5 :	Describe the working principle of MRI and its different components	3	80%	70%	M												M		L
CLO-6 :	Illustrate the working of Different ultrasound scanners	3	80%	70%	M														

		X-ray Imaging and Digital Radiography	Computed Tomography	Nuclear imaging	Magnetic resonance imaging	Ultrasound imaging
Duration (hour)		9	9	9	9	9
S-1	SLO-1	Nature of X-rays	Computed Tomography	Radio isotopes in medical diagnosis	Principles of NMR	Diagnostic Ultrasound
	SLO-2	Properties of X -rays	basic principle	Physics of Radioactivity	Free induction decay	Physics of Ultrasonic Waves
S-2	SLO-1	Production of X-rays	Contrast scale – CT number	Radiation Detectors – Ionization chamber	T1 and T2 relaxation	Generation and detection of ultrasound
	SLO-2	Stationary X –ray anode tube	CT – system components	Scintillation detector	Fourier transformation of FID	Medical Ultrasound
S-3	SLO-1	Rotating anode tube	Scanning system	Semiconductor detectors	Bloch equation	Basic Pulse-echo Apparatus
	SLO-2	X –ray machine	Different generation of CT	Solid state detectors	Image Reconstruction Techniques	A scanner and applications
S-4	SLO-1	High frequency generator	X – ray source	Pulse Height Analyzer	Sequential point method, Sequential line method	B scanner and applications
	SLO-2	Collimators and grids	X –ray detectors and types	Uptake Monitoring Equipment	Sequential plane method	Echocardiograph (M-mode)
S-5	SLO-1	Automatic exposure control – photo cell method	Data acquisition system	Radio-isotope Rectilinear Scanner	Discrimination based on relaxation rates	Block diagram of echo cardiograph circuit
	SLO-2	Ionization method	Processing unit	The Gamma Camera	Saturation recovery	Doppler scanner
S-6	SLO-1	Visualization of X-rays – X- ray film	Iterative reconstruction	Multi crystal gamma camera	Inversion recovery	Principles of Elastography, Shear wave elastography
	SLO-2	Fluorescent screen	Back projection reconstruction	Block diagram and description of Multi crystal gamma camera	Spin echo imaging technique	Real time ultrasonic imaging systems
S-7	SLO-1	X –ray image intensifier tube	Filtered back projection	Emission computed tomography	Generic pulse sequence used in MRI	Multi-element Linear Array Scanners
	SLO-2	X –ray image intensifier system	Block diagram of the image computer	Single-photon Emission Computed Tomography – Principle	Basic NMR Components	Linear array scanner
S-8	SLO-1	Dental X-ray Machines	Viewing system	SPECT system – simplified diagram and description	NMR Detection system, NMR gradient control system	Phased array system
	SLO-2	Portable and Mobile X-ray Units	Storing and documentation	Positron Emission Tomography - Principle	Biological Effects of NMR Imaging Advantages of NMR Imaging System	Area array system

S-9	**SLO-1**	*Digital Radiography*	*Gantry geometry*	*PET – Gantry and detector module*	*fMRI basic physics, Image acquisition procedure*	*Duplex scanner*
	SLO-2	*Flat panel detectors*	*Patient dose in CT scanners*	*Data acquisition system for PET scanner*	*MR spectroscopy basic block diagram and applications*	*Intravascular imaging*

Learning Resources	*1.* R.S.Khandpur., 'Handbook of Biomedical instrumentation', Tata McGraw Hill Publishing Co Ltd., 3rd edition, 2014. *2.* Jerrold T. Bushberg, John M. Boone., "The essential physics of medical imaging", Lippincott Williams & Wilkins, 3rd edition, 2011.	*3.* 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. Nadine Barrie Smith, Andrew Webb, "Introduction tomedical imaging: Physics, Engineering and clinical applications", Cambridge University Press, 1st edition, 2010. *4.* K. Kirk Shung, Michael Smith, Benjamin M.W. Tsui., "Principles of medical imaging", Academic Press, 1st edition, 2012.

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

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

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

Course Code	18BMC205J	Course Name	LINEAR AND DIGITAL INTEGRATED 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:

		Learning		
CLR-1 :	Understand the operation and analysis of op-amp oscillators, single chip oscillators and frequency generators	1	2	3
CLR-2 :	Identify the active filter types, filter response characteristics, filter parameters and IC voltage regulators			
CLR-3 :	Gain knowledge on data converter terminology, its performance parameters, and various circuit arrangements for A/D and D/A conversions.			
CLR-4 :	Familiarize mathematical operations			
CLR-5 :	Able to design simple combinational logics using basic gates and MSI circuits			
CLR-6 :	Familiarize with basic sequential logic components: flip-flops, registers, counters and their usage, and able to design and analyze sequential logic circuits and Finite State Machines			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Program Learning Outcomes (PLO) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
					Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	Elucidate and design the linear and non-linear applications of an opamp and special application ICs	1, 2	80	70	M	M	L	-	-	-	-	-	-	-	-	M	M	-	-
CLO-2 :	Classify and comprehend the working principle of data converters and active filters	1, 2	80	70	M	L	-	-	-	-	-	-	-	-	-	L	L	-	-
CLO-3 :	Illustrate the function of application specific ICs such as Voltage regulators and ADC and DAC	1,2	80	70	-	M	-	L	-	-	-	-	-	-	-	-	L	L	-
CLO-4 :	Understand, analyze, design and troubleshoot various combinational logic circuits	2	80	70	M	M	L	M	M	-	-	-	-	-	-	-	-	L	M
CLO-5 :	Understand, analyze, design and troubleshoot various clocked sequential logic circuits.	2,3	80	70	-	-	M	M	M	-	-	-	-	-	-	-	-	L	M
CLO-6 :	Analyze, design and implement various digital logic circuits using PLDs	3	80	70	-	M	-	M	-	-	-	-	-	-	-	-	-	L	M

Duration (hour)		Applications of Op-amp	Oscillators and Filters	Analog and digital converters	Combinational Systems	Sequential System
		15	15	15	12	12
S-1	SLO-1	Basic op-amp circuits: Inverting & Noninverting voltage amplifiers	Waveform Generators: Sine-wave Generators - Design	Digital to Analog Conversion: DAC Specifications	Binary arithmetic units	Flip-flop and Latch: SR latch,
	SLO-2	Voltage follower	Implementation & Solving problems	Solving problems	Adder	JK flip-flop, T flip-flop, D flip-flop
S-2	SLO-1	Summing, scaling & averaging amplifiers,	Square Wave generators- Design	Weighted Resistor DAC'	Design of Half adder	Master-slave RS flip-flop
	SLO-2	AC amplifiers	Implementation & Solving problems	Solving problems'	Design of Full adder	Master-slave JK flip-flop
S-3	SLO-1	Linear Applications: Instrumentation Amplifiers	Triangle wave generators	R-2R Ladder DAC	Subtractor	Registers & Counters
	SLO-2	Instrumentation Amplifiers, Solving Problems	Saw-tooth Wave generators	Solving problems	Design subtractor using logic gates	Shift registers (SISO, SIPO, PISO, PIPO)
S-4	SLO-1	Lab 1: Comparators	Lab 4: Waveform generators: using opamp & 555 Timer	Lab 7: Flash Type ADC	LAB 10: Implement combinational logic functions using standard ICs	LAB 13: Design and implement Synchronous Counters
	SLO-2	Lab 1: Comparators	Lab 4: Waveform generators: using opamp & 555 Timer	Lab 7: Flash Type ADC	LAB 10: Implement combinational logic functions using standard ICs	LAB 13: Design and implement Synchronous Counters
S-5	SLO-1	Lab 1: Comparators	Lab 4: Waveform generators: using opamp & 555 Timer	Lab 7: Flash Type ADC	LAB 10: Implement combinational logic functions using standard ICs	LAB 13: Design and implement Synchronous Counters
	SLO-2	Lab 1: Comparators	Lab 4: Waveform generators: using opamp & 555 Timer	Lab 7: Flash Type ADC	LAB 10: Implement combinational logic functions using standard ICs	LAB 13: Design and implement Synchronous Counters

S-6	**SLO-1**	V-to-I Converters	Comparison between Passive and Active Networks	Inverted R-2R Ladder DAC	n-bit parallel adder & subtractor	Universal shift register
	SLO-2	I-to-V converter	Active Network Design	Monolithic DAC'	look ahead carry generator	Synchronous counters, Modulus-n Counter
S-7	**SLO-1**	Differentiators	Filter Approximations	Analog to Digital conversion: ADC specifications	Decoder	Mealy and Moore model
	SLO-2	Integrators	Design of LPF & Solving problems	Solving problems	Encoder	Mealy and Moore model
S-8	**SLO-1**	Non-linear Applications: Precision Rectifiers	Design of HPF & Solving problems	Ramp Type ADC	Multiplexer	Synchronous (Clocked) sequential circuits
	SLO-2	Wave Shaping Circuits (Clipper and Clampers)	Design of BPF& Solving problems	Solving problems	Demultiplexer	Synchronous (Clocked) sequential circuits
S-9	**SLO-1**	Lab 2: Wave shaping circuits	Lab 5: Design of LPF, HPF, BPF and Band Reject Filters	Lab 8: Simulation experiments using EDA SLO-2 tools	LAB 11: Verify characteristic table of flipflops	LAB 14:Design of parallel Adder
	SLO-2	Lab 2: Wave shaping circuits	Lab 5: Design of LPF, HPF, BPF and Band Reject Filters	Lab 8: Simulation experiments using EDA SLO-2 tools	LAB 11: Verify characteristic table of flipflops	LAB 14:Design of parallel Adder
S-10	**SLO-1**	Lab 2: Wave shaping circuits	Lab 5: Design of LPF, HPF, BPF and Band Reject Filters	Lab 8: Simulation experiments using EDA SLO-2 tools	LAB 11: Verify characteristic table of flipflops	LAB 14:Design of parallel Adder
	SLO-2	Lab 2: Wave shaping circuits	Lab 5: Design of LPF, HPF, BPF and Band Reject Filters	Lab 8: Simulation experiments using EDA SLO-2 tools	LAB 11: Verify characteristic table of flipflops	LAB 14:Design of parallel Adder
S-11	**SLO-1**	Log and Antilog Amplifiers	Voltage Regulators: Basics of Voltage Regulator	Successive Approximation ADC	Code converters	Design of combinational circuits using PLD's
	SLO-2	Analog voltage multiplier circuit and its applications	Specifications and characteristic parameters	Solving problems	Magnitude comparators	Design of combinational circuits using PLD's
S-12	**SLO-1**	Operational Trans-Conductance Amplifier (OTA)	Linear Voltage Regulators using Op-amp	Dual Slope ADC'	Applications	RAM Memory decoding
	SLO-2	Comparators : operation	IC Regulators (78xx, 79xx, LM 317, LM 337, 723),	Flash Type ADC	Parity generators (Odd parity)	ROM
S-13	**SLO-1**	Comparators applications	Switching Regulators -operation	Solving problems on Flash Type ADC	Parity generators (Even parity)	Programmable Array Logic (PAL)
	SLO-2	Sample and Hold circuit.	Types	Monolithic ADC	Implementation of combinational logic by standard IC's.	Programmable Array Logic (PAL)
S-14	**SLO-1**	Lab 3: Waveform generators: using opamp & 555 Timer	Lab 6: R-2R ladder DAC	Lab 9: Simulation experiments using EDA SLO-2 tools'	LAB 12: Construct and verify 4-bit ripple counter, Mod-10/Mod-12 ripple counters	LAB 15: Design of subractor
	SLO-2	Lab 3: Waveform generators: using opamp & 555 Timer	Lab 6: R-2R ladder DAC	Lab 9: Simulation experiments using EDA SLO-2 tools	LAB 12: Construct and verify 4-bit ripple counter, Mod-10/Mod-12 ripple counters	LAB 15: Design of subractor
S-15	**SLO-1**	Lab 3: Waveform generators: using opamp & 555 Timer	Lab 6: R-2R ladder DAC	Lab 9: Simulation experiments using EDA SLO-2 tools'	LAB 12: Construct and verify 4-bit ripple counter, Mod-10/Mod-12 ripple counters	LAB 15: Design of subractor
	SLO-2	Lab 3: Waveform generators: using opamp & 555 Timer	Lab 6: R-2R ladder DAC	Lab 9: Simulation experiments using EDA SLO-2 tools	LAB 12: Construct and verify 4-bit ripple counter, Mod-10/Mod-12 ripple counters	LAB 15: Design of subractor

Learning Resources	1. Morris Mano M, Michael D. Ciletti, Digital Design with an Introduction to the Verilog HDL, 5th ed., Pearson Education, 2014 2. Charles H Roth (Jr), Larry L. Kinney, Fundamentals of Logic Design, 5th ed., Cengage Learning India 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 io Franco, Design with operational amplifier and analog integrated circuits, McGraw Hill, 1997

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

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

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

Course Code	18BMC206J	Course Name	BIOMATERIALS- TISSUE INTERACTION	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):	To study the learners to acquire knowledge to the basic properties of biomaterials and various biomaterials used in biomedical applications.
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
CLR-6 :	Have an Gain the knowledge about biomaterials used in various biomedical implant application

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (Bloom)	Learning 2 Expected Proficiency (%)	Learning 3 Expected Attainment (%)	PLO 1 Engineering Knowledge	PLO 2 Problem Analysis	PLO 3 Design & Development	PLO 4 Analysis, Design, Research	PLO 5 Modern Tool Usage	PLO 6 Society & Culture	PLO 7 Environment & Sustainability	PLO 8 Ethics	PLO 9 Individual & Team Work	PLO 10 Communication	PLO 11 Project Mgt. & Finance	PLO 12 Life Long Learning	PSO 1	PSO 2	PSO 3
CLO-1 :	Understand the basic principle and properties of biomaterials	1, 2	80%	70%	L				L							L			M
CLO-2 :	Analyze various types of metals used in implant applications.	2	80%	70%	L				M							M			M
CLO-3 :	Explain the process of importance of ceramics and polymer used biomedical diagnostics	2	80%	70%	L				M			M				L			M
CLO-4 :	Select appropriate class of polymers using knowledge of, prosthetic and medical implants.	3	80%	70%	M											L	M	M	
CLO-5 :	Understand the concepts different types biomaterials applied in-vitro and in-vivo biomedical implant application.	3	80%	70%	M											M	M	M	
CLO-6 :	Apply the various biomaterials used in implants and artificial organs	3	80%	70%	M		M	H				M						M	M

Duration (hour)		Introduction to biomaterials and its properties	Metallic and Ceramics implants materials	Polymeric Implant materials	Soft and Hard Tissue Replacements	Biomaterials in Tissue interaction
		9	9	9	9	9
S-1	SLO-1	Introduction to Biomaterials	Metallic implant materials	Polymer Materials: Synthetic polymer	Sutures, skin, Tapes, and Adhesives	Scaffolds for tissue engineering
	SLO-2	Performance of biomaterials	Stainless steel, Co alloy properties and application	Polymers in biomedical use	Maxillofacial implants	Classes of potential scaffold materials
S-2	SLO-1	Characterization of biomaterials	T i based alloys properties and application	Polyethylene and polypropylene	Cardiovascular Grafts and Stents.	The criteria for an ideal scaffold
	SLO-2	Mechanical properties	Dental metals: Dental Amalgam, Gold	Perfluorinted polymers	Heart Valve Implants.	Polymer scaffolds
S-3	SLO-1	Stress–Strain Behavior	Shape memory alloys:	Acrylic polymers and Hydrogel		Polymer scaffolds applications
	SLO-2	Mechanical Failure	Application of Nickel titanium materials	Polyurethane	Hard Tissue replacement: Wires, Pins, and Screws	Bioactive ceramic scaffolds
S-4	SLO-1	Lab1 Study of metallurgical Microscope	Lab 4 Preparation and characterization of Hydroxyapatite	Lab7 Physical Characterization of Coated/Uncoated Surfaces Contact Angle measurement polycaprolactone (PCL).	Lab 10 Chemical Characterization of modified/unmodified surfaces(PVA)	Lab 13 Preparation and characterization of Poly (2-hydroxyethyl methacrylate) hydrogels
	SLO-2	Lab1 Specimen preparation for identification of metals/alloys B1 Hand Polishing B2 Etching	Lab 4 Preparation and characterization of Hydroxyapatite	Lab7 Physical Characterization of Coated/Uncoated Surfaces Contact Angle measurement polycaprolactone (PCL).	Lab 10 Chemical Characterization of modified/unmodified surfaces(PVA)	Lab 13 Preparation and characterization of Poly (2-hydroxyethyl methacrylate) hydrogels

S-5	*SLO-1*	*Lab1 Study of metallurgical Microscope*	*Lab 4 Preparation and characterization of Hydroxyapatite*	*Lab7 Physical Characterization of Coated/Uncoated Surfaces Contact Angle measurement polycaprolactone (PCL).*	*Lab 10 Chemical Characterization of modified/unmodified surfaces(PVA)*	*Lab 13 Preparation and characterization of Poly (2-hydroxyethyl methacrylate) hydrogels*
	SLO-2	*Lab1 Specimen preparation for identification of metals/alloys B1 Hand Polishing B2 Etching*	*Lab 4 Preparation and characterization of Hydroxyapatite*	*Lab7 Physical Characterization of Coated/Uncoated Surfaces Contact Angle measurement polycaprolactone (PCL).*	*Lab 10 Chemical Characterization of modified/unmodified surfaces(PVA)*	*Lab 13 Preparation and characterization of Poly (2-hydroxyethyl methacrylate) hydrogels*
S-6	*SLO-1*	*Static failure*	*Other metallic materials and properties ,Applications*	*Polyamides*	*Lower Extremity Implants: Hip Joint Replacements*	*Bioactive ceramic scaffolds and its applications*
	SLO-2	*Dynamic failure.*	*Other metallic materials and properties ,Applications*	*Biodegradable synthetic polymer*	*Knee Joint Replacements*	*Substrate Scaffold Materials*
S-7	*SLO-1*	*Friction and wear failure*	*New generation of bimetallic materials: Properties and application*	*Silicone rubber*	*Introduction to Kidney implant*	*A guide to basic cell culture and applications in biomaterials and tissue engineering*
	SLO-2	*viscoelastic properties*	*Corrosion metallic implants: Electrochemical Aspects*	*Plasma polymerization and Polymer sterilization*	*Artificial Lung implant*	*sterilization of scaffolds, Sterilization methods*
S-8	*SLO-1*	*Thermal Properties*	*Structure and properties of ceramic materials*	*Composite materials: Structure*	*Liver implant,*	*Cell culture protocols*
	SLO-2	*Surface properties: Contact angle*	*Impact of fabrication on microstructure and properties :Alumina and its properties*	*Mechanics of composite and application of composite materials*	*Artificial Pancreas*	*Basic techniques for assessment of cell viability*
S-9	*SLO-1*	*Lab2 Determination of hardness using Micro Vickers Tester*	*Lab 5 Preparation and characterization of titanium oxide*	*Lab8 Physical Characterization of Coated/Uncoated Surfaces Contact Angle measurement poly lactic acid (PLA).*	*Lab 11 Chemical Characterization of modified/unmodified any biodegradable polymers*	*Lab 14 Preparation and characterization of any ceramics*
	SLO-2	*Lab2 Determination of hardness using Micro Vickers Tester*	*Lab 5 Preparation and characterization of titanium oxide*	*Lab 8 Physical Characterization of Coated/Uncoated Surfaces Contact Angle measurement poly lactic acid (PLA)*	*Lab 11 Chemical Characterization of modified/unmodified any biodegradable polymers*	*Lab 14 Preparation and characterization of any ceramics*
S-10	*SLO-1*	*Lab2 Determination of hardness using Micro Vickers Tester*	*Lab 5 Preparation and characterization of titanium oxide*	*Lab 8 Physical Characterization of Coated/Uncoated Surfaces Contact Angle measurement poly lactic acid (PLA).*	*Lab 11 Chemical Characterization of modified/unmodified any biodegradable polymers*	*Lab 14 Preparation and characterization of any ceramics*
	SLO-2	*Lab2 Determination of hardness using Micro Vickers Tester*	*Lab 5 Preparation and characterization of titanium oxide*	*Lab 8 Physical Characterization of Coated/Uncoated Surfaces Contact Angle measurement poly lactic acid (PLA)*	*Lab 11 Chemical Characterization of modified/unmodified any biodegradable polymers*	*Lab14 Preparation and characterization of any ceramics*
S-11	*SLO-1*	*Ceramics and Glasses and Polymers and Elastomers*	*Zirconia and its properties*	*Porous Implants materials*	*Optical implants Contact lenses*	*maintenance of cells in vitro, cryopreservation*
	SLO-2	*Adhesion, Problem for surface properties*	*Calcium phosphate and its properties*	*Fibrous and Particulate Composites in Orthopedic Implants*	*Ear implant*	*Regeneration stimulated electrically*
S-12	*SLO-1*	*Electrical properties*	*Glass ceramics.Yitria ceramics and its properties*	*Design criteria for bio composites*	*Blood flow in artificial devices*	*Immunochemical techniques in tissue engineering and biomaterial science*
	SLO-2	*Piezoelectricity, Density of various materials*	*Other ceramics*	*Inflammation and wound healing*	*Artificial Nose*	*Basic immunological principles*
S-13	*SLO-1*	*Porosity of various materials*	*Hydroxyapatite ceramics and its properties*	*Normal wound healing*	*Regeneration and Potential Future Uses for Stem Cells*	*Common immunochemical techniques used in biomaterials*
	SLO-2	*Diffusion properties*	*Manufacture of Implants in ceramics*	*Body response to implants, Biocompatibility*	*Ethical consideration*	*Immunochemical applications in biomaterial science and tissue engineering research*
S-14	*SLO-1*	*Lab 3 Determination of coating thickness using Image analyzer*	*Lab 6 study the corrosion behaviour of coated and uncoated substrate*	*Lab 9 preparation of simulated body fluid solution*	*Lab 12 In-vitro Study in any metallic medical implants*	*Lab 15 Model Exam*
	SLO-2	*LAB 3 Determination of coating thickness using Image analyzer*	*Lab 6 study the corrosion behaviour of coated and uncoated substrate*	*Lab 9 preparation of simulated body fluid solution*	*Lab 12 In-vitro Study in any metallic medical implants*	*Lab 15 Model Exam*
S-15	*SLO-1*	*Lab 3 Determination of coating thickness using Image analyzer*	*Lab 6 study the corrosion behaviour of coated and uncoated substrate*	*Lab 9 preparation of simulated body fluid solution*	*Lab 12 In-vitro Study in any metallic medical implants*	*Lab 15 Model Exam*
	SLO-2	*Lab 3 Determination of coating thickness using Image analyzer*	*Lab 6 study the corrosion behaviour of coated and uncoated substrate*	*Lab 9 preparation of simulated body fluid solution*	*Lab 12 In-vitro Study in any metallic medical implants*	*Lab 15 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

Learning Assessment

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

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

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

Course Code	18BMC301J	Course Name	MEDICAL INSTRUMENTATION	Course Category	C	Professional Core	L	T	P	C
							3	0	2	4

Pre-requisite Courses	Basic Electronic Devices and Circuits, Linear Integrated Circuits	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Biomedical Engineering	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Understand the basic function of physiological system and basic instrument for picking up biological signals
CLR-2 :	Analyze various biological signal acquired from physiological system using various instruments
CLR-3 :	Get an idea about various blood pressure and blood flow measurement techniques
CLR-4 :	Understand various technique used for measurement in the respiratory system
CLR-5 :	Identify the various instruments used for the therapeutic and patient safety
CLR-6 :	Understanding the overall bioelectronics instruments used for physiological measurement

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)															
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency(%)	Expected Attainment (%)	EngineeringKnowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & TeamWork	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	Describe the function of physiological system and basic man instrument system used for analyzes	1, 2	80%	70%	M														
CLO-2 :	Identify the various biological signal and its abnormalities .Applying procedure to obtain biological signal	2	80%	70%	M														
CLO-3 :	Apply the blood pressure and flow measurement technique	2	80%	70%			M		M								M		L
CLO-4 :	Analyze the various technique used for measurement of respiratory system	3	80%	70%					M										
CLO-5 :	Apply the various instrument used for the emergency therapeutic application and patient safety	3	80%	70%	M												M		L
CLO-6 :	Outline the job opportunities in biomedical device in India	3	80%	70%	M														

Duration (hour)		Introduction to Bioinstrumentation system	Biosignal acquisition from physiological system	Blood Pressure and blood flow measurement	Measurements in the Respiratory system	Biomedical instrument for therapeutic and patient safety
		15	15	15	15	15
S-1	SLO-1	Physiological systems of the human body	Cardiovascular system: Basic anatomy and physiology of heart	Measurement of blood pressure: indirect Methods	Introduction of respiratory system	Need for cardiac pacemaker
	SLO-2	Biometrics	Electrophysiology of the Heart	Measurement of blood pressure: indirect Methods	Gas exchange and distribution	External pacemaker
S-2	SLO-1	Introduction to the Man-Instrument system	Electrocardiography waveform and its characteristics	Measurement of blood pressure: Direct methods	Measurement of Respiratory volumes and capacities	Implantable pacemaker
	SLO-2	Components of Man-Instrument system	ECG lead configurations	Measurement of blood pressure: Direct methods	Spirometry	Implantable pacemaker
S-3	SLO-1	Problem encountered in measuring in a living system	12 lead ECG machine circuit	Blood flow measuring techniques: electromagnetic blood flow meter, Ultrasonic blood flow meter	Spirometry	Recent developments in Implantable pacemaker
	SLO-2	Intelligent medical instrumentation system	Various Arrhythmias occurring in ECG signal	NMR blood flow meter, Laser Doppler blood flow meter	Pneumotachometers: different types	Pacing system analyzer
S-4	SLO-1	Lab1: Study of block diagram of man instrument system	Lab4: Real time ECG recording	Lab 7: Measurement of blood flow	Lab 10: Pulmonary analysis using spirometer	Lab 13: Study of pacemakers
	SLO-2	Lab1: Study of block diagram of man instrument system	Lab4: Real time ECG recording	Lab 7: Measurement of blood flow	Lab 10: Pulmonary analysis using spirometer	Lab 13: Study of pacemakers
S-5	SLO-1	Lab1: Study of block diagram of man instrument system	Lab4: Real time ECG recording	Lab 7: Measurement of blood flow	Lab 10: Pulmonary analysis using spirometer	Lab 13: Study of pacemakers
	SLO-2	Lab1: Study of block diagram of man instrument system	Lab4: Real time ECG recording	Lab 7: Measurement of blood flow	Lab 10: Pulmonary analysis using spirometer	Lab 13: Study of pacemakers

S-6	**SLO-1**	Resting and action potential	Introduction to basic Anatomy and function of brain	Cardiac output measuring techniques: dye dilution method	Pneumotachometers: different types	DC Defibrillator
	SLO-2	Propagation of Action potential	Bioelectric potential from the brain	Thermal dilution method	Pneumotachometers: different types	DC Defibrillator
S-7	**SLO-1**	Nernst equation, Goldman equation, Hodgkin-Huxley model	10-20 system of placement of electrode	Cardiac output from aortic pressure waveform	Respiratory gas analyzers: Infrared gas analyzer	Types of implantable Defibrillators
	SLO-2	Sources of Bioelectric potentials	EEG Machine block diagram description	Impedance technique	Oxygen analyzers	Pacer-Cardioverter-defibrillator
S-8	**SLO-1**	Bio potential measurement: electrode electrolyte interface,	Computerized analysis of EEG	Ultrasound method	Thermal conductivity analyser	Defibrillator analysers
	SLO-2	polarizable and non-polarizable electrodes, The electrode skin interface and motion artifact	Magnetoencephalography	Bioreactance method, CO2 rebreathing method	Nitrogen gas analyzer	Left ventricular assist device
S-9	**SLO-1**	Lab2: Study of sources of Biopotentials	Lab5: Real time EEG monitoring	Lab 8: Measurement of cardiac output	Lab 11: Study of pneumotachometers	Lab 14: Study of defibrillators
	SLO-2	Lab2: Study of sources of Biopotentials	Lab5: Real time EEG monitoring	Lab 8: Measurement of cardiac output	Lab 11: Study of pneumotachometers	Lab 14: Study of defibrillators
S-10	**SLO-1**	Lab2: Study of sources of Biopotentials	Lab5: Real time EEG monitoring	Lab 8: Measurement of cardiac output	Lab 11: Study of pneumotachometers	Lab 14: Study of defibrillators
	SLO-2	Lab2: Study of sources of Biopotentials	Lab5: Real time EEG monitoring	Lab 8: Measurement of cardiac output	Lab 11: Study of pneumotachometers	Lab 14: Study of defibrillators
S-11	**SLO-1**	Biopotential electrodes:Surface,and Micro electrodes	Electromyography(EMG):Basics of EMG	Heart rate measurement	Measurement of respiration rate: displacement method,	Electric shock hazards
	SLO-2	Biopotential electrodes:Needle electrodes	Recording of EMG	Heart rate measurement	Thermistor method,	Microshock and Macroshock
S-12	**SLO-1**	Biochemical electrodes: pH	Electrooculography(EOG):Origin and measurement	Invitro-oximetry, invivo-oximetry	Impedance pneumography	Threshold of perception and Leakage current
	SLO-2	Biochemical electrodes: pO2, pCO2	Electroretinography(ERG): Origin and measurement	Ear oximeter	CO_2 method	Safety codes for electromedical equipment
S-13	**SLO-1**	Transcutaneous electrodes,	Phonocardiography(PCG):Origin of heartsound, Measurement of PCG	Pulse oximeter	Apnea detector	Electrical safety analyzer
	SLO-2	Ion sensitive field effect Transistor	Biofeedback instrumentation	Skin reflectance oximeter, Intravascular oximeter	Bedside and Central Monitoring system	Testing of biomedical equipments
S-14	**SLO-1**	Lab 3: Study of biopotential electrodes	Lab 6: Real time EMG monitoring	Lab 9: Measurement of heart rate	Lab12: Measurement of respiration rate	Lab15:Model exam
	SLO-2	Lab 3: Study of biopotential electrodes	Lab 6: Real time EMG monitoring	Lab 9: Measurement of heart rate	Lab12: Measurement of respiration rate	Lab15:Model exam
S-15	**SLO-1**	Lab 3: Study of biopotential electrodes	Lab 6: Real time EMG monitoring	Lab 9: Measurement of heart rate	Lab12: Measurement of respiration rate	Lab15:Model exam
	SLO-2	Lab 3: Study of biopotential electrodes	Lab 6: Real time EMG monitoring	Lab 9: Measurement of heart rate	Lab12: Measurement of respiration rate	Lab15:Model exam

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, 4thedition, 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 (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Understand										
Level 2	Apply	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
	Analyze										
Level 3	Evaluate	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Create										
	Total	100 %		100 %		100 %		100 %		-	

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

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

Course Code	18BMC302T	Course Name	BIOMECHANICS	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:*

		Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	Understand the fundamentals of kinetic and kinematic concepts of human motion			
CLR-2 :	Get an idea about the skeletal and muscular movements			
CLR-3 :	Get an idea about the Functional anatomy of the upper extremity			
CLR-4 :	Get an idea about the Functional anatomy of the lower extremity			
CLR-5 :	Understand the biomechanics of spine and gait			
CLR-6 :	Get an overall idea about the various functional and movement characteristics of upper extremity and lower extremity			

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

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	Apply the common kinematic and kinetic concepts to various human motion	1, 2	80	70	M	M	L	-	-	-	-	-	-	-	-	M	M	-	-
CLO-2 :	Identify the mechanical properties of bone and muscle tissues	1, 2	80	70	M	L	-	-	-	-	-	-	-	-	-	L	L	-	-
CLO-3 :	Analyze the functional and movement characteristics of upper extremity bones and joints	1,2	80	70	-	M	-	L	-	-	-	-	-	-	-	L	L	L	-
CLO-4 :	Analyze the functional and movement characteristics of lower extremity bones and joints	2	80	70	M	M	L	M	M	-	-	-	-	-	-	L	-	L	M
CLO-5 :	Analyze the biomechanics of spine and human locomotion	2,3	80	70	-	-	M	M	M	-	-	-	-	-	-	L	-	L	M
CLO-6 :	Outline the factors involved in analyzing the performance of lower and upper extremity bones and joints	3	80	70	-	M	-	M	-	-	-	-	-	-	-	-	-	L	M

Duration (hour)		Kinematic and Kinetic concepts of human motion	Skeletal and muscular movements	Functional Anatomy for the upper extremity	Functional Anatomy for the lower extremity	Biomechanics of spine and gait
		9	9	9	9	9
S-1	SLO-1	Forms of Motion	Mechanical properties of body tissues-Structural Analysis	Shoulder complex- Functional Characteristics of the Joints of the Shoulder	Pelvis and Hip Complex	Vertebral column
	SLO-2	Standard Reference Terminology	Mechanical properties of body tissues-Structural Analysis	Shoulder complex- Functional Characteristics of the Joints of the Shoulder	Pelvis and Hip Complex	Vertebral column
S-2	SLO-1	Joint Movement Terminology	Biomechanical Characteristics of Bone-Bone tissue function	Movement Characteristics of the Shoulder Complex	Structure of Hip joint	Structural and movement characteristics of spine
	SLO-2	Joint Movement Terminology	Composition of bone tissue	Movement Characteristics of the Shoulder Complex	Muscular actions of Hip	Structural and movement characteristics of spine
S-3	SLO-1	Qualitative analysis of human movement	Bone Modeling and Remodeling	Loads on the shoulder	Loads on the hip	Movements of spine
	SLO-2	Qualitative analysis of human movement	Bone Modeling and Remodeling	Loads on the shoulder	Loads on the hip	Movements of spine
S-4	SLO-1	Tools for measuring Kinematic quantities	Mechanical properties of bone-Strength and stiffness of bone	Elbow and Radioulnar joints- Functional Characteristics of the Joints of the Elbow	Structure of Knee joint	Posture and spinal stabilization
	SLO-2	Tools for measuring Kinematic quantities	Mechanical properties of bone-Strength and stiffness of bone	Elbow and Radioulnar joints- Functional Characteristics of the Joints of the Elbow	Structure of Knee joint	Posture and spinal stabilization

S-5	SLO-1	*Basic concepts related to kinetics*	*Maxwell and voight model*	*Movement Characteristics of the Elbow*	*Movement Characteristics of the Knee*	*Loads on spine*
	SLO-2	*Basic concepts related to kinetics*	*Maxwell and voight model*	*Movement Characteristics of the Elbow*	*Movement Characteristics of the Knee*	*Common injuries of spine*
S-6	SLO-1	*Mechanical loads on the human body*	*Loads applied on bone*	*Loads on the elbow*	*Loads on the knee*	*Gait cycle*
	SLO-2	*Mechanical loads on the human body*	*Stress fractures*	*Loads on the elbow*	*Loads on the Knee*	*Gait cycle*
S-7	SLO-1	*Effects of loading*	*Stress-Strain Relationship*	*Functional Characteristics of the joints Of the wrist and hand*	*Ankle and foot*	*Contribution of lower extremity musculature to movements*
	SLO-2	*Effects of loading*	*Soft tissue mechanics*	*Functional Characteristics of the joints Of the wrist and hand*	*Ankle and foot*	*Contribution of lower extremity musculature to movements*
S-8	SLO-1	*Tools for Measuring Kinetic quantities*	*Muscle tissue Properties*	*Combined movements of wrist and hand*	*Combined movements of Ankle and foot*	*Forces acting on the joints in the lower extremity*
	SLO-2	*Tools for Measuring Kinetic quantities*	*Muscle tissue Properties*	*Combined movements of wrist and hand*	*Combined movements of Ankle and foot*	*Forces acting on the joints in the lower extremity*
S-9	SLO-1	*Vector Composition*	*Force generation in the muscle*	*Common injuries of upper extremity*	*Common injuries of lower extremity*	*Case study*
	SLO-2	*Vector Resolution*	*Biomechanical Analysis of joints*	*Common injuries of upper extremity*	*Common injuries of lower extremity*	*Case study*

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

Learning Assessment

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

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

Course Designers

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

Course Code	18BMC303J	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 :	Understand the basic of signal processing techniques
CLR-2 :	Apply the concept of IIR filter design
CLR-3 :	Understand the concepts of FIR filter design and its application
CLR-4 :	Analyze the various signal processing algorithms in ECG.
CLR-5 :	Gain knowledge in Heart rate variability analysis
CLR-6 :	Analyze the speech signal and other biosignals using suitable signal processing techniques

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	Describe the DIT-FFT and DIF-FFT algorithm	1, 2	80%	70%	M														
CLO-2 :	Implement the IIF filter design in real time biosignals	2	80%	70%	M														
CLO-3 :	Analyze the FIR fitler design and its application	2	80%	70%			M		M								M		L
CLO-4 :	Apply the various signal processing algorithms in analysis of ECG.	3	80%	70%					M										
CLO-5 :	Analyze the signal processing methods used in HRV analysis	3	80%	70%	M												M		L
CLO-6 :	Apply the advanced techniques in various biosignals.	3	80%	70%	M														

		Basics of Signal Processing	IIR Filter design	FIR Filter design and its application	Analysis of ECG	Advanced techniques in Biosignal processing
Duration (hour)		15	15	15	15	15
S-1	SLO-1	Sampling	IIR Filter-Introduction	FIR filter-advantages and disadvantages	P-Wave detection	Speech signal analysis-Cepstrum
	SLO-2	Aliasing	Impulse invariant method	Characteristics	Estimation of R-R Interval	Analysis of complex cepstrum
S-2	SLO-1	FFT-Decimation in time radix-2 algorithm	Bilinear transformation method	Frequency method sampling method	QRS complex detection-Template subtraction method	Homomorphic filtering of speech signals
	SLO-2	Butterfly diagram	Problems	Type I and Type II	Template correlation method	Application
S-3	SLO-1	Implementation of DIT- FFT algorithm	Butterworth filter- magnitude response	FIR filter design using windowing techniques-Rectangular window	Pan Tompkins algorithm for QRS detection-block diagram	Spectral distortion using a warped frequency scale
	SLO-2	Implementation of DIT -FFT algorithm	Chebyshev filter-Magnitude response	Filter design using Hamming window	Algorithm and waveforms	LPC and MFCC co-efficient
S-4	SLO-1	Lab1: Basic signal operations	Lab4: Design of digital Butterworth IIR filter	Lab 7: FIR Filter using hamming windowing techniques	Lab 10: Analysis of ECG	Lab 13: Analysis of speech signals
	SLO-2	Lab1: Basic signal operations	Lab4: Design of digital Butterworth IIR filter	Lab 7: FIR Filter using hamming windowing techniques	Lab 10: Analysis of ECG	Lab 13: Analysis of speech signals
S-5	SLO-1	Lab1: Basic signal operations	Lab4: Design of digital Butterworth IIR filter	Lab 7: FIR Filter using hamming windowing techniques	Lab 10: Analysis of ECG	Lab 13: Analysis of speech signals
	SLO-2	Lab1: Basic signal operations	Lab4: Design of digital Butterworth IIR filter	Lab 7: FIR Filter using hamming windowing techniques	Lab 10: Analysis of ECG	Lab 13: Analysis of speech signals
S-6	SLO-1	FFT-Decimation in Frequency radix-2 algorithm	Design of butterworth filter using bilinear transformation technique	Filter design using Hanning window	Heart rate variability –Physiological origin	Synchronized averaging of PCG envelopes
	SLO-2	Butterfly diagram	Design of butterworth filter using bilinear transformation technique	Filter design using Hanning window	Generation of HRV	Envelogram
	SLO-1	Implementation of DIF- FFT algorithm	Design of butterworth filter using impulse invariant method	Magnitude response of hanning window	Clinical significance of HRV	Signal averaged ECG-Clinical significance

S-7	**SLO-2**	*Implementation of DIF -FFT algorithm*	*Design of butterworth filter using impulse invariant method*	*Phase response of hanning window*	*Factors Influences on HRV*	*Advantages and disadvantage*
S-8	**SLO-1**	*Different types of bioelectric signals*	*Design of Chebyshev filter using bilinear transformation technique*	*Filter design using Blackman window*	*Time domain methods of HRV*	*Normal and Ectopic ECG beats classification*
	SLO-2	*Characteristics*	*Design of Chebyshev filter using bilinear transformation technique*	*Filter design using Blackman window*	*Frequency domain Methods*	*Analysis of Exercise ECG*
S-9	**SLO-1**	*Lab2: DFT and FFT computations*	*Lab5: Design of digital Low pass Chebyshev IIR*	*Lab 8: FIR Filter using Hanning windowing*	*Lab 11: Analysis of Heart rate variability*	*Lab 14: Classification of Normal and abnormal*
			filter	*techniques*		*ECG*
	SLO-2	*Lab2: DFT and FFT computations*	*Lab5: Design of digital Low pass Chebyshev IIR filter*	*Lab 8: FIR Filter using Hanning windowing techniques*	*Lab 11: Analysis of Heart rate variability*	*Lab 14: Classification of Normal and abnormal ECG*
S-10	**SLO-1**	*Lab2: DFT and FFT computations*	*Lab5: Design of digital Low pass Chebyshev IIR filter*	*Lab 8: FIR Filter using Hanning windowing techniques*	*Lab 11: Analysis of Heart rate variability*	*Lab 14: Classification of Normal and abnormal ECG*
	SLO-2	*Lab2: DFT and FFT computations*	*Lab5: Design of digital Low pass Chebyshev IIR filter*	*Lab 8: FIR Filter using Hanning windowing techniques*	*Lab 11: Analysis of Heart rate variability*	*Lab 14: Classification of Normal and abnormal ECG*
S-11	**SLO-1**	*Bio impedance signals*	*Design of Chebyshev filter using impulse invariant method*	*Time domain filters -Moving averaging filters*	*Non-linear analysis of HRV*	*Adaptive segmentation of EEG signals –SEM method*
	SLO-2	*Characteristics*	*Design of Chebyshev filter using impulse invariant method*	*Algorithm*	*Pit falls in understanding HRV*	*ACF distance method*
S-12	**SLO-1**	*Bio acoustic signals*	*Frequency warping*	*Synchronized averaging filters*	*Adaptive filter –Introduction*	*Adaptive segmentation –procedure*
	SLO-2	*Characteristics*	*Prewarping effect*	*Algorithm*	*Adaptive noise canceller –block diagram*	*Adaptive segmentation –procedure*
S-13	**SLO-1**	*Bio mechanical signal*	*Frequency transformation-digital domain*	*Synchronized averaging filters*	*LMS adaptive filter algorithm*	*Spectral Analysis-Power spectral density*
	SLO-2	*Characteristics*	*Frequency transformation-digital domain*	*Algorithm*	*LMS adaptive filter algorithm*	*Cross Spectral density*
S-14	**SLO-1**	*Lab 3: Representation of biosignals*	*Lab 6: Design of digital high pass Chebyshev IIR filter*	*Lab 9: FIR Filter using blackman windowing techniques*	*Lab12: Adaptive filtering techniques*	*Lab15:Spectral analysis of signals*
	SLO-2	*Lab 3: Representation of biosignals*	*Lab 6: Design of digital high pass Chebyshev IIR filter*	*Lab 9: FIR Filter using blackman windowing techniques*	*Lab12: Adaptive filtering techniques*	*Lab15:Spectral analysis of signals*
S-15	**SLO-1**	*Lab 3: Representation of biosignals*	*Lab 6: Design of digital high pass Chebyshev IIR filter*	*Lab 9: FIR Filter using blackman windowing techniques*	*Lab12: Adaptive filtering techniques*	*Lab15:Spectral analysis of signals*
	SLO-2	*Lab 3: Representation of biosignals*	*Lab 6: Design of digital high pass Chebyshev IIR filter*	*Lab 9: FIR Filter using blackman windowing techniques*	*Lab12: Adaptive filtering techniques*	*Lab15: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 (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Understand										
Level 2	Apply	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
	Analyze										
Level 3	Evaluate	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Create										
	Total	100 %		100 %		100 %		100 %		-	

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

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Course Code	18BMC304J	Course Name	MICROCONTROLLER 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 :	Understand the fundamental concepts of 8086 microprocessors
CLR-2 :	Explain the basic concepts of 8051 microcontroller
CLR-3 :	Obtain knowledge on interfacing devices
CLR-4 :	Have an insight on Microcontroller
CLR-5 :	Familiarize about ARM microcontroller
CLR-6 :	Acquire knowledge on applications of microprocessor and microcontroller in biomedical domain.

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (Bloom)	Learning 2 Expected Proficiency (%)	Learning 3 Expected Attainment (%)	PLO 1 Engineering Knowledge	PLO 2 Problem Analysis	PLO 3 Design & Development	PLO 4 Analysis, Design, Research	PLO 5 Modern Tool Usage	PLO 6 Society & Culture	PLO 7 Environment & Sustainability	PLO 8 Ethics	PLO 9 Individual & Team Work	PLO 10 Communication	PLO 11 Project Mgt. & Finance	PLO 12 Life Long Learning	PLO 13 PSO - 1	PLO 14 PSO - 2	PLO 15 PSO - 3
CLO-1 :	Describe the fundamental concepts of 8086 microprocessors	1, 2	80%	70%	M														
CLO-2 :	Implement the concepts of 8051 microcontroller	2	80%	70%	M														
CLO-3 :	Analyze the features of interfacing devices	2	80%	70%			M		M								M		L
CLO-4 :	Apply the concepts of RISC Processor	3	80%	70%					M										
CLO-5 :	Develop programming skill	3	80%	70%	M												M		L
CLO-6 :	Program for Biomedical appplications	3	80%	70%	M														

		8086 Processor	8051 Microcontroller	Interfacing devices	ARM Microcontroller	Applications in Medicine
Duration (hour)		15	15	15	15	15
S-1	SLO-1	Evolution of Microprocessor	Introduction to Microcontroller	Introduction to 8251	Reduced Instruction Set Computer (RISC) Design Physiology	Mobile phone based bio signal recording
	SLO-2	Evolution of Microprocessor	Difference between Microprocessor and Microprocessor	8251 : Architecture	Difference between RISC and Complex Instruction Set Computer (Processor	Mobile phone based bio signal recording
S-2	SLO-1	signal description of 8086	signal description of 8051	8251 : Architecture	Major Design rules	Mobile phone based bio signal recording
	SLO-2	signal description of 8086	signal description of 8051	8251: Processing Mode	Major Design rules	Design of pulse oximeter circuit using ARM microcontroller
S-3	SLO-1	Architecture	Architecture	Interfacing to external memory	ARM Design Physiology	Design of pulse oximeter circuit using ARM microcontroller
	SLO-2	Architecture	Architecture	Interfacing to external memory	ARM core data flow model	Design of pulse oximeter circuit using ARM microcontroller
S-4	SLO-1	Lab1: 16 Bit addition	Lab4: 8 bit addition using 8051 microcontroller	Lab 7: Generate Sawtooth Waveform	Lab 10: Assembly language program to compute sum of n consecutive numbers and to find the factorial of the result	Lab 13: Mini Project
	SLO-2	Lab1: 16 Bit addition	Lab4: 8 bit addition using 8051 microcontroller	Lab 7: Generate Sawtooth Waveform	Lab 10: Assembly language program to compute sum of n consecutive numbers and to find the factorial of the result	Lab 13: Mini Project
S-5	SLO-1	Lab1: Block transfer of data type	Lab4: 8 bit subtraction using 8051 microcontroller	Lab 7: Generate Triangular Waveform	Lab 10: Assembly language program to compute sum of n consecutive numbers and to find the factorial of the result	Lab 13: Mini Project
	SLO-2	Lab1: Block transfer of data type	Lab4: 8 bit subtraction using 8051 microcontroller	Lab 7: Generate Triangular Waveform	Lab 10: Assembly language program to compute sum of n consecutive numbers and to find the factorial of the result	Lab 13: Mini Project

S-6	**SLO-1**	*Addressing modes*	*Addressing modes*	*Timer interfacing*	*ARM core data flow model*	*Design of EOG based home appliances using PIC microcontroller*
	SLO-2	*Addressing modes*	*Addressing modes*	*Timer interfacing*	*Processor Modes*	*Design of EOG based home appliances using PIC microcontroller*
S-7	**SLO-1**	*Minimum mode operation*	*Register set of 8051*	*Basic techniques for reading & writing from I/O port pins*	*Registers*	*Design of EOG based home appliances using PIC microcontroller*
	SLO-2	*Minimum mode operation*	*Instruction set : Data transfer*	*Basic techniques for reading & writing from I/O port pins*	*ARM Instruction set*	*Analysis of EMG signal using microcontroller*
S-8	**SLO-1**	*Maximum mode operation*	*Instruction set : Arithmetic, Logical*	*Interfacing 8051 to ADC*	*ARM Instruction set*	*Analysis of EMG signal using microcontroller*
	SLO-2	*Maximum mode operation*	*Instruction set : String Manipulating Instructions, control transfer*	*Interfacing 8051 to ADC*	*ARM Instruction set*	*Analysis of EMG signal using microcontroller*
S-9	**SLO-1**	*Lab2: Sum of n numbers*	*Lab5: One and two complement of a number*	*Lab 8: Generate Sine Waveform*	*Lab 11: Assembly language program to compute factorial of a number and to compute the parity of the result*	*Lab 14: Mini Project*
	SLO-2	*Lab2 Sum of n numbers*	*Lab5: One and two complement of a number*	*Lab 8: Generate Sine Waveform*	*Lab 11: Assembly language program to compute factorial of a number and to compute the parity of the result*	*Lab 14: Mini Project*
S-10	**SLO-1**	*Lab2: Sum of n numbers*	*Lab5: One and two complement of a number*	*Lab 8: Generate Square Waveform*	*Lab 11: Assembly language program to compute factorial of a number and to compute the parity of the result*	*Lab 14: Mini Project*
	SLO-2	*Lab2: Sum of n numbers*	*Lab5: One and two complement of a number*	*Lab 8: Generate Square Waveform*	*Lab 11: Assembly language program to compute factorial of a number and to compute the parity of the result*	*Lab 14: Mini Project*
S-11	**SLO-1**	*Instruction set : Data transfer*	*Special Function Registers*	*Stepper motor*	*Exceptions*	*Analysis of EEG signal using microcontroller*
	SLO-2	*Instruction set : Arithmetic, Logical*	*Special Function Registers*	*Stepper motor*	*Exceptions*	*Analysis of EEG signal using microcontroller*
S-12	**SLO-1**	*Instruction set : String Manipulating Instructions*	*Special Function Registers*	*Keyboard Interfacing*	*Thumb Instruction set*	*Analysis of EEG signal using microcontroller*
	SLO-2	*Instruction set : Control Transfer Instructions*	*8086 Interrupt*	*Keyboard Interfacing*	*Thumb Instruction set*	*Design of heart rate monitoring circuit using ARM microcontroller*
S-13	**SLO-1**	*8086 Interrupt*	*8086 Interrupt*	*Liquid crystal display (LCD)*	*Thumb Instruction set*	*Design of heart rate monitoring circuit using ARM microcontroller*
	SLO-2	*8086 Interrupt*	*Memory interfacing*	*Liquid crystal display (LCD)*	*Thumb Instruction set*	*Design of heart rate monitoring circuit using ARM microcontroller*
S-14	**SLO-1**	*Lab 3: Sorting even and odd numbers in an array*	*Lab 6: Fibonacci series*	*Lab 9: Stepper motor Interface*	*Lab12: Assembly language program to determine the bigger number of two given number*	*Lab 15: Mini Project*
	SLO-2	*Lab 3: Sorting even and odd numbers in an array*	*Lab 6: Fibonacci series*	*Lab 9: Stepper motor Interface*	*Lab12: Assembly language program to determine the bigger number of two given number*	*Lab 15: Mini Project*
S-15	**SLO-1**	*Lab 3: Sorting even and odd numbers in an array*	*Lab 6: Fibonacci series*	*Lab 9: Stepper motor Interface*	*Lab12: Assembly language program to determine the bigger number of two given number*	*Lab 15: Mini Project*
	SLO-2					

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, 2nd edition, 2006.*	3. *Andrew N.Sloss,DonimicSymes, Chris Wright, "ARM System Developer's Guide", Elsevier, 1st edition, 2007.* 4. *Muhammad Ali Mazidi and JanicaGilliMazidi, 'The 8051 microcontroller and embedded systems', Pearson Education, 5th Indian reprint, 2003.*

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

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

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Course Code	18BMC305T	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 :	Learn about mathematical modeling of mechanical and electrical systems
CLR-2 :	Acquire knowledge about the transient and steady state error and analysis
CLR-3 :	Identify and analyze stability of a system in time domain using root locus technique
CLR-4 :	Know about different frequency domain analytical techniques
CLR-5 :	Acquire the knowledge of various controllers used in control systems
CLR-6 :	Learn about the biomedical applications of control systems

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (Bloom)	Learning 2 Expected Proficiency (%)	Learning 3 Expected Attainment (%)
CLO-1 :	Determine Transfer function of a system by mathematical modeling, block diagram reduction and signal flow graphs	1, 2	80	70
CLO-2 :	Identify the standard test inputs, time domain specifications and calculate steady state error	1, 2	80	70
CLO-3 :	Plot a root locus curve and analyze the system stability using Routh array	2	80	70
CLO-4 :	Analyze the frequency domain specifications from bode plot	1	80	70
CLO-5 :	Plot polar plots	1	80	70
CLO-6 :	Modelling of lung mechanics	1,2	80	70

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

Duration (hour)		Mathematical Modelling	Time Response Analysis	Stability Analysis	Frequency Response Analysis	State Space Variable Analysis and Biomedical Applications
		9	9	9	9	9
S-1	SLO-1	Control system terminology-classification of control systems, SISO and MIMO control systems	Standard test signals- step, ramp, parabolic and impulse	Poles and zeros of a system	Frequency domain analysis	Introduction to state space
	SLO-2	Feedback and its effects on overall gain, stability, noise and sensitivity	Derivation of expression for standard test signals	Pole zero plot and concept of s plane	Frequency domain specifications	General state space representation
S-2	SLO-1	Open loop and closed loop control systems with physiological system examples	Type and order of a system	Characteristic equation	Estimation of frequency domain specifications	Applying the state space representation
	SLO-2	Advantages and disadvantages of OLCS and CLCS systems	Transfer function of First order system for Step and ramp input signal	Concept of stability from pole zero location	Correlation between time and frequency domain	Applying the state space representation
S-3	SLO-1	Transfer function of a system and basics of Laplace transform	Transfer function of First order system Impulse and parabolic input signal	Need for Stability analysis and available techniques	Bode plot approach and stability analysis	Converting a transfer function to state space
	SLO-2	Transfer function of translational mechanical systems	General transfer function of second order system	Necessary and sufficient Conditions for stability	Rules for sketching bode plot	Converting a transfer function to state space
S-4	SLO-1	Transfer function of translational mechanical systems	Identification of damping factor and classification based on it	Routh Hurwitz Technique	Bode plot of typical systems	Converting from state space to a transfer function
	SLO-2	Transfer function of rotational mechanical systems	Step response of critically damped second order system	Significance of Routh Hurwitz Technique	Bode plot of typical systems	Converting from state space to a transfer function

S-5	**SLO-1**	*Transfer function of electrical systems*	*Step response of under damped second order system*	*Computation of Routh array*	*Bode plot of typical systems*	*Controllers-P, PI and PID controllers*
	SLO-2	*Transfer function of electrical systems*	*Step response of over damped second order system*	*Routh array of stable systems*	*Bode plot of typical systems*	*Controllers-P, PI and PID controllers*
S-6	**SLO-1**	*Analogous systems*	*Step response of undamped second order system*	*Routh array of Unstable systems*	*Nyquist stability criterion*	*Physiological control system analysis*
	SLO-2	*Analogous systems*	*Transfer function-Time constant form and pole zero form*	*Routh array of Unstable systems*	*Nyquist stability criterion*	*A simple example*
S-7	**SLO-1**	*Block diagram reduction technique*	*Time domain specifications*	*Root locus technique*	*Sketching of polar plot*	*Linear model of physiological system-Example1*
	SLO-2	*Block diagram reduction technique*	*Evaluation of time domain specifications*	*Rules for construction of root locus*	*Sketching of polar plot*	*Linear model of physiological system-Example2*
S-8	**SLO-1**	*Signal flow graph*	*Transient and steady state error analysis*	*Root locus plot of typical systems*	*Sketching of polar plot*	*Distributed parameter Vs Lumped paramter models*
	SLO-2	*Signal flow graph*	*Static and dynamic Error coefficients*	*Root locus plot of typical systems*	*Sketching of polar plot*	*Distributed parameter Vs Lumped paramter models*
S-9	**SLO-1**	*Conversion of block diagram to signal flow graph*	*Static error constants and evaluation of steady state error*	*Root locus plot of typical systems*	*Polar plot and significance*	*Lung mechanics model with proportional control*
	SLO-2	*Conversion of block diagram to signal flow graph*	*Dynamic error constants and evaluation of steady state error*	*Effect of adding poles and zeros to a system*	*Polar plot and significance*	*Lung mechanics model with proportional control*

Learning Resources	*1.* Nagrath.J and Gopal.M,, "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 (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*40 %*	-	*40 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*20 %*	-	*20 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

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Course Designers

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

Course Code	18BMC306J	Course Name	MEDICAL IMAGE PROCESSING	Course Category	C	Professional core	L	T	P	C
							3	0	2	4

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Understand the basic image operations and image transforms
CLR-2 :	Apply various image enhancement techniques in medical images
CLR-3 :	Understand the concepts of Image restoration and reconstruction techniques
CLR-4 :	Analyze the various types of image segmentation algorithms
CLR-5 :	Gain knowledge in Image compression methods
CLR-6 :	The learner gains knowledge in fusion of two different modality images

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (Bloom)	Learning 2 Expected Proficiency (%)	Learning 3 Expected Attainment (%)	PLO 1 Engineering Knowledge	PLO 2 Problem Analysis	PLO 3 Design & Development	PLO 4 Analysis, Design, Research	PLO 5 Modern Tool Usage	PLO 6 Society & Culture	PLO 7 Environment & Sustainability	PLO 8 Ethics	PLO 9 Individual & Team Work	PLO 10 Communication	PLO 11 Project Mgt. & Finance	PLO 12 Life Long Learning	PLO 13 PSO - 1	PLO 14 PSO - 2	PLO 15 PSO - 3
CLO-1 :	Describe the elements of visual perception and various types of image transforms	1, 2	80%	70%	M														
CLO-2 :	Implement the image enhancement techniques for improving the quality of images	2	80%	70%	M														
CLO-3 :	Analyze the various image restoration and reconstruction methods used for medical images	2	80%	70%			M		M								M		L
CLO-4 :	Apply the different image segmentation algorithms for various medical applications	3	80%	70%					M										
CLO-5 :	Differentiate and analyze the various image compression techniques	3	80%	70%	M												M		L
CLO-6 :	Illustrate the concepts of image fusion	3	80%	70%	M														

		Fundamental Image operations and Transforms	Image Enhancement methods	Image Restoration and Reconstruction Techniques	Image Segmentation Techniques	Image Compression and Image Fusion methods
Duration (hour)		15	15	15	15	15
S-1	SLO-1	Fundamentals steps in Digital Image processing	Basic Intensity transformation functions - image negative, intensity slicing techniques	Image restoration-Mean filters	Point detection- Detection of isolated points	Image compression-Introduction
	SLO-2	Components of an Image processing system	Contrast stretching, log transformation and power law transformation	Order-statistic and Adaptive filters	Line detection	Types of redundancies
S-2	SLO-1	Elements of Visual Perception- structure of human eye and image formation	Histogram equalization	Image degradation model	Basic edge detection	Huffman coding technique
	SLO-2	Brightness range adaptation and discrimination	Histogram equalization	properties	Marr-Hildreth edge detector	Procedure
S-3	SLO-1	Image sensing and acquisition-using a single sensor	Histogram specification	Inverse filtering	Canny edge detector	Arithmetic coding technique
	SLO-2	Using sensor strips	Histogram matching	Minimum mean square error (wiener) filtering	Algorithm	Run length coding technique
S-4	SLO-1	Lab1: Basic operations on images	Lab4: Intensity transformation and histogram equalization	Lab 7: Image restoration using adaptive filters	Lab 10: Edge detection techniques	Lab 13: Image compression
	SLO-2	Lab1: Basic operations on images	Lab4: Intensity transformation and histogram equalization	Lab 7: Image restoration using adaptive filters	Lab 10: Edge detection techniques	Lab 13: Image compression
S-5	SLO-1	Lab1: Basic operations on images	Lab4: Intensity transformation and histogram equalization	Lab 7: Image restoration using adaptive filters	Lab 10: Edge detection techniques	Lab 13: Image compression
	SLO-2	Lab1: Basic operations on images	Lab4: Intensity transformation and histogram equalization	Lab 7: Image restoration using adaptive filters	Lab 10: Edge detection techniques	Lab 13: Image compression
S-6	SLO-1	Basic concepts in Image sampling and quantization	Smoothening linear filters	Image reconstruction from projections- Transmission tomography	Thresholding- Foundation	Predictive coding- lossless

	SLO-2	*Spatial and intensity resolution*	*Non linear filters*	*Refection and emission tomography*	*Basic global thresholding*	*Lossy predictive coding*
S-7	**SLO-1**	*Some basic relationships between pixels-Neighbors of pixel*	*Sharpening spatial filters*	*Radon transform- derivation*	*Optimum global thresholding using otsu's method*	*Image fusion-Introduction*
	SLO-2	*Adjacency, connectivity and distance measures*	*First order Derivative filters*	*Properties*	*Alogrithm*	*Pixel based image fusion techniques*
S-8	**SLO-1**	*Image Arithmetic operations*	*Second order derivative filters*	*Inverse radon transform- convolution back projection*	*Region based segmentation- Region growing*	*Wavelet transform based image fusion*
	SLO-2	*Logical operations*	*Un sharp masking and high boost filtering*	*Filter back projection*	*Region splitting and merging algorithm*	*Wavelet transform based image fusion*
S-9	**SLO-1**	*Lab2: Image Arithmetic and logical operations*	*Lab5: Filtering using averaging filter, unsharp masking and high boost filtering*	*Lab 8: Image reconstruction using radon transform*	*Lab 11: Global and otsu's thresholding*	*Lab 14: Image fusion*
	SLO-2	*Lab2: Image Arithmetic and logical operations*	*Lab5: Filtering using averaging filter, unsharp masking and high boost filtering*	*Lab 8: Image reconstruction using radon transform*	*Lab 11: Global and otsu's thresholding*	*Lab 14: Image fusion*
S-10	**SLO-1**	*Lab2: Image Arithmetic and logical operations*	*Lab5: Filtering using averaging filter, unsharp masking and high boost filtering*	*Lab 8: Image reconstruction using radon transform*	*Lab 11: Global and otsu's thresholding*	*Lab 14: Image fusion*
	SLO-2	*Lab2: Image Arithmetic and logical operations*	*Lab5: Filtering using averaging filter, unsharp masking and high boost filtering*	*Lab 8: Image reconstruction using radon transform*	*Lab 11: Global and otsu's thresholding*	*Lab 14: Image fusion*
S-11	**SLO-1**	*Image transforms-DFT and its properties*	*Color image processing-Introduction*	*Digital implementation of filter back projection-Block diagram*	*Segmentation using morphological watersheds-dam construction*	*PCA based image fusion techniques*
	SLO-2	*DCT and its properties*	*Color models*	*Different filters*	*Watershed segmentation algorithm*	*PCA based image fusion techniques*
S-12	**SLO-1**	*DST and its properties*	*Conversion of RGB to HSI model*	*Digital implementation of filter back projection-Algorithm*	*Clustering based segmentation techniques*	*Transform based fusion techniques- DCT*
	SLO-2	*Hadamard transform and its properties*	*Conversion of HSI to RGB Model*	*Implementation procedure*	*Algorithms*	*Transform based fusion techniques- DCT*
S-13	**SLO-1**	*Haar transform and its properties*	*Pseudo color image processing- slicing technique*	*Fourier reconstruction of MRI images-projection geometry mode*	*Basic Active Contour Model*	*Image registration-Introduction*
	SLO-2	*Haar transform and its properties*	*Filtering approach*	*Fourier geometry mode.*	*Formulation (Feature extraction techniques)*	*Types of image registration*
S-14	**SLO-1**	*Lab 3: Image transforms in frequency domain*	*Lab 6: Color image processing*	*Lab 9: Fourier reconstruction of MRI images*	*Lab 12:Image segmentation by watershed algorithm*	*Lab 15: Image registration*
	SLO-2	*Lab 3: Image transforms in frequency domain*	*Lab 6: Color image processing*	*Lab 9: Fourier reconstruction of MRI images*	*Lab 12:Image segmentation by watershed algorithm*	*Lab 15: Image registration*
S-15	**SLO-1**	*Lab 3: Image transforms in frequency domain*	*Lab 6: Color image processing*	*Lab 9: Fourier reconstruction of MRI images*	*Lab 12:Image segmentation by watershed algorithm*	*Lab 15: Image registration*
	SLO-2	*Lab 3: Image transforms in frequency domain*	*Lab 6: Color image processing*	*Lab 9: Fourier reconstruction of MRI images*	*Lab 12:Image segmentation by watershed algorithm*	*Lab 15: 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 (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Understand										
Level 2	Apply	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
	Analyze										
Level 3	Evaluate	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Create										
	Total	100 %		100 %		100 %		100 %		-	

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

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Course Code	18BMC401T	Course Name	BIOMEDICAL EQUIPMENTS FOR CLINICAL APPLICATIONS	Course Category	C	Professional Core	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning		
		1	2	3
CLR-1 :	Understand the fundamentals of diagnostic and therapeutic equipments	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-2 :	Get an idea about functioning of different types of physiotherapy and electrotherapy equipments			
CLR-3 :	Acquire an idea about the the instruments dealing with bone			
CLR-4 :	Get an idea about the respiratory care equipments			
CLR-5 :	Get an idea about diagnosis procedure of hearing problems and Hearing aids			
CLR-6 :	Get an overall idea about laparoscope			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	Outline the importance of therapeutic and diagnostic devicesmedical device	1, 2	80	70
CLO-2 :	Analyze the types of pacemakers	1, 2	80	70
CLO-3 :	Apply the principle of ultrasound in diagnostic and therapeutic application	2	80	70
CLO-4 :	Outline the importance of respiratory care equipments	1	80	70
CLO-5 :	Understand the importance and design procedure of hearing aids	1	80	70
CLO-6 :	Understand the concept of surgical diathermy	1,2	80	70

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

Duration (hour)		Coronary Care Equipments	Physiotherapy, Electrotherapy and Phototherapy Equipments	Instruments Dealing With Bones and Respiratory Care	Sensory Diagnosis and Hearing Aid Equipments	Surgical and Therapeutic Equipments
		9	9	9	9	9
S-1	SLO-1	Cardiac pacemakers: different modes of operation	Short wave diathermy	Introduction to Respiratory care equipments	Mechanism of hearing	Surgical diathermy unit
	SLO-2	external pacemaker	Short wave diathermy	humidifier	Mechanism of hearing	Surgical diathermy unit
S-2	SLO-1	implantable pacemakers,	Advantages of Microwave diathermy over shortwave diathermy	nebulizer	sound conduction system	Endoscopy basic components
	SLO-2	pacemaker standard codes	Microwave diathermy	aspirators	sound conduction system	Endoscopy basic components
S-3	SLO-1	Defibrillator: AC defibrillator	Ultrasound application in medical diagnostic	Working of Ventilators	basic audiometer	Endoscopy different types
	SLO-2	DC defibrillator	Working details of Ultrasonic therapy unit	Ventilators types	pure tone audiometer	Endoscopy different types
S-4	SLO-1	Implantable defibrillator	Electro diagnostic apparatus	capnography	Speech audiometer	Laparoscope
	SLO-2	types	Electro diagnostic apparatus	capnography	bekesyaudiometer system	Laparoscope
	SLO-1	automated external defibrillator (AED)	Electro therapeutic apparatus	Anesthesia machine	bekesyaudiometer system	gastro scope

S-5	SLO-2	*automated external defibrillator (AED)*	*Electro therapeutic apparatus*	*Anesthesia machine*	*Evoked response audiometry system*	*bronchoscope*
S-6	SLO-1	Pacer- cardioverter defibrillator,	*Interferential current therapy,)*	*Baby incubator*	*Evoked response audiometry system*	*Cryogenic techniques*
	SLO-2	Pacer- cardioverter defibrillator	*Interferential current therapy,)*	*BMD measurements: Single X-ray absorptiometry (SXA)*	*Hearing aids*	*Cryogenic techniques*
S-7	SLO-1	*defibrillator analysers*	*Transcutaneous electrical nerve stimulation (TENS)*	*BMD measurements: Single X-ray absorptiometry (SXA)*	*Hearing aids*	*Cryogenic technique application*
	SLO-2	*Heart lung machine (HLM)*	*bladder stimulator*	*Dual X-ray absorptiometry (DXA)*	*galvanic skin response*	*Operating microscope*
S-8	SLO-1	*Heart lung machine (HLM)*	*Spinal cord stimulator,*	*Dual X-ray absorptiometry (DXA)*	*galvanic skin response*	*arthroscopy*
	SLO-2	*Functional details of oxygenators*	*deep brain stimulation*	*Quantitative ultrasound bone densitometer*	*Tonometry*	*Modern lithotripter system*
S-9	SLO-1	*types of oxygenators*	*Photo therapy unit*	*Quantitative ultrasound bone densitometer*	*Measurement of basal skin response*	*laser lithotripsy*
	SLO-2	*types of oxygenators*	*Photo therapy unit*	*Comparison of DXA and Bone densitometer*	*galvanic skin response*	*Hospital visit*

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

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		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*40 %*	-	*40 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*20 %*	-	*20 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

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