Faculty of Engineering and Technology

CURRICULUM, PRE-REQUISITES/ CO-REQUISITES CHART, AND SYLLABUS FOR B.TECH

UNDER CHOICE BASED FLEXIBLE CREDIT SYSTEM

REGULATIONS 2015

(For students admitted from 2015-16 onwards)

Specialization: Biomedical Engineering
Offering Department: Biomedical Engineering

Placed in the 32nd Academic Council Meeting held on 23rd July 2016

CONTENTS

FACULTY of ENGinEERinG and TECHNOLOGY, SRM UNIVERSITY

DEPARTMENT of BIOMEDICAL ENGinEERinG ENGinEERinG

B.TECH BIOMEDICAL ENGinEERinG CHOICE BASED FLEXIBLE CREDIT SYSTEM (CBFCS) Curriculum Under Regulations 2015 (for students admitted from 2015-16 onwards)

L	Lecture Hours / Week	T Tutorial Hours / Week	C	Credits	P Practical Hours / Week	L	Laboratory Course	E Elective Courses	J	Theory jointly with Lab	M Course with Multidisciplinary content

Category	Category - wise % of Credits	Year 1												Year 2									
		1st Semester						2nd Semester						1st Semester						2nd Semester				
		Course Code	Course Title	L	T	P	C	Course Code	Course Title	L	T	P	C	Course Code	Course Title	L	T	P	C	Course Code	Course Title	L	T	P	C
Arts & Humanities-G	8.33%	15LE101	English	2	0	0	2	15LE102	Value Education	2	0	0	2	15LE201E	German Language -I	2	0	0	2	15LE207E	German Language -II	2	0	0	2
		15PD101	Soft Skills-I	1	1	0	1	15PD102	Soft Skills-II	1	1	0	1	15LE202E	French Language -I					15LE208E	French Language -II				
								15NC101	NCC- National Cadet Corps	0	0	1	1	15LE203E	Japanese Language - I					15LE209E	Japanese Language -II				
								15NS101	NSS- National Service Scheme					15LE204E	Korean Language -I					15LE210E	Korean Language - II				
								15SP101	NSO- National Sports Organization					15LE205E	Chinese Language - I					15LE211E	Chinese Language - II				
								15YG101	Yoga					15PD201	Quantitative Aptitude & Logical Reasoning -I	1	1	0	1	15PD202	Verbal Aptitude	1	1	0	1
	15		Total	3	1	0	3		Total	3	1	1	4		Total	3	1	0	3		Total	3	1	0	3
Basic Sciences - B	19.44%	15MA103	Matrices and Calculus	3	1	0	4	15MA104	Multiple integrals and Differential Equations	3	1	0	4	15MA204	Transform Techniques and Partial Differential Equations for Biomedical Engineering	4	0	0	4	15MA206	Numerical Methods	4	0	0	4
		15PY101	Physics	3	0	0	3	15PY102L	Materials Science	2	0	2	3												
		15PY101L	Physics Laboratory	0	0	2	1	15CY102	Principles of Environmental Science	2	0	0	2												
		15CY101	Chemistry	3	0	0	3																		
		15CY101L	Chemistry Laboratory	0	0	2	1																		
		15BT101	Biology for Engineers	2	0	0	2																		
	35		Total	11	1	4	14		Total	7	1	2	9		Total	4	0	0	4		Total	4	0	0	4
Engineering Sciences -E	8.33%	15CE101	Basic Civil Engineering	2	0	0	2	15ME101	Basic Mechanical Engineering	2	0	0	2												
		15EE101	Basic Electrical Engineering	2	0	0	2	15EC101	Basic Electronics Engineering	2	0	0	2												
		15ME105L	Engineering Graphics	1	0	4	3	15EE102L	Electrical Engineering Practices	0	0	2	1												
		15CS101L	Programming Laboratory	1	0	2	2	15EC102L	Electronics Engineering Practices	0	0	2	1												
	15		Total	6	0	6	9		Total	4	0	4	6		Total	0	0	0	0		Total	0	0	0	0
Professional - Core -P	40.56%							15BT103	Biochemistry	3	0	0	3	15EE234J	Fundamentals of Circuits and Networks	3	0	2	4	15EC251J	Introduction to Electronic Devices and Circuits	3	0	2	4
														15BM202J	Digital Logic Circuits for Clinical Engineers	3	0	2	4	15BM207J	Integrated Circuit Design for Bioinstrumentation	3	0	2	4
														15BM203	Human Anatomy and Physiology for Engineers	3	1	0	4	15BM208	Biomedical Signals and Systems	3	0	0	3
														15BM204J	Biomedical Sensors and Measurement Devices	3	0	2	4						
														15BM205	Biomaterials and Artificial Organs	3	0	0	3						
	73		Total	0	0	0	0		Total	3	0	0	3		Total	15	1	6	19		Total	9	0	4	11
Prof - Electives -P	8.33%																				**Dept Elective-I**	**3**	**0**	**0**	**3**
																					Dept Elective-II	**3**	**0**	**0**	**3**
	18		Total	0	0	0	0		Total	0	0	0	0		Total	0	0	0	0		Total	6	0	0	6
Project / Seminar / internship-P	8.33%																			15BM375L / 15BM380L / 15BM385L / 15BM490L	Minor Project I / Seminar I / Massive open online courses (MOOCs) I / Industry Module I	0	0	3	2
	18		Total	0	0	0	0		Total	0	0	0	0		Total	0	0	0	0		Total	0	0	3	2
Open Electives	`																								
	6		Total	0	0	0	0		Total	0	0	0	0		Total	0	0	0	0		Total	0	0	0	0
Total	**180**			**20**	**2**	**10**	**26**			**17**	**2**	**7**	**22**			**22**	**2**	**6**	**26**			**22**	**1**	**7**	**26**
			Contact hours	**32**					**Contact hours**	**26**					**Total contact hours**	**30**					**Total Contact hours**	**30**			

FACULTY of ENGinEERinG and TECHNOLOGY, SRM UNIVERSITY

DEPARTMENT of BIOMEDICAL ENGinEERinG ENGinEERinG

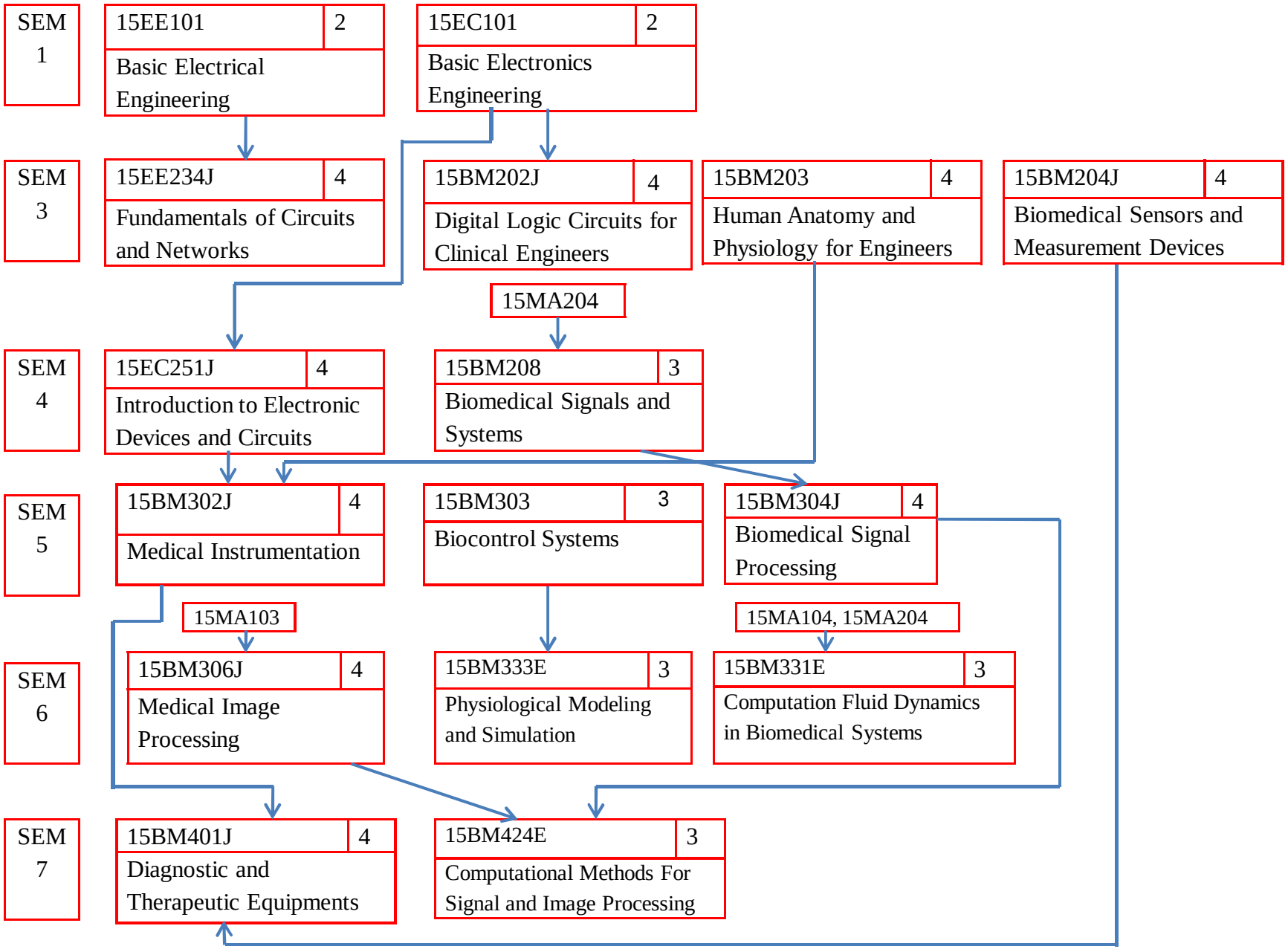
B.TECH BIOMEDICAL ENGinEERinG CHOICE BASED FLEXIBLE CREDIT SYSTEM (CBFCS) Curriculum Under Regulations 2015 (for students admitted from 2015-16 onwards)

L	Lecture Hours / Week	T	Tutorial Hours / Week		C Credits	P Practical Hours / Week	L	Laboratory Course			E Elective Courses	J	Theory jointly with Lab			M Course with Multidisciplinary content				
	Year 3												Year 4							
	1st Semester					2nd Semester							1st Semester					2nd Semester				
Course Code	**Course Title**	**L**	**T**	**P**	**C**	**Course Code**	**Course Title**	**L**	**T**	**P**	**C**	**Course Code**	**Course Title**	**L**	**T**	**P**	**C**	**Course Code**	**Course Title**	**L**	**T**	**P**	**C**
15PD301	Communication & Reasoning Skills	1	1	0	1	15PD302	Quantitative Aptitude & Logical Reasoning –II	1	1	0	1												
	Total	1	1	0	1		Total	1	1	0	1		Total	0	0	0	0		Total	0	0	0	0
15MA301	Probability and Statistics	4	0	0	4																		
	Total	4	0	0	4		Total	0	0	0	0		Total	0	0	0	0		Total	0	0	0	0
	Total	0	0	0	0		Total	0	0	0	0		Total	0	0	0	0		Total	0	0	0	0
15BM301	Diagnostic Imaging Systems	3	0	0	3	15BM305J	Microprocessor Systems in Medicine	3	0	2	4	15BM401J	Diagnostic and Therapeutic Equipments	3	0	2	4						
15BM302J	Medical instrumentation	3	0	2	4	15BM306J	Medical Image Processing	3	0	2	4	15BM402	Neural Networks and Fuzzy Logic Systems in Medicine	3	1	0	4						
15BM303	Biocontrol Systems	3	0	0	3	15BM307M	Multi-Disciplinary Design	2	2	0	3												
15BM304J	Biomedical Signal Processing	3	0	2	4							15BM403	Human Assist Devices and Implant Technology	3	0	0	3						
												15BM404	Analog and Digital Communication	3	1	0	4						
	Total	12	0	4	14		Total	8	2	4	11		Total	12	2	2	15		Total	0	0	0	0
	Dept Elective-III	**3**	**0**	**0**	**3**		**Dept Elective-IV**	**3**	**0**	**0**	**3**		**Dept Elective-VI**	**3**	**0**	**0**	**3**						
							Dept Elective-V	**3**	**0**	**0**	**3**												
	Total	3	0	0	3		Total	6	0	0	6		Total	3	0	0	3		Total	0	0	0	0
15BM390L	Internship/Industrial Training I (To undertake after IV semester)	0	0	2	1	15BM376L / 15BM381L / 15BM386L / 15BM491L	Minor Project II / Seminar II / Massive open online courses (MOOCs) II /Industry Module II	0	0	3	2	15BM391L	Internship/Industrial Training II (To undertake after VI semester)	0	0	2	1	15BM496L	Major Project	0	0	24	12
	Total	0	0	2	1		Total	0	0	3	2		Total	0	0	2	1		Total	0	0	24	12
	Open Elective I	3	0	0	3		Open Elective II	3	0	0	3												
	As per list / as taken by the student						As per list / as taken by the student																
	Total	3	0	0	3		Total	3	0	0	3		Total	0	0	0	0		Total	0	0	0	0
		23	**1**	**6**	**26**			**18**	**3**	**7**	**23**			**15**	**2**	**4**	**19**			**0**	**0**	**24**	**12**
	Total Contact hours	**30**					**Total contact hours**	**28**					**Total contact hours**	**21**					**Total contact hours**	**24**			

B.Tech Biomedical Engineering (Regulations 2015)							B.Tech Biomedical Engineering (Regulations 2015)							
Department Elective I and II							Department Elective VI							
COURSE CODE	**Course Title**	**L**	**T**	**P**	**C**		**COURSE CODE**	**Course Title**	**L**	**T**	**P**	**C**		
15BM221E	Biophotonics	3	0	0	3		15BM422E	BioMEMS	3	0	0	3		
15BM222E	Applied Optoelectronics in Medicine	3	0	0	3		15BM423E	Pattern Recognition and Expert Systems in Medicine	3	0	0	3		
15BM223E	Medical Physics	3	0	0	3		15BM424E	Computational Methods For Signal and Image Processing	3	0	0	3		
15BM224E	Biomedical Laser Instruments	3	0	0	3		15BM425E	Modeling and Designing of Bone and Dental Implants	3	0	0	3		
15BM225E	Dental Engineering	3	0	0	3		15BM426E	Nuclear Imaging	3	0	0	3		
15BM226E	Medical Simulation in Life Supporting Devices	3	0	0	3		15BM427E	Acoustics and Optical Imaging	3	0	0	3		
15BM227E	Hospital information System	3	0	0	3		15BM428E	Picture Archiving and Communication Systems	3	0	0	3		
15BM228E	Home Medicare Technology	3	0	0	3		15BM429E	Body Area Networks and Mobile Healthcare	3	0	0	3		
	Department Elective III													
15BM321E	Design and Development of Medical Devices	3	0	0	3									
15BM322E	Embedded Systems in Medical Devices	3	0	0	3			**COURSES CUSTOMIZED TO OTHER DEPARTMENTS**						
15BM323E	Machine Vision in Medical Technology	3	0	0	3		**COURSE CODE**	**Course Title**	**L**	**T**	**P**	**C**		**OFFERED TO**
15BM325E	Medical Simulation in Cardiology	3	0	0	3		15BM324E	Principles of Biomedical instrumentation	3	0	0	3		ECE & EEE
15BM326E	Radiotherapeutic Equipments	3	0	0	3		15BM421E	Medical Electronics	3	0	0	3		EEE
15BM327E	Biomedical Nanotechnology	3	0	0	3									
15BM328E	Rehabilitation Robotics	3	0	0	3									
15BM329E	Biomechanics	3	0	0	3									
	Department Elective IV & V													
15BM330E	Troubleshooting and Quality Control in Medical Equipments	3	0	0	3									
15BM331E	Computational Fluid Dynamics in Biomedical Systems	3	0	0	3									
15BM332E	Machine Learning Techniques in Medicine	3	0	0	3									
15BM333E	Physiological Modeling and Simulation	3	0	0	3									
15BM334E	Electrocardiogram	3	0	0	3									
15BM335E	Medical Radiation Safety	3	0	0	3									
15BM336E	X-Ray Imaging and Computed Tomography	3	0	0	3									
15BM337E	Bone Densitometry	3	0	0	3									
15BM338E	MRI and its clinical Applications	3	0	0	3									
15BM339E	Neurorehabilitation and Human Machine interface	3	0	0	3									
15BM340E	Introduction to Telemedicine	3	0	0	3									

Foot Note: Regarding open electives, as far as 2015 curriculum is concerned, all core / elective courses can be listed / delisted every semester, under open electives, based on the availability of resources and demand.

B.Tech Biomedical Engineering
Prerequisites and Co requisites flow chart



Department of Biomedical Engineering			
B. Tech Biomedical Engineering			
Course Code	**Course Title**	**Prerequisite course**	**Co requisite courses**
15EE234J	Fundamentals of Circuits and Networks	15EE101	NIL
15BM202J	Digital Logic Circuits for Clinical Engineers	15EC101	NIL
15EC251J	Introduction to Electronic Devices and Circuits	15EC101	NIL
15BM208	Biomedical Signals and Systems	15MA204	NIL
15BM302J	Medical Instrumentation	15BM203,15EC251J	NIL
15BM304J	Biomedical Signal Processing	15BM208	NIL
15BM306J	Medical Image Processing	15MA103	NIL
15BM401J	Diagnostic and Therapeutic Equipments	15BM204J, 15BM302J	NIL
15BM331E	Computational Fluid Dynamics in Biomedical Systems	15MA104, 15MA204	NIL
15BM333E	Physiological Modeling and Simulation	15BM303	NIL
15BM424E	Computational Methods for Signal and Image Processing	15BM304J, 15BM306J	NIL

15BM202J	Digital Logic Circuits for Clinical Engineers			L	T	P	C
				3	0	2	4
Co-requisite:	NIL						
Prerequisite:	15EC101						
Data Book / Codes/Standards	NIL						
Course Category	P	PROFESSIONAL CORE	MEDICAL ELECTRONICS				
Course designed by	Department of Biomedical Engineering						
Approval	32nd Academic Council Meeting held on 23rd July 2016						

PURPOSE	The purpose of learning this course on Digital logic circuits for clinical Engineers for biomedical engineering students is to impart knowledge in the field of digital electronics and its applications in the medical field.

INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able to								
1.	Construct the basic digital logic circuits for clinical decision making	a						
2.	Summarize the various combinational circuits	a						
3.	Design the counters and flipflops	b						
4.	Describe the various memory organization and its devices for storing of medical data	c						
5.	Demonstrate how the basic digital circuits are utilized in various medical devices	c						

Session	Description of Topic (Theory)	Contact hours	C-D-I-O	IOs	Reference
	UNIT I: Boolean Simplification and Digital IC	**9**			
1.	Logic gates-boolean algebra postulates and theorems	1	C	1	1,2,3
2.	Karnaughmap	2	C,D	1	1,2,3
3.	QuineMcCluskey method	2	C,D	1	1,2,3
4.	Levels of integration, digital logic families special characteristics	1	C	1	1
5.	RTL, DTL and open collector TTL	1	C	1	1
6.	Schottky TTL, ECL, MOS and CMOS	2	C	1	1
	UNIT II: Combinational Circuits	**9**			
7.	Analysis and design of combinational circuit	1	C,D	1,2	1,2,3
8.	Half adder and full adder	1	C,D	1,2	1,2,3
9.	Code converters (Binary to Gray, Gray to Binary, BCD to XS-3)	2	C,D	1,2	1,2
10.	Decimal adder, magnitude comparator	2	C,D	1,2	1
11.	Encoder, decoder and priority encoder	2	C,D	1,2	1
12.	Multiplexer, demultiplexer	1	C,D	1,2	1
	UNITIII: Sequential Circuits	**9**			
13.	Latches	1	C	1,3	1
14.	Flipflops (D, JK & T)-characteristic tables and equations	1	C	1,3	1
15.	Analysis of clocked sequential circuits: (D, JK & T) flipflops, Mealy and Moore model	2	C	1,3	1
16.	Registers:4 bit shift register	1	C	1,3	1
17.	Ripple counters: 4 bit binary and BCD	2	C,D	1,3	1
18.	4-bit synchronous counter, Modulo-N-counter, ring Counter	2	C,D	1,3	1
	UNIT IV: Memory and Programmable Logic	**9**			
19.	Types of memories, RAM memory unit, memory decoding	3	C	4	1
20.	ROM, internal logic and programming, types	2	C	4	1
21.	Combinational PLD's, Programmable Logic Array (PLA)	2	C,D	4	1
22.	PAL	2	C,D	4	1
	UNIT V: Medical Applications	**9**			
23.	Digital stethoscope and digital blood pressure monitor	2	C	1,5	4,5
24.	Digital blood glucose monitor and thermometer	2	C	1,5	4,5
25.	Activity monitor and heart rate monitor	2	C	1,5	4,5

Session	Description of Topic (Theory)	Contact hours	C-D-I-O	IOs	Reference
26.	Digital hearing aid, DSP processor and Digital X-ray system	3	C	1,5	4,5
	Total contact hours	**45 (Exclusive of Assessment hours)**			

Session	Description of experiments	Contact hours	C-D-I-O	IOs	Reference
1.	Realization of basic logic gates to study the various anatomical/physiological functions of the human body	2	D,I	1,4	6
2.	Realization of the basal body metabolic functions in humans based on the logic expression using digital IC's	2	D,I	1,4	6
3.	Design a logic circuit to convert BCD code to XS-3 code	2	D,I	1	6
4.	Design a logic circuit to study the level of the either the systolic or diastolic blood pressure using magnitude comparator	2	D,I	1,4	6
5.	Realize the RS, JK, T and D digital storage circuits and to study the function table	2	D,I	1,2	6
6.	Design an asynchronous BCD/Binary up counter to study the action of a pacemaker	2	D,I	1,4	6
7.	Design a synchronous BCD/Binary down counter to study the action of a defibrillator	2	D,I	1,4	6
8.	Design of serial shift register and ring counter	2	D,I	1,5	6
9.	Design a TTL digital integrated circuit and study the basic parameters using NI Multisim circuit simulation software	2	D,I	1,5	6
10.	Design a prototype of the clinical decision support system using any of the diagnostic/therapeutic equipments which is readily available	2	D,I	1,4	6
11.	Realization of basic logic gates using NI Multisim	2	D,I	1,4	6
12.	Design a serial shift register and ring counter using NI Multisim circuit simulation software	2	D,I	1,5	6
13.	Design a TTL digital integrated circuit and study the basic parameters using NI Multisim circuit simulation software	2	D,I	1,5	6
14.	Realize the RS, JK, T and D digital storage circuits and to study the function table using NI Multisim circuit simulation software	4	D,I	1,2	6
	Total contact hours	**30**			

LEARNING RESOURCES	
Sl. No.	**TEXT BOOKS**
1.	M.Morris Mano and Michael D.Ciletti, "*Digital design"*, Pearson, 5th edition 2013.
2.	Thomas L. Floyd, "*Digital fundamentals"*, Pearson, 11th edition 2015.
	REFERENCE BOOKS/OTHER READING MATERIAL
3.	Ronald J. Tocci, Neal S.Widmer, Gregory L.Moss, "*Digital systems principles and applications", Pearson*, 12th edition 2016.
4.	http://ieeexplore.ieee.org
5.	http://freescale.com/medical
6.	Digital logic circuits for clinical engineers laboratory manual

Course nature				**Theory + Practical**			
Assessment Method – Theory Component (Weightage 50%)							
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Cycle Test III	Surprise Test	Quiz	**Total**
	Weightage	**10%**	**15%**	**15%**	**5%**	**5%**	**50%**
						End semester examination Weightage :	**50%**
Assessment Method – Practical Component (Weightage 50%)							
In-semester	**Assessment tool**	Experiments	Record	MCQ/Quiz/Viva Voce	Model examination		**Total**
	Weightage	**40%**	**5%**	**5%**	**10%**		**60%**
						End semester examination Weightage :	**40%**

15BM203	Human Anatomy and Physiology for Engineers			L	T	P	C
				3	1	0	4
Co-requisite:	NIL						
Prerequisite:	NIL						
Data Book / Codes/Standards	NIL						
Course Category	P	PROFESSIONAL CORE	BIOMEDICAL INSTRUMENTATION				
Course designed by	Department of Biomedical Engineering						
Approval	32nd Academic Council Meeting held on 23rd July 2016						

PURPOSE	The purpose of learning this course on human anatomy and physiology for engineers for biomedical engineering students is to provide the students a basic understanding of the various parts of the human body, their anatomical position and their functions.

INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able to								
1.	Understand basic human body functions and life processes	a	b					
2.	Familiarize the concepts of cardiac and nervous systems	e						
3.	Gain knowledge about functions of respiratory and musculoskeletal systems	c						
4.	Understand the structure and functions of digestive systems and excretory systems	a	b					
5.	Attain the knowledge about ear, eye and endocrine systems	c						

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	UNIT I: Cell and Blood Groups	**12**			
1.	Structure of cell, organelles and description, function of each component of the cell	1	C	1	1
2.	Membrane potential, generation of action potential	2	C	1	2
3.	Action potential conduction, electrical stimulation	2	C	1	1
4.	Blood cell , composition, origin of RBC	2	C	1	1
5.	Blood groups, estimation of RBC, WBC and platelet count	2	C	1	1
6.	Blood groups identification	3	D	1	1
	UNIT II: Cardiac and Nervous System	**12**			
7.	Heart, major blood vessels, cardiac cycle, blood pressure	2	C	2	2,3
8.	Cardiac output , coronary and peripheral circulation	1	C	2	3
9.	Structure and function of nervous tissue, neuron ,synapse	2	C	2	3
10.	Brain, spinal cord, reflex action	2	C	2	2
11.	Peripheral nervous system	1	C	2	2
12.	Autonomic nervous system	1	C	2	2
13.	Identification of nervous system	3	D	2	2
	UNIT III: Respiratory System and Musculo Skeletal System	**12**			
14.	Physiological aspects of respiration	1	C	3	3
15.	Trachea and lungs, exchange of gases	2	C	3	3
16.	Regulation of respiration, disturbance of respiration function	2	C	3	2
17.	Muscles, structure of skeletal muscle	1	C	3	1
18.	Physiology of muscular contraction	2	C	2	1,2
19.	Joints and its classification	1	C	3	3
20.	System identification of lung model	3	D	3	3
	UNIT IV: Digestive and Excretory System	**12**			
21.	Organization of GI system, digestion and absorption	1	C	4	2
22.	Movements of GI tract, intestine	2	C	4	2
23.	Liver, pancreas, structure of nephron	2	C	4	2
24.	Mechanism of urine formation, urine reflex	2	C	4	2
25.	Skin and sweat gland, temperature regulation	2	C	4	4
26.	Explanation of digestive system with model	3	D	4	4
	UNIT V: Eye, Ear, Endocrine Glands	**12**			
27.	Optics of eye, retina, photochemistry of vision, accommodation	1	C	5	4

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
28.	Neurophysiology of vision	2	C	5	5
29.	Physiology of internal ear, mechanism of hearing	2	C	5	5
30.	Auditory pathway	1	C	5	5
31.	Endocrine glands	3	C	5	5
32.	Hospital visit	3	D	5	5
	Total contact hours	**60 (Exclusive of Assessment hours)**			

LEARNING RESOURCES	
Sl. No.	**TEXT BOOKS**
1.	SaradaSubramanyam, K.MadhavanKutty and H.D.Singh, "*Text book of human physiology*", S.Chand& Company, 5th edition, 2014.
2.	Ranganathan T.S., "*Text book of human anatomy*", S.Chand&Co. Ltd., Delhi, 5th edition, 2014.
	REFERENCE BOOKS/OTHER READING MATERIAL
3.	Tobin, C.E., "*Basic human anatomy*", McGraw-Hill Publishing Co. Ltd., Delhi, 2nd edition, 1997.
4.	J.Gibson, "*Modern physiology and anatomy for nurses*", Blackwell SC Publishing, 2nd edition, 1981.
5.	Arthur.C.Guyton, John E Hall, "*Textbook of medical physiology*", W.B. Saunders Company, 11th edition, 2000.

Course nature				**Theory**			
Assessment Method (Weightage 100%)							
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Cycle Test III	Surprise test	Quiz	**Total**
	Weightage	**10%**	**15%**	**15%**	**5%**	**5%**	**50%**
End semester examination Weightage :							**50%**

15BM204J	Biomedical Sensors and Measurement Devices	L	T	P	C
		3	0	2	4
Co-requisite:	NIL				
Prerequisite:	NIL				
Data Book / Codes/Standards	NIL				
Course Category	P PROFESSIONAL CORE	BIOMEDICAL INSTRUMENTATION			
Course designed by	Department of Biomedical Engineering				
Approval	32nd Academic Council Meeting held on 23rd July 2016				

PURPOSE	The purpose of learning this course on biomedical sensors and measurement devices for biomedical engineering students is to attain adequate knowledge about the various sensors and measuring instruments used for measurement and detection of physical quantities.							
INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able to								
1.	Explain the basics of measurements and the errors associated with measurement	a						
2.	Describe the working principles of passive transducers	b	k					
3.	Describe the working principles of active and radiation transducers	b	k					
4.	Explain the working principles of signal generators and analyzers	b	k					
5.	Demonstrate the various sensors used in medical diagnosis	b	k					

Session	Description of Topic (Theory)	Contact hours	C-D-I-O	IOs	Reference
	UNITI: Measurement Systems	**9**			
1.	Functional elements of an instrumentation system	1	C	1	1,5
2.	Static characteristics and dynamic characteristics	3	C	1	1,5
3.	Errors in measurements: sources of errors, types of errors	1	C	1	1,5
4.	Statistical analysis of data	2	C	1	5
5.	Standards: international standards, primary standards, secondary standards and working standards	1	C	1	1
6.	Calibration methodologies	1	C	1	5
	UNIT II: Passive Transducers	**9**			
7.	Classification of transducers and characteristics for selection of transducers	2	C	2	1
8.	Resistive transducers	3	C	2	1
9.	Inductive transducers	2	C	2	1
10.	Capacitive transducers	2	C	2	1
	UNIT III: Active and Radiation Transducers	**9**			
11.	Piezoelectric effect transducer	1	C	3	1,3,5
12.	Hall effect transducer	1	C	3	1,3,5
13.	Optoelectronic sensors	2	C	3	1,3,5
14.	Optical encoder & optical displacement transducer	2	C	3	1
15.	X ray and nuclear radiation sensors	3	C	3	2
	UNIT IV: Signal Generators and Signal Analyzer	**9**			
16.	Function generator- principle of generation with block diagram	1	C	4	1,4,5
17.	Heterodyne wave analyser	1	C	4	1,4,5
18.	Spectrum analyser	1	C	4	1,4,5
19.	Logic analyser	1	C	4	1,4,5
20.	Distortion analyser	1	C	4	1,4,5
21.	Dual trace oscilloscope	1	C	4	1,4,5
22.	Dual beam oscilloscope	1	C	4	1,4,5
23.	Sampling oscilloscope	1	C	4	1,4,5
24.	Digital storage oscilloscope	1	C	4	1,4,5
	UNIT V : Medical Applications of Sensors	**9**			
25.	Biosensors: Principles of optical biosensors, classification, immobilization techniques	3	C	5	7,8

Session	Description of Topic (Theory)	Contact hours	C-D-I-O	IOs	Reference
26.	Optical biosensors for measurement of blood glucose level	1	C	5	7,8
27.	Smart sensor	1	C	5	2
28.	Electronic nose	2	C	5	6
29.	Lab on a chip	2	C	5	9
	Total contact hours	**45 (Exclusive of Assessment hours)**			

Sl. No.	Description of experiments	Contact hours	C-D-I-O	IOs	Reference
1.	Resistance temperature characteristics of RTD	2	D,I	2	10
2.	Resistance temperature characteristics of thermistor	2	D,I	2	10
3.	Voltage-temperature characteristics of thermocouple	2	D,I	2	10
4.	Characteristics of load cell and hall effect transducer	4	D,I	2	10
5.	Measurement of displacement using LVDT	2	D,I	2	10
6.	Measurement of strain using strain gauge	2	D,I	2	10
7.	Measurement and recording of cardiac signals	4	D,I	2	10
8.	Measurement and recording of ECG using NI ELVIS	4	D,I	2	10
9.	Measurement and recording of NIBP using NIELVIS	4	D,I	2	10
10.	Measurement and recording of EEG	4	D,I	2	10
	Total contact hours	30			

LEARNING RESOURCES	
Sl. No.	**TEXT BOOKS**
1.	Sawhney A.K, "*A Course in electrical and electronic measurements and instrumentation*", DhanpatRai& Co (P) Ltd, Educational and Technical Publishers, 19th Revised edition 2011, Reprint 2014.
	REFERENCE BOOKS/OTHER READING MATERIAL
2.	Patranabis D, *"Sensors and transducers"*, PHI, 2nd edition,2004.
3.	Murty DVS, *"Transducer and instrumentation"*, PHI, 2nd edition, 2010.
4.	A. D. Helfrick and W. D. Cooper, *"Modern electronic instrumentation and measurement techniques"*, Prentice Hall of India, 4th edition, 1998.
5.	U.A.Bakshi, A.V.Bakshi, *"Measurements and instrumentation"*, Technical Publications, 3rd revised edition, 2010.
6.	Open Journal of Applied Biosensor, 2013, 2, 39-50 http://dx.doi.org/10.4236/ojab.2013.22005 Published Online May 2013 (http://www.scirp.org/journal/ojab).
7.	Manoj Kumar Ram, Venkat R, Bhethanabolta, "*Sensors for chemical and biological applications"*, CRC press, 1st edition, 2010.
8.	Paras N, Prasad, "*Introduction to biophotonics*", John Wiley & Sons, 1st edition, 2003.
9.	YukselTemiz, Robert D. Lovchik, Govind V. Kaigala, Emmanuel Delamarche, *"Lab-on-a-chip devices: How to close and plug the lab?"*,doi:10.1016/j.mee.2014.10.013.
10.	Biomedical sensors and measurement devices lab manual.

Course nature				**Theory + Practical**			
Assessment Method – Theory Component (Weightage 50%)							
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Cycle Test III	Surprise Test	Quiz	**Total**
	Weightage	**10%**	**15%**	**15%**	**5%**	**5%**	**50%**
					End semester examination Weightage :		**50%**
Assessment Method – Practical Component (Weightage 50%)							
In-semester	**Assessment tool**	Experiments	Record	MCQ/Quiz/Viva Voce	Model examination		**Total**
	Weightage	**40%**	**5%**	**5%**	**10%**		**60%**
					End semester examination Weightage :		**40%**

15BM205	Biomaterials and Artificial Organs	L	T	P	C
		3	0	0	3
Co-requisite:	NIL				
Prerequisite:	NIL				
Data Book / Codes/Standards	NIL				
Course Category	P PROFESSIONAL CORE	REHABILITATION ENGINEERING			
Course designed by	Department of Biomedical Engineering				
Approval	32nd Academic Council Meeting held on 23rd July 2016				

PURPOSE	The purpose of learning this course on biomaterials and artificial organs for biomedical engineering students is to provide an understanding of different biomaterials and their applications in implantable medical devices and organs.

INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able to								
1.	Explain the various basic biomaterials, its properties and wound healing process	a						
2.	Investigate the different basic commodity biomaterials	a						
3.	Summarize the various advanced biomaterials	a	c	e				
4.	Explain the different medical devices and organs	a	c	e				
5.	Illustrate the future application of biomaterials	a	c	e				

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	UNIT I: Essential Biomaterial Science	**9**			
1.	Introduction: Metallic biomaterials	1	C	1	1,5
2.	Ceramic biomaterials	1	C	1	1,5
3.	Polymeric biomaterials	1	C	1	1,5
4.	Composite biomaterials	1	C	1	1,5
5.	Physical, mechanical and surface properties	2	C	1	1,5
6.	Characteristics testing-biocompatibility	2	C	1	1,5
7.	Cells and tissues, inflammation and wound healing	1	C	1	1,5
	UNIT II: Commodity Biomaterials	**9**			
8.	Titanium and cobalt-chromium alloys for hips and knees	2	C	2	1,2,6
9.	Polymeric joint bearing surfaces for total joint replacements	2	C	2	1,2,3
10.	Biomaterials for pacemakers, defibrillators	2	C	2	1,2,3
11.	Mechanical and bio prosthetic heart valve	2	C,I	2,5	1,6,7
12.	Recent advancement in commodity biomaterials	1	C,I	2,5	1,6,7
	UNIT III: Advanced Biomaterials	**9**			
13.	New ceramics for joint replacement surgery	2	C	3	1,2,7
14.	Composites for joint replacement surgery	1	C	3	1,2,7
15.	New biomaterials for improving the blood and tissue compatibility of total artificial hearts (TAH)	2	C	3	1,6,7
16.	Ventricular assist devices (VAD)	2	C	3	1,6,7
17.	Recent advancement in next generation biomaterials	2	C,I	3,5	1,6,7
	UNIT IV: Implantable Medical Devices and Organs – I	**9**			
18.	Implants in liver	2	C	4	2,8
19.	Implants in kidney	1	C	4	2,8
20.	Implants in eyes	2	C	4	2,8
21.	Implants in ears	2	C	4	2,8
22.	Recent advancement and future directions.	2	C,I	4,5	2,8
	UNIT V: Implantable Medical Devices and Organs – II	**9**			
23.	Gastrointestinal system	2	C	4	2,8
24.	Dentistry	2	C	4	2,9
25.	Maxillofacial and craniofacial replacement	1	C	4	2,9

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
26.	Soft tissue repair, replacement and augmentation	2	C	4	2,8
27.	Recent advancement and future directions.	2	C,I	4,5	2,8
	Total contact hours	**45 (Exclusive of Assessment hours)**			

LEARNING RESOURCES	
Sl. No.	**TEXT BOOKS**
1.	David Williams, "*Essential biomaterials science*", Cambridge University Press, 1st edition, 2014.
2.	Lysaght M, Webster T J., "*Biomaterials for artificial organs"*, Woodhead Publishing Limited, 1st edition, 2011.
	REFERENCE BOOKS/OTHER READING MATERIAL
3.	Jason A. Burdick, Robert L. Mauck., "*Biomaterials for tissue engineering applications*", Springer, 1st edition, 2014.
4.	Joseph D. Bronzino, Donald R. Peterson., "*Biomedical engineering fundamentals"*, CRC Press, 4th edition, 2014.
5.	Hench L, Jones J., "*Biomaterials, artificial organs and tissue engineering",* Woodhead Publishing Limited, 1st edition, 2005.
6.	Reis, L. A., Chiu, L. L. Y., Feric, N., Fu, L. and Radisic, M., "*Biomaterials in myocardial tissue engineering*", Journal of Tissue Engineering Regeneration and Medicine, 2014.
7.	MilicaRadisic., "*Biomaterials for cardiac tissue engineering",* Biomedical Materials,Vol.3, 2015.
8.	Monika Saini, Yashpal Singh, Pooja Arora, Vipin Arora, and Krati Jain., "*Implant biomaterials: A comprehensive review"*, World Journal of Clinical Cases, 2015.
9.	Donatella Duraccio , Federico Mussano, Maria Giulia Faga., "*Biomaterials for dental implants: current and future trend*s", Journal of Materials Science, 2015.

Course nature				**Theory**			
Assessment Method (Weightage 100%)							
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Cycle Test III	Surprise Test	Quiz	**Total**
	Weightage	**10%**	**15%**	**15%**	**5%**	**5%**	**50%**
End semester examination Weightage :							**50%**

15BM207J	Integrated Circuit Design for Bioinstrumentation	L	T	P	C
		3	0	2	4
Co-requisite:	NIL				
Prerequisite:	NIL				
Data Book / Codes/Standards	NIL				
Course Category	P PROFESSIONAL CORE	MEDICAL ELECTRONICS			
Course designed by	Department of Biomedical Engineering				
Approval	32nd Academic Council Meeting held on 23rd July 2016				

PURPOSE	The purpose of learning the course onIntegrated circuit design for bioinstrumentation for biomedical engineering students is to enable the students to understand the fundamentals of linear integrated circuits and to implement and study in relation to the various medical related applications

INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able to								
1.	Design the basic building blocks of linear integrated circuits	a						
2.	Design and develop the comparators and waveform generators	b	c					
3.	Demonstrate the basic concepts and design of active filters and data converters	b	c					
4.	Explain the theory and applications of timers	a	c					
5.	Describe the basic concepts of PLL and voltage regulators	a						

Session	Description of Topic (Theory)	Contact hours	C-D-I-O	IOs	Reference
	UNIT I: Opamp and Its Characteristics	**9**			
1.	Basics of operational amplifier (op amp) and its ideal characteristics	2	C	1	1,2
2.	Op amp-inverting amplifier, non-inverting amplifier, buffer amplifier, AC amplifier	2	C	1	1,2
3.	Differential amplifier	1	C	1	1
4.	Instrumentation amplifier	1	C	1	1
5.	Basics of DC characteristics and AC characteristics	2	C	1	1
6.	Analysis of data sheet of 741 op-amp	1	C	1	1
	UNIT II: Basic Op Amp Applications	**9**			
7.	Scale changer, Inverting and non-inverting adder, subtractor	2	C	1	1
8.	V-I and I-V converter	1	C	1	1
9.	Half wave rectifier and full wave rectifier	1	C	1	1,2,3
10.	Peak detector, clipper and clamper	2	C	1	1,3
11.	Sample & hold circuit and log amplifier	2	C	1	1
12.	Differentiator and integrator	1	C,D	1	1
	UNIT III: Comparators and Waveform Generators	**9**			
13.	Comparator and its applications	2	C	1,2	1
14.	Schmitt trigger, Astablemultivibrator	2	C	1,2	1
15.	Monostablemultivibrator, Triangular wave generator	2	C	1,2	1
16.	Sawtooth wave generator	1	C	1,2	2
17.	RC Phase shift oscillator and Wien bridge oscillator	2	C,D	1,2	1
	UNIT IV: Active Filters and Data Converters	**9**			
18.	First order RC active low pass and high pass filter	2	C,D	1,3	1
19.	Band pass filter and basics of Notch filter	2	C	1,3	1
20.	Digital to analog converter (DAC)/Analog to digital converter (ADC) specifications	1	C	1,3	1
21.	Weighted resistor DAC, R-2R ladder DAC, inverted R-2R DAC	2	C	1,3	1
22.	Flash type ADC, successive approximation ADC and dual slope ADC	2	C	1,3	1

Session	Description of Topic (Theory)	Contact hours	C-D-I-O	IOs	Reference
	UNIT V: Timer, PLL and Voltage Regulators	**9**			
23.	555 timer IC pin diagram and functional diagram	1	C	1,4,5	1
24.	555 timer in monostable mode and its application as pulse width modulation	1	C	1,4,5	1
25.	555 timer in as table mode and its application as frequency shift keying (FSK)	1	C	1,4,5	1
26.	Phase Locked loop (PLL) and Voltage controlled oscillator	2	C	1,4,5	1
27.	Series op-amp regulator, fixed voltage regulator and 723 general purpose regulator	2	C	1,4,5	1
28.	Medical Applications: pulse oximetry, bio data acquisition system	2	C	1,4,5	4
	Total contact hours	**45 (Exclusive of Assessment hours)**			

Sl. No.	Description of experiments	Contact hours	C-D-I-O	IOs	Reference
1.	Realization of buffer, inverting and non-inverting amplifier using op-amp	2	D,I	1	5
2.	Realize the op-amp frequency response characteristics	2	D,I	1,2	5
3.	Design of Summer, differentiator and integrator using op-amp	2	D,I	1,2	5
4.	Design of instrumentation amplifier for bio-signal acquisition	2	D,I	1,2	5
5.	Design of half wave and full wave rectifier using op-amp	2	D,I	1,2	5
6.	Design of clipper and clamper using op-amp	2	D,I	1	5
7.	Realize the zero crossing detector and time marker using op-amp	2	D,I	1,2	5
8.	Design a RC phase shift oscillator and Wien bridge oscillator using op-amp	2	D,I	1,2	5
9.	Design of first order and second order active low pass filter	2	D,I	1,3	5
10.	Design of weighted resistor DAC and R-2R ladder DAC using op-amp	2	D,I	1,3	5
11.	Simulation - realization of buffer, inverting and non-inverting amplifier using op-amp	2	D,I	1	5
12.	Simulation -Design of summer, differentiator and integrator using op-amp	2	D,I	1,2	5
13.	Simulation -Design of instrumentation amplifier for bio-signal acquisition	2	D,I	1,2	5
14.	Simulation -Design of half wave and full wave rectifier using op-amp	2	D,I	1,2	5
15.	Simulation -Design of clipper and clamper using op-amp	2	D,I	1	5
	Total contact hours	**30**			

LEARNING RESOURCES	
Sl. No.	**TEXT BOOKS**
1	D Roy Choudhury and Shail Jain, "*Linear integrated circuits"*, New Age Science Limited, 4th edition, 2011.
	REFERENCE BOOKS/OTHER READING MATERIAL
2	Coughlin & Driscoll, "*Operational amplifiers &linear integrated circuits"*, Prentice Hall of India, 6th edition, 2003.
3	Gayakwad A.R, "*Op-Amp and linear integrated circuits",* Prentice Hall of India, 4th edition, 2009.
4	http://www.ti.com/lsds/ti/apps/medical/tech_docs.page.
5	Integrated circuit design for bioinstrumentation laboratory manual.

Course nature				Theory + Practical			
Assessment Method – Theory Component (Weightage 50%)							
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Cycle Test III	Surprise Test	Quiz	**Total**
	Weightage	**10%**	**15%**	**15%**	**5%**	**5%**	**50%**
End semester examination Weightage :							**50%**
Assessment Method – Practical Component (Weightage 50%)							
In-semester	**Assessment tool**	Experiments	Record	MCQ/Quiz/Viva Voce	Model examination		**Total**
	Weightage	**40%**	**5%**	**5%**	**10%**		**60%**
End semester examination Weightage :							**40%**

15BM208	Biomedical Signals and Systems			L	T	P	C
				3	0	0	3
Co-requisite:	NIL						
Prerequisite:	15MA204						
Data Book / Codes/Standards	NIL						
Course Category	P	PROFESSIONAL CORE	SIGNAL AND IMAGE PROCESSING				
Course designed by	Department of Biomedical Engineering						
Approval	32nd Academic Council Meeting held on 23rd July 2016						

PURPOSE	To purpose of learning this course on biomedical signals and systems for biomedical engineering students is to acquire knowledge for analyzing the continuous time discrete time signals & systems and its biosignal applications.

INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course on biomedical signals and systems, the student will be able to								
1.	Classify the continuous time signals and systems and discrete-time signals and systems	a						
2.	Analyze the continuous time signals using fourier series and fourier transforms	a	c					
3.	Compute the convolution and correlation of discrete time systems.	a						
4.	Understand the concepts of z-transform and discrete Fourier transform	a	c					
5.	Analyze the discrete time IIR and FIR systems by using suitable structures and bio signal applications	a						

Session	Description of Topic (Theory)	Contact hours	C-D-I-O	IOs	Reference
	UNIT I: Basics of Discrete and Continuous Time Signals and Systems	**9**			
1.	Generation, representation of discrete time signals and continuous time signals, standard discrete time signals, standard continuous time signals	2	C	1	1,2
2.	Classification of signals: Continuous time(CT)	2	C	1	1,2
3.	Discrete time (DT) signals	1	C	1	1,2
4.	Mathematical operations on CTS and DTS-scaling, folding, time shifting, addition and multiplication.	1	C	1	1,2
5.	Classification of systems: static and dynamic systems, time invariant and time variant, linear and nonlinear systems, causal and non-causal systems, stable and unstable systems	2	C	1	1,2
6.	Basic bio signal measurements	1	C	1	5
	UNIT II: Analysis of Continuous Time Signals and System	**9**			
7.	Fourier series analysis-trigonometric fourier series	1	C,D	2	1,2
8.	Cosine fourier series	1	C,D	2	1,2
9.	Exponential fourier series	1	C,D	2	1,2
10.	Fourier transform analysis	1	C,D	2	1,2
11.	Laplace transform analysis	1	C,D	2	1,2
12.	Poles and zeros	1	C,D	2	1,2
13.	Analysis of differential equation- impulse response	1	C,D	2	1,2
14.	Transfer function	1	C,D	2	1,2
15.	Frequency response	1	C,D	2	1,2
	UNIT III: Convolution and Correlation of Discrete Time Signals	**9**			
16.	Convolution-graphical method, properties, methods of performing linear convolution	2	C	3	1,2

Session	Description of Topic (Theory)	Contact hours	C-D-I-O	IOs	Reference
17.	Circular convolution-circular representation and circular shift of DT signals-procedure for evaluating circular convolution, linear convolution via circular convolution, methods of computing circular convolution	2	C	3	3
18.	Sectioned convolution-overlap add method	1	C	3	3
19.	Overlap save method	1	C	3	3
20.	Inverse system, deconvolution	1	C	3	3
21.	Correlation- autocorrelation and cross correlation	2	C, I		1,3
	UNIT IV: Transforms of Discrete Time Signals and Systems	**9**			
22.	Z transform-properties-region of convergence- representation of poles and zeros in z transform	1	C	4	1,2
23.	Inverse z transform- residue method	1	C	4	1,2
24.	Partial fraction method	1	C	4	1,2
25.	Discrete time fourier transform-properties, frequency response of LTI DT signals	1	C	4	1,2
26.	Frequency response of first order, second order DT signals	1	C	4	1,2
27.	Analysis of impulse response using differential equation	1	C	4	1,2
28.	Relation between Z transform and DTFT	1	C	4	1,2
29.	Introduction to discrete fourier transform	1	C	4	1,2
30.	Inverse discrete fourier transform	1	C	4	1,2
	UNIT V: Realization and Biosignal Applications	**9**			
31.	Introduction to discrete time Infinite impulse response (IIR) and finite impulse response (FIR) systems	1	C	5	1,3
32.	Structure for realization of IIR systems-direct form-I, direct form-II	1	C	5	1,3
33.	Cascade form, parallel form of IIR system	1	C	5	1,3
34.	Structure for realization of FIR systems-direct form, cascade and linear phase realization of FIR systems	2	C	5	1,3
35.	Neural Firing rate analysis	2	C	5	5
36.	Linearized model and system equations for immune response	2	C	5	5
	Total contact hours	**45 (Exclusive of Assessment hours)**			

LEARNING RESOURCES	
Sl. No.	**TEXT BOOKS**
1.	Allan V. Oppenheim, Alan S. Willsky and S. Hamid, "*Signals and systems"*, Prentice Hall of India Pvt. Ltd, 2nd edition, 1997.
2.	A. Anand Kumar, "*Signals and systems"*, PHI learning Pvt. Ltd., 3rd edition, 2015.
	REFERENCE BOOKS/OTHER READING MATERIAL
3.	Simon Haykin and Barry Van Veen, *"Signals and systems",* John Wiley & Sons, 2nd Edition, 2001, Reprint 2002.
4.	M.J. Roberts, *"Signals and Systems: Analysis using transform methods & MATLAB*" Tata McGraw Hill,2nd edition, 2007.
5.	Suresh R, Devashayam, *"Signals and Systems in Biomedical Engineering",* Springer US, 2nd edition, 2013.

Course nature				**Theory**			
Assessment Method (Weightage 100%)							
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Cycle Test III	Surprise Test	Quiz	**Total**
	Weightage	**10%**	**15%**	**15%**	**5%**	**5%**	**50%**
					End semester examination Weightage :		**50%**

15BM375L	Minor Project I	L	T	P	C
		0	0	3	2
Co-requisite:	NIL				
Prerequisite:	NIL				
Data Book / Codes/Standards	NIL				
Course Category	P PROFESSIONAL				
Course designed by	Department of Biomedical Engineering				
Approval	32nd Academic Council Meeting held on 23rd July, 2016				

PURPOSE	To obtain an hands-on experience in converting a small novel idea / technique into a working model / prototype involving multi-disciplinary skills and / or knowledge and working in at team.							
INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able								
1.	To conceptualise a novel idea / technique into a product	c						
2.	To think in terms of multi-disciplinary environment		d					
3.	To understand the management techniques of implementing a project				k			
4.	To take on the challenges of teamwork, prepare a presentation in a professional manner, and document all aspects of design work.			g				

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	An Multidisciplinary project to be taken up by a team of maximum of ten students. Development of prototype product, a 3D model, simulation, blueprint for a larger project and any other development work are permitted. The contribution of the individuals in the project should be clearly brought out. A combined report is to be submitted. A presentation is to be made for the reviewers on the work done by the candidate.		C,D,I	1,2,3,4	
	Total contact hours				

Course nature		**Project – 100% internal continuous assessment**	
Assessment Method (Weightage 100%)			
In-semester	**Assessment tool**	Refer the table	**Total**
	Weightage	Refer the table below	**100%**
End semester examination Weightage :			**0%**

Assessment components

Assessment component	Expected outcome	Evaluators	Criteria or basis	Marks
Project proposal (Review – I)	A short presentation to be delivered on: • A brief, descriptive project title (2-4 words). This is critical! • The 3 nearest competitors (existing solutions) and price. • Team members name, phone number, email, department/degree program, and year. • A description of the product opportunity that has been identified. To include: Documentation of the market need, shortcomings of existing competitive products, and definition of the target market and its size. • Proposed supervisor / guide	Panel of reviewers	Viability / feasibility of the project Extent of preliminary work done.	**0**
Review II	• Mission Statement / Techniques • Concept Sketches, Design Specifications / Modules & Techniques along with System architecture • Coding	Panel of reviewers	Originality, Multi-disciplinary component, clarity of idea and presentation, team work, handling Q&A.	**20**
Review III	• Final Concept and Model / Algorithm/ Technique • Drawings, Plans / programme output • Financial Model / costing • Prototype / Coding • Final Presentation and Demonstration	Panel of reviewers	Originality, Multi-disciplinary component, clarity of idea and presentation, team work, handling Q&A.	**50**
Final technical Report	A good technical report	Supervisor / Guide	Regularity, systematic progress, extent of work and quality of work	**30**
			Total	**100**

15BM380L	Seminar I	L	T	P	C
		0	0	3	2
Co-requisite:	NIL				
Prerequisite:	NIL				
Data Book / Codes/Standards	NIL				
Course Category	P PROFESSIONAL				
Course designed by	Department of Biomedical Engineering				
Approval	32nd Academic Council Meeting held on 23rd July, 2016				

PURPOSE	To enhance the disseminating skills of the student about the current and contemporary research work that are being carried out across the world.							
INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able								
1.	To understand the research methodology adopted by various researchers	h	i	j				
2.	To mathematically model a problem, critically analyse it and adopt strategies to solve	b	c	e				
3.	To understand and present a well documented research	e	g					

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	Guidelines for conducting 15BM380L Seminar for B.Tech 1. Upon registering for the course the student must identify a sub-domain of the degree specialization that is of interest to the student and start collecting research papers as many as possible. 2. After collecting sufficient number of research papers the student must peruse all the papers, meet the course faculty and discuss on the salient aspects of each and every paper. 3. The course faculty, after discussion with the student will approve TWO research papers that is appropriate for presentation. 4. The student must collect additional relevant reference materials to supplement and compliment the two research papers and start preparing the presentation. 5. Each student must present a 15-minute presentation on each of the approved research paper to the panel of evaluators. 6. The presenter must present one research paper within the first half of the semester (6 weeks) and another research paper in the next half of the semester (6 weeks) as per the schedule. 7. All other students registered for the course will form the audience. 8. The audience as well as the evaluators will probe the student with appropriate questions and solicit response from the presenter. 9. The presentation will be evaluated against 7 to 8 assessment criteria by 4 to 5 evaluators. 10. The score obtained through the presentations of TWO research papers will be converted to appropriate percentage of marks. This course is 100% internal continuous assessment.		C,D	1,2,3,4	
	Total contact hours				

Course nature		**100% internal continuous assessment**		
Assessment Method (Weightage 100%)				
In-semester	**Assessment tool**	Presentation 1	Presentation 2	**Total**
	Weightage	**50%**	**50%**	**100%**
End semester examination Weightage :				**0%**

Department of Biomedical Engineering

EVALUATION OF SEMINAR PRESENTATIONS

Name of the Student: Date:
Register Number: Degree and Branch:
Topic:

Sl. No.	Criteria for Assessment	Evaluator 1	Evaluator 2	Evaluator 3	Evaluator 4	Evaluator 5
1	Understanding of the subject					
2	Clarity of presentation					
3	Appropriate use of Audio visual aids					
4	Whether cross references have been consulted					
5	Ability to respond to questions on the subject					
6	Time scheduling					
7	Completeness of preparation					

Poor	1	Below	2	Average	3	Good	4	Very Good	5

Overall Grades:
Remarks:
Signature of Course Coordinator

15BM385L	Massive Open Online Courses (MOOCs) I	L	T	P	C
		0	0	3	2
Co-requisite:	NIL				
Prerequisite:	NIL				
Data Book / Codes/Standards	NIL				
Course Category	P PROFESSIONAL				
Course designed by	Department of Biomedical Engineering				
Approval	32nd Academic Council Meeting held on 23rd July, 2016				

PURPOSE	To offer students the opportunity to study with the world's best universities by integrating select MOOCs in a regular degree programme and providing students full credit transfer, as per university regulations, if they earn a "Verified / Completion Certificate" and take a proctored examination through a secure, physical testing center.							
INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able								
1.	To apply the concepts, theories, laws, technologies learnt herein to provide engineering solutions.	f	h	i	j			

Course nature		**Online - 100% internal continuous assessment.**				
Assessment Method (Weightage 100%)						
In-semester	**Assessment tool**	Quiz	Assignment	Non-proctored / Unsupervised Tests	Proctored / Supervised Test	**Total**
	Weightage	**25%**	**25%**	**10%**	**40%**	**100%**
End semester examination Weightage :						**0%**

Registration process, Assessment and Credit Transfer:

1. Students can register for courses offered by approved global MOOCs platforms like edX, Coursera or Universities with which SRM partners specifically for MOOCs.
2. Annually, each department must officially announce, to the students as well as to the Controller of Examinations, the list of courses that will be recognised and accepted for credit transfer.
3. The department must also officially announce / appoint one or more faculty coordinator(s) for advising the students attached to them, monitoring their progress and assist the department in proctoring the tests, uploading the marks / grades, and collecting and submitting the graded certificate(s) to the CoE, within the stipulated timeframe.
4. Student who desires to pursue a course, from the above department-approved list, through MOOCs must register for that course during the course registration process of the Faculty of Engineering and Technology, SRM University.
5. The maximum credit limits for course registration at SRM will include the MOOCs course registered.
6. The student must periodically submit the marks / grades obtained in various quizzes, assignments, tests etc immediately to the Faculty Advisor or the Course Coordinator for uploading in the university's academic module.
7. The student must take the final test as a Proctored / Supervised test in the university campus.
8. The student must submit the "Certificate of Completion" as well as the final overall Marks and / or Grade within the stipulated time for effecting the grade conversion and credit transfer, as per the regulations. It is solely the responsibility of the individual student to fulfill the above conditions to earn the credits.
9. The attendance for this course, for the purpose of awarding attendance grade, will be considered 100% , if the credits are transferred, after satisfying the above (1) to (7) norms; else if the credits are not transferred or transferable, the attendance will be considered as ZERO.

15BM490L	Industry Module I	L	T	P	C
		0	0	3	2
Co-requisite:	NIL				
Prerequisite:	NIL				
Data Book / Codes/Standards	NIL				
Course Category	P PROFESSIONAL				
Course designed by	Department of Biomedical Engineering				
Approval	32nd Academic Council Meeting held on 23rd July, 2016				

PURPOSE	To impart an insight into the current industrial trends and practices							
INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able								
1.	To obtain an insight into the current industrial trends and practices			j				
2.	To obtain an insight into the technologies adopted by industries			j				
3.	To obtain an insight into the technical problems encountered by the industries and the scope for providing solutions.		h					
4.	To network with industry	g						

Description of Topic	Contact hours	C-D-I-O	IOs	Reference
1. The department will identify and shortlist few emerging topics that are trending in industry. 2. The department will identify experts from industry who are willing to deliver modules on the shortlisted topics. 3. The identified expert will assist the department in formulating the course content to be delivered as a 30-hour module, prepare lectures notes, ppt, handouts and other learning materials. 4. The department will arrange to get the necessary approvals for offering the course, from the university's statutory academic bodies well before the actual offering. 5. The department must officially announce, to the students as well as to the Controller of Examinations, the list of courses that will be offered as industry module. 6. The department must also officially announce / appoint one or more faculty coordinator(s) for advising the students attached to them, monitoring their progress and assist the department in proctoring/supervising/assessment the quizzes, assignments, tests etc, uploading the marks, attendance etc, within the stipulated timeframe. 7. The Student who desires to pursue a course, from the above department-approved list, must register for that course during the course registration process of the Faculty of Engineering and Technology, SRM University. 8. The maximum credit limits for course registration at SRM will include the Industry Module also. 9. All academic requirements of a professional course like minimum attendance, assessment methods, discipline etc will be applicable for this Industry Module. 10. The course will be conducted on weekends or beyond the college regular working hours.		C,D,I,O	1,2,3,4	
Total contact hours	**30**			

Course nature			**100% internal continuous assessment**				
Assessment Method – Theory Component (Weightage 50%)							
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Cycle Test III	Surprise Test	Quiz	**Total**
	Weightage	**10%**	**15%**	**15%**	**5%**	**5%**	**50%**
End semester examination Weightage							**50%**

	Biomedical System Design (A)	L	T	P	C
		0	0	3	2
Co-requisite:	NIL				
Prerequisite:	NIL				
Data Book / Codes/Standards	NIL				
Course Category	P PROFESSIONAL				
Course designed by	Department of Biomedical Engineering				
Approval					

PURPOSE	The purpose of the course on Biomedical System Design for biomedical engineering students is to enhance their knowledge and educate real time system development.							
INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able to								
1.	To develop professionals with practical knowledge							
2.	To develop programming and problem solving skills							
3.	To develop industrial competent people.							
4.	To re-engineer and improve their ability in embedded system design							

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	UNIT I: Graphical Programming Language LabView	**15**	C,D,I,O	1,2,3,4	1,2,3,4,5,6
1.	Navigating Graphical System Design Software Platform LabVIEW	6			
2.	Developing modular applications - Managing file and hardware resources	3			
3.	Implementing design patterns	2			
4.	Overview of a DAQ system	2			
5.	Bio-medical signal conditioning	2			
	UNIT II: Integrated Real-Time Design	**7**			
6.	Getting started with LabVIEW Field-Programmable gate array (FPGA)	2			
7.	Programming using LabVIEW FPGA - Synchronizing FPGA loops and I/O	2			
8.	Sharing physiological data like ECG, EEG etc..., on FPGA	2			
9.	Communicating between the FPGA and host	1			
	UNIT III: Building Biomedical System Design	**8**			
10.	Creating and investigating a NI myRIO project	2			
11.	Exploring the myRIO FPGA personality	2			
12.	Communication between RT target and HOST	2			
13.	Development of full prototype model of any biomedical system	2			
	Total contact hours	**30 (Exclusive of assessment hours)**			

LEARNING RESOURCES	
Sl. No.	**TEXT BOOKS**
1.	Nasser Kehtarnavaz, "Digital Signal Processing System-Level Design Using LabVIEW", Newnes0-7506-7914-X, 2005.
2.	Leonard Sokoloff, "Applications in LabVIEW", Prentice Hall, 0-13-833949-X, 2003.
3.	JaakkoMalmivuo& Robert Plonsey: Bioelectromagnetism - Principles and Applications of Bioelectric and Biomagnetic Fields, Oxford University Press, New York, 1995.
4.	http://www.ni.com/white-paper/6349/en/
5.	www.ni.com
6.	http://sine.ni.com/nips/cds/view/p/lang/en/nid/211023

Course nature				100% internal continuous assessment			
Assessment Method – Theory Component (Weightage 50%)							
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Cycle Test III	Surprise Test	Quiz	**Total**
	Weightage	**10%**	**15%**	**15%**	**5%**	**5%**	**50%**
End semester examination Weightage							**50%**

15BM301	Diagnostic Imaging Systems	L	T	P	C
		3	0	0	3
Co-requisite:	NIL				
Prerequisite:	NIL				
Data Book / Codes/Standards	NIL				
Course Category	P PROFESSIONAL CORE	BIOMEDICAL INSTRUMENTATION			
Course designed by	Department of Biomedical Engineering				
Approval	32nd Academic Council Meeting held on 23rd July 2016				

PURPOSE	The purpose of learning this course on diagnostic imaging systems for biomedical engineering students is to have an understanding of how medical image is acquired, reconstructed and visualized.							
INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able to								
1.	Perceive the physics behind x-ray imaging and computed tomography (CT)	a	k					
2.	Understand the hardware and techniques involved in nuclear imaging	a	k					
3.	Describe the properties and techniques in ultrasound imaging	a	k					
4.	Understand the physics behind magnetic resonance and the techniques in resonance imaging	a	k					
5.	Explain the basic principles behind the modern imaging techniques	a	k					
6.	Understand the different parts of medical imaging systems and its working principle	a	k					

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	UNIT I: X-Ray and CT	**9**			
1.	Production of X-rays, X-ray tubes and generators	2	C	1	1,4
2.	Screen film and digital radiography, mammography	2	C	1	1,4
3.	CT system design, Hounsfield unit, modes of acquisition	2	C	1	1,4
4.	CT reconstruction: filtered back projection, micro CT	3	C,D	1	1,4
	UNIT II: Nuclear Medicine	**9**			
5.	Radioisotopes, radionuclide production	2	C	2	1
6.	types of detectors, scintillators, gamma camera	2	C	2	1
7.	Emission tomography –positron emission tomography (PET) and Single photon emission computer tomography (SPECT)	2	C	2	1
8.	Dual modality imaging – SPECT/CT and PET/CT	3	C,D	2	1
	UNIT III: Ultrasound	**9**			1
9.	Characteristics of sound, interactions of ultrasound with matter	2	C	3	1
10.	Ultrasound transducers, ultrasound beam properties, image data acquisition	2	C	3	1
11.	Modes of image display and storage	2	C	3	1
12.	Doppler ultrasound, intravascular ultrasound techniques	2	C	3	1
13.	Ultrasound image quality and artifacts	1	C	3	1
	UNIT IV: MRI	**9**			
14.	Basic concepts of MR physics, spin polarization	2	C	4	1
15.	Resonance, relaxation, spin echoes, gradient echoes	2	C	4	1
16.	Spatial encoding using magnetic field gradients, k-space and image reconstruction	3	C	4	1
17.	MRI scanner hardware, functional MRI, MR spectroscopy	2	C	4	1
	UNIT V: Other Imaging Techniques	**9**			
18.	Spectroscopy techniques: light source, optical fibers, monochromator,filters and polarizers	2	C	5	2
19.	Real time spectroscopy techniques, fractional flow reserve measurement techniques	1	C	5	2
20.	Magnetoencephalography, optical coherence tomography	1	C	5	2

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
21.	Infrared imaging: Thermal radiation, single photon detectors, Thermographic scanning systems, clinical thermography and its applications	2	C	5	3
22.	Hospital visit	3	C	6	
	Total contact hours	**45 (Exclusive of Assessment hours)**			

LEARNING RESOURCES	
Sl. No.	**TEXT BOOKS**
1.	Jerrold T. Bushberg, John M. Boone, "*The essential physics of medical imaging"*, Lippincott Williams & Wilkins, 3rd edition, 2011.
2.	Rongguang Liang, "*Biomedical optical imaging technologies: Design and applications"*, Springer Science & Business Media, 1st edition, 2012
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.
4.	Nadine Barrie Smith, Andrew Webb, "*Introduction to medical imaging: Physics, Engineering and clinical applications",* Cambridge University Press, 1st edition, 2010.
	REFERENCE BOOKS/OTHER READING MATERIAL
5.	Arnulf Oppelt, "*Imaging Systems for Medical Diagnostics: Fundamentals, Technical solutions and applications for systems applying ionizing radiation, Nuclear magnetic resonance and Ultrasound"*, John Wiley & Sons, 2nd edition, 2011.
6.	K. Kirk Shung, Michael Smith, Benjamin M.W. Tsui, "*Principles of medical imaging"*, Academic Press, 1st edition, 2012.

Course nature				**Theory**			
Assessment Method (Weightage 100%)							
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Cycle Test III	Surprise Test	Quiz	**Total**
	Weightage	**10%**	**15%**	**15%**	**5%**	**5%**	**50%**
					End semester examination Weightage :		**50%**

15BM302J	Medical Instrumentation			L	T	P	C
				3	0	2	4
Co-requisite:	NIL						
Prerequisite:	15BM203, 15EC251J						
Data Book / Codes/Standards	NIL						
Course Category	P	PROFESSIONAL CORE	BIOMEDICAL INSTRUMENTATION				
Course designed by	Department of Biomedical engineering						
Approval	32nd Academic Council Meeting held on 23rd July 2016						

PURPOSE	The purpose of learning this course on Medical Instrumentation for biomedical engineering students is to acquire knowledge about the different components of various biomedical equipments and its working principle and to measure various physiological parameters.							
INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able to								
1.	Describe the origin of bio potential and its measurements using different type of electrodes	a	b					
2.	Illustrate the basic working principle of cardiac function parameters such as blood pressure, blood flow, heart rate,cardiac output and blood oxygen content	a	b					
3.	Outline the different components and working principle of pulmonary function measuring devices and basic patient monitoring system	a	b					
4.	Explain the working principle of different bioanalytical equipments	a	b					
5.	Predict various electrical hazards and implement safety methods while using biomedical equipments	a	c					
6.	Measure and interpret various physiological parameters	a	c					
7.	Understand the different parts of medical equipments and its working principle	a	c					

Session	Description of Topic (Theory)	Contact hours	C-D-I-O	IOs	Reference
	UNIT I: Physiological Electrodes	**9**			
1.	Basic medical instrumentation system	1	C	1	1,2
2.	Origin of bio potentials: resting and action potential, Nernst equation, Goldman equation	1	C	1	2
3.	Hodgkin-Huxley model	1	C	1	5
4.	Bio potential measurement: electrode electrolyte interface, polarization, polarizable and non-polarizable electrodes, electrode skin interface	2	C	1	2
5.	Surface, Micro and Needle electrodes	2	C	1	1,2
6.	Biochemical electrodes: pH, pO_2, pCO_2	1	C	1	1,2
7.	Transcutaneous electrodes, ion sensitive field effect transistors	1	C	1	2
	UNIT II: Bio Signals Recording	**9**			
8.	ECG: origin, waveforms and their characteristics, Einthoven triangle, lead configurations, electrocardiograph, 12 lead ECG machine circuit, common mode and interference reduction circuits, Vector cardiograph	3	C	1	1,2,3
9.	Recording of EMG	1	C	1	1,2,3
10.	EEG : origin, waveforms and their characteristics, 10-20 electrode placement system, Electro encephalogram, Magneto encephalogram	2	C	1	1,2
11.	EOG & ERG: origin, measurement of EOG, electroretinogram	2	C	1	1,2,3
12.	Heart sounds: origin, phonocardiography	1	C	1	1,2,3
	UNIT III: Cardiac Function Measurements	**9**			
13.	Measurement of blood pressure: direct methods and indirect methods	1	C	2	1,2

Session	Description of Topic (Theory)	Contact hours	C-D-I-O	IOs	Reference
14.	Blood flow measuring techniques: electromagnetic blood flow meter	1	C	2	1,2
15.	Ultrasonic blood flow meter, NMR blood flow meter, Laser doppler blood blow meter	1	C	2	1,2
16.	Cardiac output measuring techniques: dye dilution method; thermal dilution method	1	C	2	1,2
17.	Cardiac output from aortic pressure waveform, impedance technique, ultrasound method, bioreactance method, CO_2 rebreathing method	2	C	2	1,2
18.	Heart rate measurement, fetal heart rate measurements, cardiac arrhythmia	2	C	2	1,2
19.	Invitrooximetry, invivooximetry: Ear oximeter, Pulse oximeter, skin reflectance oximeter, intravascular oximeter	1	C	2	1,2
	UNIT IV: Pulmonary Function Mesurements and Patient Monitoring System	**9**			
20.	Respiratory volumes and capacities, spirometry	1	C	3	1,2
21.	Pneumotachometers: different types	1	C	3	1
22.	Measurement of gas volume	1	C	3	1
23.	Pulmonary function analyzers	1	C	3	1
24.	Respiratory gas analyzers: Infrared gas analyzer, oxygen analyzers, thermal conductivity analyser, nitrogen gas analyzer	1	C	3	1
25.	Measurement of respiration rate: displacement method, thermistor method, impedance pneumography, CO_2 method	2	C	3	1
26.	Apnea detector	1	C	3	1
27.	Bedside and Central Monitoring system	1	C	3	1
	UNIT V: Bioanalytical Equipments and Patient Safety	**9**			
28.	Blood cell counters –microscopic method, automatic optical method, coulter counter,automatic recognition and differential counting of cells, flow cytometer	2	C	4	1,2
29.	Spectrophotometers, colorimeters, flame photometer	1	C	4	1
30.	Selective ion electrodes, ion analyzer	1	C	4	1
31.	Electric shock hazards, micro current shock, leakage currents	1	C	4	1
32.	Precautions to minimize electric hazards, safety codes for electro medical equipment, electrical safety analyzer	1	C	5	1
33.	Hospital visit	3	C	7	
	Total contact hours	**45 (Exclusive of Assessment hours)**			

Sl. No.	Description of experiments	Contact hours	C-D-I-O	IOs	Reference
1.	Simulation of action potential- Hodgkin- Huxley model	2	C,D,I	6	6
2.	Recording and analysis of ECG signal	2	D,I	6	6
3.	Recording and analysis of EEG signal	2	D,I	6	6
4.	Recording and analysis of EMG signal	2	D, I	6	6
5.	Pulmonary function measurement and analysis using spirometer	2	D,I	6	6
6.	Understanding the concept of biotelemetry: ECG, EEG, pulse	4	D,I	6	6
7.	Measurement of oxygen saturation level using pulse oximeter	2	D, I	6	6
8.	Patient monitoring system	2	D,I	6	6
9.	Design of bio amplifier	6	I,O	6	6
10.	Designof pulse oximeter	6	I,O	6	6
	Total contact hours	**30**			

LEARNING RESOURCES	
Sl.No.	**TEXT BOOKS**
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
	REFERENCE BOOKS/OTHER READING MATERIAL
3.	Joseph J Carr and John MBrown, "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. doi:10.1113/jphysiol.1952.sp004764. PMC 1392413. PMID 12991237.
6.	Medical Instrumentation lab manual

Course nature				**Theory + Practical**			
Assessment Method – Theory Component (Weightage 50%)							
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Cycle Test III	Surprise Test	Quiz	**Total**
	Weightage	**10%**	**15%**	**15%**	**5%**	**5%**	**50%**
						End semester examination Weightage :	**50%**
Assessment Method – Practical Component (Weightage 50%)							
In-semester	**Assessment tool**	Experiments	Record	MCQ/Quiz/Viva Voce	Model examination		**Total**
	Weightage	**40%**	**5%**	**5%**	**10%**		**60%**
						End semester examination Weightage :	**40%**

15BM303	Biocontrol Systems			L	T	P	C
				3	0	0	3
Co-requisite:	NIL						
Prerequisite:	NIL						
Data Book / Codes/Standards	NIL						
Course Category	P	PROFESSIONAL CORE	SIGNAL AND IMAGE PROCESSING				
Course designed by	Department of Biomedical Engineering						
Approval	32nd Academic Council Meeting held on 23rd July 2016						

PURPOSE	The purpose of learning this course on Biocontrol systems for biomedical engineering students is to acquire knowledge in the elements and techniques employed in designing and analysis of control systems

INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able to								
1.	Explain the system concepts and the different mathematical modeling techniques applied in analyzing any given system	a	e					
2.	Analyze the given system in time domain	a	e					
3.	Estimate the stability of any system by using various techniques	a	e					
4.	Estimate the frequency response of any system by using various plots	a	e					
5.	Associate the basic concepts of state space representation	a	e					

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	UNIT I: Modelling of Systems	**9**			
1.	Control system terminology-classification of control systems, feedback and its effects on overall gain, stability, noise and sensitivity	1	C	1	1, 2, 3
2.	Open loop and closed loop control systems with physiological system examples- advantages and disadvantages	1	C, I	1	1, 2, 4, 5
3.	Transfer function, modeling of electrical systems	1	C, D	1	1, 2, 3
4.	Modeling of translational and rotational mechanical systems and electromechanical systems, analogous systems	2	C, D	1	1, 2, 3
5.	Block diagram reduction technique	2	C, D	1	1, 2, 3
6.	Signal flow graph, conversion of block diagram to signal flow graph	2	C, D	1	1, 2, 3, 4
	UNIT II: Time Response Analysis	**9**			
7.	Standard test signals- step, ramp, parabolic and impulse type and order of a system	1	C	2	1, 2, 3
8.	Time response of first order systems	1	C, D	2	1, 2, 3, 4
9.	Time response of second order systems	2	C, D	2	1, 2, 3, 4
10.	Transfer function-Time constant form and pole zero form, time domain specifications	1	C, D	2	1, 2, 3
11.	Evaluation of time domain specifications	2	C, D	2	1, 2, 3
12.	Steady state error and error constants and its computation	2	C, D	2	1, 2, 3
	UNIT III: Stability Analysis	**9**			
13.	Stability criterion, necessary conditions for stability	1	C, D	3	1, 2
14.	Determining the stability by Routh and Hurwitz criterion	2	C, D	3	1, 2, 3
15.	Root locus concepts	1	C, D	3	1, 2, 3, 4
16.	Rules for the construction of root locus	2	C, D	3	1, 2, 3
17.	Sketching of root locus for various systems	2	C, D	3	1, 2, 3
18.	Effect of adding poles and zeros to a system	1	C, D	3	1, 2, 3
	UNIT IV: Frequency Response Analysis	**9**			
19.	Frequency response	1	C, D	4	1, 2, 3
20.	Frequency domain specifications	2	C, D	4	1, 2, 3
21.	Polar plot	2	C, D	4	1, 2, 3

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
22.	Bode plot	2	C, D	4	1, 2, 3, 4
23.	Nyquist plot	2	C, D	4	1, 2, 3
	UNIT V: State Space Variable Analysis and Biomedical Applications	**9**			
24.	Introduction-general state space representation	1	C	5	2, 3
25.	Applying the state space representation	2	C, D	5	2, 3
26.	Converting a transfer function to state space	2	C, D	5	2, 3
27.	Converting from state space to a transfer function	2	C, D	5	2, 3
28.	Controllers-P, PI and PID controllers	1	C	5	3, 5
29.	Lung mechanics model with proportional control	1	C	5	6
	Total contact hours	**45 (Exclusive of Assessment hours)**			

LEARNING RESOURCES	
Sl. No.	**TEXT BOOKS**
1.	Nagrath J and Gopal M, "*Control system engineering"*, New Age International Publishers, 5th edition, 2011.
2.	Rajeev Gupta, "*Control systems engineering*", Wiley India Pvt Ltd, 1st edition, 2011.
3.	A.Anand Kumar, "*Control systems*", PHI Learning Pvt Ltd, 2nd edition, 2015.
	REFERENCE BOOKS/OTHER READING MATERIAL
4.	Norman S Nice, "*Control system engineering*", Wiley India Pvt Ltd, 7th edition, 2015.
5.	K R Varmah, "*Control systems*", Tata McGraw Hill, 1st edition, 2010.
6.	Michael C K Khoo, "*Physiological control systems-Analysis, simulation and estimation*", Prentice Hall of India, 2nd edition, 2000.

Course nature				**Theory**			
Assessment Method (Weightage 100%)							
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Cycle Test III	Surprise Test	Quiz	**Total**
	Weightage	**10%**	**15%**	**15%**	**5%**	**5%**	**50%**
					End semester examination Weightage :		**50%**

15BM304J	Biomedical Signal Processing			L	T	P	C
				3	0	2	4
Co-requisite:	NIL						
Prerequisite:	15BM208						
Data Book / Codes/Standards	NIL						
Course Category	P	PROFESSIONAL CORE	SIGNAL AND IMAGE PROCESSING				
Course designed by	Department of Biomedical Engineering						
Approval	32nd Academic Council Meeting held on 23rd July 2016						

PURPOSE	To purpose of learning this course on biomedical signal processing for biomedical engineering students is to acquire the knowledge on the fundamental concepts of signal processing and to apply common signal processing techniques for various biomedical signals.							
INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able to								
1.	Understand the fundamentals of signal processing for various bio-signal analysis	a						
2.	Design the Infinite impulse response (IIR) filter and study its applications	a	c	k				
3.	Attain in-depth knowledge about the basic concepts of finite impulse response (FIR) filter and study its applications	a	c	k				
4.	Apply different methods of signal processing techniques in analyzing the various bio-signals such as Electro cardiogram (ECG), Electromyogram (EMG) and Phonocardiogram (PCG)	a	b	c	k			
5.	Analyze the various case studies approach in processing the bio-signals	a	c	e	k			

Session	Description of Topic (Theory)	Contact hours	C-D-I-O	IOs	Reference
	UNIT I: Fundamentals of Signal Processing	**9**			
1.	Sampling and aliasing, simple signal conversion systems, spectral analysis	2	C	1	2,5
2.	FFT -decimation in time algorithm	2	C,D	1	2,3,5
3.	Decimation in Frequency algorithm	2	C,D	1	2,3,5
4.	Different types of bioelectric signals and its basic characteristics	3	C	1	1,4
	UNIT II: IIRDigital Filter Design and its Applications	**9**			
5.	Impulse invariant method	1	C,D	2	2,3,5
6.	Bilinear transformation method	1	C,D	2	2,3,5
7.	Design of bilinear transformation method using Butterworth technique	1	C,D	2	2,3,5
8.	Design of impulse invariant method using Butterworth technique	1	C,D	2	2,3,5
9.	Design of bilinear transformation Method- using Chebyshev technique	1	C,D	2	2,3,5
10.	Design of impulse invariant method using Chebyshev technique	1	C,D	2	2,3,5
11.	Warping and pre-warping effect, frequency transformation	1	C	2	2,3,5
12.	Frequency domain filters- removal of high frequency noise-Butterworth low pass filters	1	C	2	1
13.	Removal of low frequency noise-Butterworth high pass filters	1	C	2	1
	UNIT III: FIR Digital Filter Designand its Applications	**9**			
14.	Characteristics of FIR filter	1	C	3	2,3,5
15.	FIR filter design using windowing techniques- rectangular window	2	C,D	3	2,3,5
16.	Hamming window	1	C,D	3	2,3,5
17.	Hanning window	1	C,D	3	2,3,5
18.	Blackmann window	1	C,D	3	2,3,5
19.	Time domain filters- synchronized averaging, moving average filters	2	C	3	1

Session	Description of Topic (Theory)	Contact hours	C-D-I-O	IOs	Reference
20.	Introduction to adaptive filters	1	C	3	1,4
	UNIT IV: Analysis of Biosignals	**9**			
21.	P-wave detection, QRS complex detection-derivative based method, Pan Tompkins algorithm	2	C,D	4	1,4
22.	Template matching method, Signal averaged ECG	2	C,D	4	1,4
23.	Analysis of heart rate variability-time domain method and frequency domain methods	1	C	4	1
24.	Synchronized averaging of PCG envelopes, envelogram, analysis of PCG signal, EMG signal analysis	4	C	4	1
	UNIT V: Case Studies in BSP	**9**			
25.	ECG rhythm analysis, normal and ectopic ECG beats, analysis of exercise ECG	2	C	5	1
26.	Analysis of respiration, spectral analysis of EEG signals	2	C	5	1
27.	Case studies- in ECG and PCG	1	C	5	1
28.	PCG and carotid pulse	1	C	5	1
29.	ECG and atrial electrogram	1	C	5	1
30.	Cardio respiratory interaction	1	C	5	1
31.	EMG and Vibromyogram (VMG)	1	C	5	1
	Total contact hours	**45 (Exclusive of Assessment hours)**			

Sl. No.	Description of experiments	Contact hours	C-D-I-O	IOs	Reference
1.	DFT and FFT computation	2	D,I	1	5
2.	IIR filters design-digital Butterworth filter and Chebyshev filter	2	D,I	1	5
3.	FIR filter design using windowing techniques	2	D,I	2	5
4.	Adaptive filter design	2	D,I	3	5
5.	Analysis of ECG signals.	2	I	4	5
6.	Detection of QRS complex in ECG	2	I	4	5
7.	Analysis of EMG	2	I	4	5
8.	Analysis of heart rate variability	2	I	4	5
9.	Analysis of respiratory signal	2	I	5	5
10.	Spectral analysis of EEG signals	2	I	5	5
11.	Implementation of bio signal analysis using lab view	10	I	5	5
	Total contact hours	**30**			

LEARNING RESOURCES	
Sl. No.	**TEXT BOOKS**
1.	Rangaraj.M.Rangayyan, "*Biomedical signal processing"*, Wiley-IEEE press, 2nd edition, 2015.
2.	S.Salivahnan, C.Gnanapriya, "*Digital signal processing*", Tata McGraw-Hill, New Delhi, 2nd edition 2011.
	REFERENCE BOOKS/OTHER READING MATERIAL
3.	John G. Proakis and DimitrisG.Manolakis, "*Digital signal processing*, *algorithms and applications"*, PHI of India Ltd., New Delhi, 4th edition, 2007.
4.	Reddy D.C, "*Biomedical signal processing: Principles and techniques",* Tata McGraw-Hill, New Delhi, 2nd edition, 2005.
5.	Biomedical signal processing labmanual.

Course nature				Theory + Practical			
Assessment Method – Theory Component (Weightage 50%)							
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Cycle Test III	Surprise Test	Quiz	**Total**
	Weightage	**10%**	**15%**	**15%**	**5%**	**5%**	**50%**
						End semester examination Weightage :	**50%**
Assessment Method – Practical Component (Weightage 50%)							
In-semester	**Assessment tool**	Experiments	Record	MCQ/Quiz/Viva Voce		Model examination	**Total**
	Weightage	**40%**	**5%**	**5%**		**10%**	**60%**
						End semester examination Weightage :	**40%**

15BM390L	Internship / Industrial Training I	L	T	P	C
		0	0	2	1
Co-requisite:	NIL				
Prerequisite:	NIL				
Data Book / Codes/Standards	NIL				
Course Category	P PROFESSIONAL CORE				
Course designed by	Department of Biomedical Engineering				
Approval	32nd Academic Council Meeting held on 23rd July, 2016				

PURPOSE	To provide short-term work experience in an Industry/ Company/ Organisation							
INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able								
1.	To get an inside view of an industry and organization/company				j			
2.	To gain valuable skills and knowledge				j			
3.	To make professional connections and enhance networking	f	g					
4.	To get experience in a field to allow the student to make a career transition			i				

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	1. It is mandatory for every student to undergo this course. 2. Every student is expected to spend a minimum of 15-days in an Industry/ Company/ Organization, during the summer vacation. 3. The type of industry must be NOT below the Medium Scale category in his / her domain of the degree programme. 4. The student must submit the "Training Completion Certificate" issued by the industry / company / Organisation as well as a technical report not exceeding 15 pages, within the stipulated time to be eligible for making a presentation before the committee constituted by the department. 5. The committee will then assess the student based on the report submitted and the presentation made. 6. Marks will be awarded out of maximum 100. 7. Appropriate grades will be assigned as per the regulations. 8. Only if a student gets a minimum of pass grade, appropriate credit will be transferred towards the degree requirements, as per the regulations. 9. It is solely the responsibility of the individual student to fulfill the above conditions to earn the credits. 10. The attendance for this course, for the purpose of awarding attendance grade, will be considered 100%, if the credits are transferred, after satisfying the above (1) to (8) norms; else if the credits are not transferred or transferable, the attendance will be considered as ZERO. 11. The committee must recommend redoing the course, if it collectively concludes, based on the assessment made from the report and presentations submitted by the student, that either the level of training received or the skill and / or knowledge gained is NOT satisfactory.		D,I,O	1,2,3,4	
	Total contact hours				

Course nature		**Training – 100% internal continuous assessment**		
Assessment Method (Weightage 100%)				
In-semester	**Assessment tool**	**Presentation**	**Report**	**Total**
	Weightage	**80%**	**20%**	**100%**
End semester examination Weightage :				**0%**

15BM305J	Microprocessor Systems in Medicine	L	T	P	C
		3	0	2	4
Co-requisite:	NIL				
Prerequisite:	NIL				
Data Book / Codes/Standards	NIL				
Course Category	P PROFESSIONAL CORE	MEDICAL ELECTRONICS			
Course designed by	Department of Biomedical Engineering				
Approval	32nd Academic Council Meeting held on 23rd July 2016				

PURPOSE	The purpose of studying this course on microprocessor systems in medicine for biomedical engineering students is to enable the students to have basic knowledge about microprocessor and microcontroller thereby aid in design of circuits for various biomedical applications							
INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able to								
1.	Understand the fundamental concepts of 8086 microprocessors	a						
2.	Explain the basic concepts of 8051 microcontroller	a						
3.	Obtain knowledge on interfacing devices	a	k					
4.	Familiarize about ARM microcontroller	a						
5.	Acquire knowledge on applications of microprocessor and microcontroller in biomedical domain.	a						

Session	Description of Topic(Theory)	Contact hours	C-D-I-O	IOs	Reference
	UNIT I: Overview of 8086 Microprocessor	**9**			
1.	Evolution of Microprocessor and its importance in biomedical domain	1	C	1,3	1,2
2.	Architecture and signal description of 8086	2	C	1	1, 2
3.	Minimum and maximum mode, addressing modes	2	C	1	1,2
4.	Instruction set	3	C	1	1,2
5.	Programs	1	I	1	1,2
	UNIT II: 8051 Microcontroller	**9**			
6.	Introduction to 8 bit microcontroller, signal descriptions of 8051	1	C	2	4
7.	Architecture of 8051	1	C	2	4
8.	Register set of 8051	2	C	2	4
9.	Instruction set	3	C	2	4
10.	Addressing mode	2	I	2	4
	UNIT III:Interfacing Devices	**9**			
11.	Timer-serial communication-interrupts programming	1	C	4	4
12.	Interfacing to external memory	2	C	4	4
13.	Basic techniques for reading & writing from I/O port pins	1	C	4	4
14.	Interfacing 8051 to ADC	2	C	4	4
15.	Liquid crystal display (LCD), keyboard	2	C	4	4
16.	Stepper motor	1	C	4	4
	UNIT IV: Arm Microcontroller	**9**			
17.	Fundamentals: registers, current program status register	2	C	5	3
18.	Pipeline, exceptions	2	C	5	3
19.	Interrupts and vector table	1	C	5	3
20.	ARM architecture	1	C	5	3
21.	ARM instruction set, thumb instruction set.	3	C	5	3
	UNIT V: Application In Medicine	**9**			
22.	Mobile phone based bio signal recording	2	C,D	3	5,6
23.	Design of pulse oximeter circuit using ARM microcontroller	2	C,D	3	5,6
24.	Design of EOG based home appliances using PIC microcontroller	2	C,D	3	5,6

Session	Description of Topic(Theory)	Contact hours	C-D-I-O	IOs	Reference
25.	Design of heart rate monitoring circuit using ARM microcontroller	3	C,D	3	5,6
	Total contact hours	**45 (Exclusive of Assessment hours)**			

Sl. No.	Description of experiments	Contact hours	C-D-I-O	IOs	Reference
1.	Addition, subtraction, multiplication, division using 8086 processor	5	C,I	1	1,7
2.	Sorting of numbers in ascending order using 8086 processor	1	C,I	1	1
3.	Sorting of numbers in descending order using 8086 processor	1	C,I	1	1
4.	Palindrome and Fibonacci series using 8086 processor	1	C,I	1	1
5.	Sorting of even numbers in an array using 8086 processor	1	C,I	1	1
6.	Finding the largest and smallest number in an array using 8086 processor	1	C,I	1	1
7.	Addition of two numbers using 8051 processor	2	C,I	2	7
8.	Subtraction of two numbers using 8051 processor	2	C,I	2	7
9.	Multiplication of two numbers using 8051 processor	2	C,I	2	7
10.	Sorting of numbers in ascending order using 8051 processor	2	C,I	2	
11.	Sorting of numbers in descending order using 8051 processor	2	C,I	2	7
12.	Palindrome and fibonacci series using 8051 processor	2	C,I	2	7
13.	Sorting of even numbers in an array using 8051 processor	3	C,I	2	7
14.	Basic programs using ARM controller	5	C,I	3	7
	Total contact hours	**30**			

LEARNING RESOURCES	
Sl. No.	**TEXT BOOKS**
1.	A.K.Ray, K.M.Bhurchandi, "*Advanced Microprocessor and Peripherals*", Tata McGraw Hill, 3rd edition, 2013.
2.	Douglas V. Hall, "Microprocessor and Interfacing:Programming and Hardware",Glencoe, 2nd edition, 2006.
	REFERENCE BOOKS/OTHER READING MATERIAL
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.
5.	www.microchip.com/medical.
6.	www.freescale.com/medical.
7.	Microprocessor systems in medicine lab manual.

Course nature					**Theory + Practical**		
Assessment Method – Theory Component (Weightage 50%)							
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Cycle Test III	Surprise Test	Quiz	**Total**
	Weightage	**10%**	**15%**	**15%**	**5%**	**5%**	**50%**
						End semester examination Weightage :	**50%**
Assessment Method – Practical Component (Weightage 50%)							
In-semester	**Assessment tool**	Experiments	Record	MCQ/Quiz/Viva Voce	Model examination		**Total**
	Weightage	**40%**	**5%**	**5%**	**10%**		**60%**
						End semester examination Weightage :	**40%**

15BM306J	Medical Image Processing			L	T	P	C
				3	0	2	4
Co-requisite:	NIL						
Prerequisite:	15MA103						
Data Book / Codes/Standards	NIL						
Course Category	P	PROFESSIONAL CORE	SIGNAL AND IMAGE PROCESSING				
Course designed by	Department of Biomedical Engineering						
Approval	32nd Academic Council Meeting held on 23rd July 2016						

PURPOSE	The purpose of learning this course on medical image processing for biomedical engineering students is to acquire the fundamental concepts of image acquisition and understand how to apply the image processing techniques for various medical images.

INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able to								
1.	Understand the image fundamentals and mathematical transforms necessary for image processing	a	k					
2.	Describe the various image enhancement and image restoration techniques	a	b	k				
3.	Apply various image segmentation methods and analysis in medical images.	a	b	c	k			
4.	Illustrate the basic concepts of wavelets and image compression techniques	a	b	c	k			
5.	Explain the different types of reconstruction techniques applied to various medical Images.	a	b	k				

Session	Description of Topic (Theory)	Contact hours	C-D-I-O	IOs	Reference
	UNIT I: Digital Image Fundamentals and 2d Image Transforms	**9**			
1.	Elements of visual perception	1	C	1	1,2
2.	Image sampling -2D sampling theory and its reconstruction, quantization-optimal quantizer, uniform quantizer, different types of quantization techniques	3	C	1	1,2
3.	Neighborhood pixel relationships, basic image operations-arithmetic, logical and morphological	2	C	1	1
4.	Image transform- 2D DFT, discrete cosine, haar and hadamard transforms, KL transform	3	C,D	1	1,2
	UNIT II: Image Enhancement and Image Restoration	**9**			
5.	Basic gray level transformation	1	C	2	1,2
6.	Histogram equalization and histogram matching	1	C,D	2	1
7.	Image smoothening, Image sharpening, both spatial and frequency domain	3	C,I	2	1,2
8.	Color image Processing color models, Pseudo color image processing	2	C,I	2	1
9.	Image degradation models, restoration - mean filter, order statistics filter, adaptive filters	2	C,D	2	1
	UNIT III:Image Segmentation and Analysis	**9**			
10.	Edge detection- Marr Hidreth edge detector,canny edge detector	2	C,D	3	1,2
11.	Thresholding-foundation, basic global thresholding	1	C,D	3	1
12.	Segmentation-amplitude segmentation methods, clustering segmentation methods, region based segmentation, watershed segmentation algorithm	4	C,D,I	3	1,2,3
13.	Shape analysis- topological attributes, distance, perimeter and area measurements	2	C,I	3	3
	UNIT IV: Basic Morphological Operations and Image Compression	**9**			
14.	Erosion and dilations, opening and closing, hit or miss transformations	3	C,D	4	1
15.	Image compression-fundamentals, basic image compression methods, run length, Huffman, arithmetic, transform and lossyand lossless predictive coding	5	C, D	4	1,2

Session	Description of Topic (Theory)	Contact hours	C-D-I-O	IOs	Reference
16.	Digital image watermarking	1	C,D,I	4	1
	UNIT V: Reconstruction of Medical Images	**9**			
17.	Image reconstruction from projections	1	C	5	1,2
18.	Radon transforms, inverse radon transform	2	C,D	5	2
19.	Filter back projection algorithm, Fourier reconstruction of MRI Images	2	C,D,I	5	2
20.	Reconstruction of PET, SPECT and fMRI images	4	C,D,I	5	2,3,4
	Total contact hours	**45 (Exclusive of Assessment hours)**			

Sl. No.	Description of experiments	Contact hours	C-D-I-O	IOs	Reference
1.	Basic operations on images	2	I	1	5
2.	Image Transforms	2	D,I	1	5
3.	Gray level transformation and histogram processing	2	D,I	2	5
4.	Color image processing	2	D,I	2	5
5.	Image smoothening and image sharpening using suitable filters	2	I	2	5
6.	Edge detection techniques.	2	I	3	5
7.	Image segmentation by thresholding	2	I	3	5
8.	Image segmentation using morphological operations	2	D,I	4	5
9.	Segmentation using watershed transform	2	I	4	5
10.	Image reconstruction using radon transform	2	I	5	5
11.	Implementation of image segmentation algorithms in medical images	8	I,O	5	5
	Total contact hours	**30**			

LEARNING RESOURCES	
Sl. No.	**TEXT BOOKS**
1.	Rafael C., Gonzalez and Richard E. Woods, "*Digital Image Processing*", Pearson Education Asia, 3rd edition, 2007.
2.	Anil K. Jain, "*Fundamentals of Digital Image Processing*", Prentice Hall of India, 3rd edition, 2001.
	REFERENCE BOOKS/OTHER READING MATERIAL
3.	William K. Pratt, "*Digital Image Processing*",John Wiley, NJ, 4thedition, 2007.
4.	Albert Macouski, "*Medical Imaging systems*", Prentice Hall, New Jersey,2nd edition,1997.
5.	Medical image processing lab manual.

Course nature				**Theory + Practical**			
Assessment Method – Theory Component (Weightage 50%)							
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Cycle Test III	Surprise Test	Quiz	**Total**
	Weightage	**10%**	**15%**	**15%**	**5%**	**5%**	**50%**
						End semester examination Weightage :	**50%**
Assessment Method – Practical Component (Weightage 50%)							
In-semester	**Assessment tool**	Experiments	Record	MCQ/Quiz/Viva Voce	Model examination		**Total**
	Weightage	**40%**	**5%**	**5%**	**10%**		**60%**
						End semester examination Weightage :	**40%**

15BM307M	Multi-Disciplinary Design	L	T	P	C
		2	2	0	3
Co-requisite:	NIL				
Prerequisite:	NIL				
Data Book / Codes/Standards	NIL				
Course Category	P PROFESSIONAL CORE				
Course designed by	Department of Biomedical Engineering				
Approval	32nd Academic Council Meeting held on 23rd July, 2016				

PURPOSE	Students of any specialization at an undergraduate level learn courses related to various sub-domains (Multi-disciplinary) of their specialization individually. They are not exposed to understanding how the various multi-disciplinary fields interact and integrate in real life situations. It is very common that an expert in a particular domain models and designs systems or products oblivious of the impact of other subsystems. This lack of multi-disciplinary thinking is very blatantly visible when the students take up their major project during their final year. This course aims to develop appropriate skills on systemic thinking on how to identify and formulate a problem, decompose the problem into smaller elements, conceptualize the design, evaluate the conceptual design by using scientific, engineering and managerial tools, select, analyze and interpret the data, consideration of safety, socio-politico-cultural, risks and hazards, disposal, regional and national laws, costing and financial model and undertake documentation and finally presentation.

INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able								
1.	To subdivide a complex system into smaller disciplinary models, manage their interfaces and reintegrate them into an overall system model	a	c	e	f	i	l	
2.	To rationalize a system architecture or product design problem by selecting appropriate design variables, parameters and constraints	a	c	e	f	i	l	
3.	To design for value and quantitatively assess the expected lifecycle cost of a new system or product	a	c	e	f	i	l	
4.	To take on the challenges of teamwork, prepare a presentation in a professional manner, and document all aspects of design work	a	c	e	f	i	l	

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
1.	Introduction: Facilitating Multidisciplinary Projects				
2.	Identifying and formulating a problem				
3.	System Modeling				
4.	Thinking perspectives: Decomposition–Composition Thinking Hierarchical Thinking, Organizational Thinking, Life-Cycle Thinking, Safety Thinking, Risk Thinking, Socio-politico-cultural thinking, Environment thinking				
5.	Decomposing a system – Identifying the major sub-systems				
6.	Mathematical Modeling and Governing equations for each sub systems				
7.	Objectives, Constraints and Design Variables		C,D,I,O	1,2,3,4	
8.	Conceptual Design				
9.	Collaborative Design – Disciplinary teams satisfy the local constraints while trying to match the global constraints set by the project coordinator.				
10.	Tools for modeling, designing, analysis, data interpretation, decision making etc				
11.	Design Analysis, evaluation and selection				
12.	Costing and Financial model				
13.	Documentation, reviewing and presentation				
	Total contact hours	**60**			

LEARNING RESOURCES	
Sl. No.	**REFERENCES**
1.	G. Maarten Bonnema, Karel T. Veenvliet, Jan F. Broenink, "*Systems Design and Engineering: Facilitating Multidisciplinary Development Projects",* December 15, 2015, CRC Press ISBN 9781498751261.
2.	Ina Wagner, Tone Bratteteig, DagnyStuedahl, "*Exploring Digital Design-Multi-Disciplinary Design Practices",* Springer-Verlag London, 2010, ISSN:1431-1496.

Course nature				**PredominantlyPractice complimented by theory**		
Assessment Method (Weightage 100%)						
In-semester	**Assessment tool**	Review 1	Review 2	Review 3	Review 4	**Total**
	Weightage	**10%**	**25%**	**25%**	**40%**	**100%**
End semester examination Weightage :						**0%**

Pedagogy:
Theme or major/broad domains will be announced by the department every semester. Multi-disciplinary designs will be made by the students in groups (group size may be decided by the course coordinator), with the topic of interest falling within the theme or major/broad domains as announced by the department, applying any combinations of the disciplines in engineering. 3D modelling and / or simulation must be used to validate the design.

In a combination of lecture and hands-on experiences, students must be exposed to understand and analyse engineering designs (or products) and systems, their realization process and project management. Analysis of the design criteria for safety, ergonomics, environment, life cycle cost and sociological impact is to be covered. Periodic oral and written status reports are required. The course culminates in a comprehensive written report and oral presentation. If required guest lecturers from industry experts from the sub-domains may be arranged to provide an outside perspective and show how the system design is being handled by the industry. The Conceive Design Implement Operate (CDIO) principles must be taught to the students.

A full-scale fabrication is not within the purview /scope of this course. Of course this design, if scalable and approved by the department, can be extended as the major project work.

This course is 100% internal continuous assessment.

15BM376L	Minor Project II	L	T	P	C
		0	0	3	2
Co-requisite:	NIL				
Prerequisite:	NIL				
Data Book / Codes/Standards	NIL				
Course Category	P PROFESSIONAL				
Course designed by	Department of Biomedical Engineering				
Approval	32nd Academic Council Meeting held on 23rd July, 2016				

PURPOSE	To obtain an hands-on experience in converting a small novel idea / technique into a working model / prototype involving multi-disciplinary skills and / or knowledge and working in at team.							
INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able								
1.	To conceptualise a novel idea / technique into a product	c						
2.	To think in terms of multi-disciplinary environment		d					
3.	To understand the management techniques of implementing a project				k			
4.	To take on the challenges of teamwork, prepare a presentation in a professional manner, and document all aspects of design work			g				

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	An Multidisciplinary project to be taken up by a team of maximum of ten students. Development of prototype product, a 3D model, simulation, blueprint for a larger project and any other development work are permitted. The contribution of the individuals in the project should be clearly brought out. A combined report is to be submitted. A presentation is to be made for the reviewers on the work done by the candidate.		C,D,I	1,2,3,4	
	Total contact hours				

Course nature		**Project – 100% internal continuous assessment**	
Assessment Method (Weightage 100%)			
In-semester	**Assessment tool**	Refer the table	**Total**
	Weightage	Refer the table below	**100%**
End semester examination Weightage :			**0%**

Assessment components

Assessment component	Expected outcome	Evaluators	Criteria or basis	Marks
Project proposal (Review – I)	A short presentation to be delivered on: • A brief, descriptive project title (2-4 words). This is critical! • The 3 nearest competitors (existing solutions) and price. • Team members name, phone number, email, department/degree program, and year. • A description of the product opportunity that has been identified. To include: Documentation of the market need, shortcomings of existing competitive products, and definition of the target market and its size. • Proposed supervisor / guide	Panel of reviewers	Viability / feasibility of the project Extent of preliminary work done.	**0**

Assessment component	Expected outcome	Evaluators	Criteria or basis	Marks
Review II	• Mission Statement / Techniques • Concept Sketches, Design Specifications / Modules & Techniques along with System architecture • Coding	Panel of reviewers	Originality, Multi-disciplinary component, clarity of idea and presentation, team work, handling Q&A.	**20**
Review III	• Final Concept and Model / Algorithm/ Technique • Drawings, Plans / programme output • Financial Model / costing • Prototype / Coding • Final Presentation and Demonstration	Panel of reviewers	Originality, Multi-disciplinary component, clarity of idea and presentation, team work, handling Q&A.	**50**
Final technical Report	A good technical report	Supervisor / Guide	Regularity, systematic progress, extent of work and quality of work	**30**
			Total	**100**

15BM381L	Seminar II	L	T	P	C
		0	0	3	2
Co-requisite:	NIL				
Prerequisite:	NIL				
Data Book / Codes/Standards	NIL				
Course Category	P PROFESSIONAL				
Course designed by	Department of Biomedical Engineering				
Approval	32nd Academic Council Meeting held on 23rd July, 2016				

PURPOSE	To enhance the disseminating skills of the student about the current and contemporary research work that are being carried out across the world.							
INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able								
1.	To understand the research methodology adopted by various researchers	h	i	j				
2.	To mathematically model a problem, critically analyse it and adopt strategies to solve	b	c	e				
3.	To understand and present a well documented research	e	g					

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	Guidelines for conducting 15BM381L Seminar for B.Tech 1. Upon registering for the course the student must identify a sub-domain of the degree specialization that is of interest to the student and start collecting research papers as many as possible. 2. After collecting sufficient number of research papers the student must peruse all the papers, meet the course faculty and discuss on the salient aspects of each and every paper. 3. The course faculty, after discussion with the student will approve TWO research papers that is appropriate for presentation. 4. The student must collect additional relevant reference materials to supplement and compliment the two research papers and start preparing the presentation. 5. Each student must present a 15-minute presentation on each of the approved research paper to the panel of evaluators. 6. The presenter must present one research paper within the first half of the semester (6 weeks) and another research paper in the next half of the semester (6 weeks) as per the schedule. 7. All other students registered for the course will form the audience. 8. The audience as well as the evaluators will probe the student with appropriate questions and solicit response from the presenter. 9. The presentation will be evaluated against 7 to 8 assessment criteria by 4 to 5 evaluators. 10. The score obtained through the presentations of TWO research papers will be converted to appropriate percentage of marks. This course is 100% internal continuous assessment.		C,D	1,2,3,4	
	Total contact hours				

Course nature			100% internal continuous assessment.	
Assessment Method (Weightage 100%)				
In-semester	**Assessment tool**	Presentation 1	Presentation 2	**Total**
	Weightage	**50%**	**50%**	**100%**
End semester examination Weightage :				**0%**

Department of Biomedical Engineering

EVALUATION OF SEMINAR PRESENTATIONS

Name of the Student: Date:
Register Number: Degree and Branch:

Topic:

Sl. No.	Criteria for Assessment	Evaluator 1	Evaluator 2	Evaluator 3	Evaluator 4	Evaluator 5
1	Understanding of the subject					
2	Clarity of presentation					
3	Appropriate use of Audio visual aids					
4	Whether cross references have been consulted					
5	Ability to respond to questions on the subject					
6	Time scheduling					
7	Completeness of preparation					

Poor	1	Below	2	Average	3	Good	4	Very Good	5

Overall Grades:
Remarks:
Signature of Course Coordinator

15BM386L	Massive Open Online Courses (MOOCs) II	L	T	P	C
		0	0	3	2
Co-requisite:	NIL				
Prerequisite:	NIL				
Data Book / Codes/Standards	NIL				
Course Category	P PROFESSIONAL				
Course designed by	Department of Biomedical Engineering				
Approval	32nd Academic Council Meeting held on 23rd July, 2016				

PURPOSE	To offer students the opportunity to study with the world's best universities by integrating select MOOCs in a regular degree programme and providing students full credit transfer, as per university regulations, if they earn a "Verified / Completion Certificate" and take a proctored examination through a secure, physical testing center.							
INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able								
1.	To apply the concepts, theories, laws, technologies learnt herein to provide engineering solutions	f	h	i	j			

Course nature				**Online - 100% internal continuous assessment**		
Assessment Method (Weightage 100%)						
In-semester	**Assessment tool**	Quiz	Assignment	Non-proctored / Unsupervised Tests	Proctored / Supervised Test	**Total**
	Weightage	**25%**	**25%**	**10%**	**40%**	**100%**
					End semester examination Weightage :	**0%**

Registration process, Assessment and Credit Transfer:

1. Students can register for courses offered by approved global MOOCs platforms like edX, Coursera or Universities with which SRM partners specifically for MOOCs.
2. Annually, each department must officially announce, to the students as well as to the Controller of Examinations, the list of courses that will be recognised and accepted for credit transfer.
3. The department must also officially announce / appoint one or more faculty coordinator(s) for advising the students attached to them, monitoring their progress and assist the department in proctoring the tests, uploading the marks / grades, and collecting and submitting the graded certificate(s) to the CoE, within the stipulated timeframe.
4. Student who desires to pursue a course, from the above department-approved list, through MOOCs must register for that course during the course registration process of the Faculty of Engineering and Technology, SRM University.
5. The maximum credit limits for course registration at SRM will include the MOOCs course registered.
6. The student must periodically submit the marks / grades obtained in various quizzes, assignments, tests etc immediately to the Faculty Advisor or the Course Coordinator for uploading in the university's academic module.
7. The student must take the final test as a Proctored / Supervised test in the university campus.
8. The student must submit the "Certificate of Completion" as well as the final overall Marks and / or Grade within the stipulated time for effecting the grade conversion and credit transfer, as per the regulations. It is solely the responsibility of the individual student to fulfil the above conditions to earn the credits.
9. The attendance for this course, for the purpose of awarding attendance grade, will be considered 100%, if the credits are transferred, after satisfying the above (1) to (7) norms; else if the credits are not transferred or transferable, the attendance will be considered as ZERO.

15BM491L	Industry Module II	L	T	P	C
		0	0	3	2
Co-requisite:	NIL				
Prerequisite:	NIL				
Data Book / Codes/Standards	NIL				
Course Category	P PROFESSIONAL				
Course designed by	Department of Biomedical Engineering				
Approval	32nd Academic Council Meeting held on 23rd July, 2016				

PURPOSE	To impart an insight into the current industrial trends and practices							
INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able								
1.	To obtain an insight into the current industrial trends and practices			j				
2.	To obtain an insight into the technologies adopted by industries			j				
3.	To obtain an insight into the technical problems encountered by the industries and the scope for providing solutions.		h					
4.	To network with industry	g						

Description of Topic	**Contact hours**	**C-D-I-O**	**IOs**	**Reference**
1. The department will identify and shortlist few emerging topics that are trending in industry. 2. The department will identify experts from industry who are willing to deliver modules on the shortlisted topics. 3. The identified expert will assist the department in formulating the course content to be delivered as a 30-hour module, prepare lectures notes, ppt, handouts and other learning materials. 4. The department will arrange to get the necessary approvals for offering the course, from the university's statutory academic bodies well before the actual offering. 5. The department must officially announce, to the students as well as to the Controller of Examinations, the list of courses that will be offered as industry module. 6. The department must also officially announce / appoint one or more faculty coordinator(s) for advising the students attached to them, monitoring their progress and assist the department in proctoring/supervising/assessment the quizzes, assignments, tests etc, uploading the marks, attendance etc, within the stipulated timeframe. 7. The Student who desires to pursue a course, from the above department-approved list, must register for that course during the course registration process of the Faculty of Engineering and Technology, SRM University. 8. The maximum credit limits for course registration at SRM will include the Industry Module also. 9. All academic requirements of a professional course like minimum attendance, assessment methods, discipline etc will be applicable for this Industry Module. 10. The course will be conducted on weekends or beyond the college regular working hours.		C,D,I,O	1,2,3,4	
Total contact hours	**30**			

Course nature			**100% internal continuous assessment.**				
Assessment Method – Theory Component (Weightage 50%)							
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Cycle Test III	Surprise Test	Quiz	**Total**
	Weightage	**10%**	**15%**	**15%**	**5%**	**5%**	**50%**
					End semester examination Weightage		**50%**

15BM401J	Diagnostic and Therapeutic Equipments	L	T	P	C
		3	0	2	4
Co-requisite:	NIL				
Prerequisite:	15BM204J, 15BM302J				
Data Book / Codes/Standards	NIL				
Course Category	P PROFESSIONAL CORE	BIOMEDICALINSTRUMENTATION			
Course designed by	Department of Biomedical engineering				
Approval	32nd Academic Council Meeting held on 23rd July 2016				

PURPOSE	The purpose of learning this course on diagnostic and therapeutic equipment for biomedical engineering students is toacquire knowledge about the working principle of the various diagnosis and therapeutic biomedical equipments used in hospitals.

INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able to								
1.	Explain the working principle of coronary care equipments	a						
2.	Illustrate the functioning of different types of physiotherapy and electrotherapy equipments	a	b					
3.	Overview the different components and working principle of sensory diagnosis and therapeutic equipments	a						
4.	Describe the functioning of various bone mineral density (BMD) measuring techniques and respiratory care equipments	a	b					
5.	Describe the use of different surgical equipments	a						
6.	Study the working principle of diagnostic and therapeutic equipments	a	b					
7.	Measure and interpret BMD using pDEXA	a	b					
8.	Design and analyse the working of basic electrical simulator	a	b					
9.	Understand the different parts of diagnostic and therapeutic equipments and its working principle	a	c					

Session	Description of Topic (Theory)	Contact hours	C-D-I-O	IOs	Reference
	UNIT I: Coronary Care Equipments	**9**			
1.	Cardiac pacemakers: different modes of operation, external and implantable pacemakers, pacemaker standard codes	2	C	1	1,2,8
2.	Defibrillator: AC and DC defibrillator	1	C	1	1,2
3.	Implantable defibrillator and automated external defibrillator (AED)	2	C	1	1,2
4.	Pacer- cardioverter defibrillator, defibrillator analysers	2	C	1	1,2
5.	Heart lung machine (HLM) and types of oxygenators	2	C	1	1,2
	UNIT II: Physiotherapy, Electrotherapy and Phototherapy Equipments	**9**			
6.	Short wave diathermy	1	C	2	1,2
7.	Microwave diathermy	1	C	2	1,2
8.	Ultrasonic therapy unit	1	C	2	1,2
9.	Electro diagnostic and therapeutic apparatus	2			1
10.	Interferential current therapy, Transcutaneous electrical nerve stimulation (TENS)	1	C	2	1,2
11.	Spinal cord stimulator, bladder stimulator, deep brain stimulation	2	C	2	1,2,3
12.	Photo therapy unit	1	C	2	1
	UNIT III: Instruments Dealing With Bones and Respiratory Care	**9**			
13.	Respiratory care equipments: humidifier, nebulizer, aspirators	1	C	2	1,2
14.	Ventilators and types, capnography	3	C	2	1,2
15.	Anesthesia machine	1	C	2	1,2
16.	Baby incubator	2	C	2	1

Session	Description of Topic (Theory)	Contact hours	C-D-I-O	IOs	Reference
17.	BMD measurements: Single X-ray absorptiometry (SXA)	1	C	4	3
18.	Dual X-ray absorptiometry (DXA)	1	C	4	3
19.	Quantitative ultrasound bone densitometer	1	C	4	3
	UNIT IV: Sensory Diagnosis and Hearing Aid Equipments	**9**			
20.	Mechanism of hearing, sound conduction system	1	C	3	1,2
21.	basic audiometer, pure tone audiometer	1	C	3	1,2
22.	Speech audiometer, bekesyaudiometer system	2	C	3	1,2
23.	Evoked response audiometry system	1	C	3	1
24.	Hearing aids, cochlear implants	2	C	3	1
25.	Tonometry	1	C	3	2
26.	Measurement of basal skin response and galvanic skin response	1	C	3	1
	UNIT V: Surgical and Therapeutic Equipments	**9**			
27.	Surgical diathermy unit	1	C	5	1,2
28.	Endoscopy basic components and types	2	C	5	1,2
29.	Laparoscope, gastro scope, bronchoscope	1	C	5	4
30.	Cryogenic techniques and application	1	C	5	6
31.	Operating microscope, arthroscopy	1	C	5	5
32.	Modern lithotripter system, laser lithotripsy	1	C	5	1,2
33.	Hospital visit	2	C	9	
	Total contact hours	**45 (Exclusive of Assessment hours)**			

Sl. No.	Description of experiments	Contact hours	C-D-I-O	IOs	Reference
1.	Study – Working principle of defibrillator	2	C,I	6	9
2.	Study – Working principle of pacemaker	2	C,I	6	9
3.	Measurement of nerve conduction velocity	2	C,I	6	9
4.	Measurement of hearing ability – audiometer	2	C,I	6	9
5.	Study – Working principle of dialysis machine	2	C,I	6	9
6.	Ultrasound diathermy – working principle	2	C,I	6	9
7.	Shortwave diathermy – working principle	2	C,I	6	9
8.	Electro surgical unit – working principle	2	C,I	6	9
9.	BMD measurement – using peripheral DEXA	2	C,I	7	9
10.	Skin impedance measurement	2	C,I	6	9
11.	Design of basic electrical simulator	8	C,D,I	8	9
	Total contact hours	30			

LEARNING RESOURCES

Sl. No.	TEXT BOOKS
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, 3rdedition, 2013.
	REFERENCE BOOKS/OTHER READING MATERIAL
4.	Cotton.P. B, and Williams. C. B., "*Endoscopic Equipment, in Practical Gastrointestinal Endoscopy: The Fundamentals*", Wiley-Blackwell, Oxford, UK, 6th edition, 2008.
5.	Marc. Safran, Bobby. Chhabra. A., Mark. Miller.D., "*Primer of Arthroscopy*",Elsevier Health Sciences, 2nd edition, 2010.
6.	Ventura.,Risegari., "*The Art of Cryogenics Low-Temperature Experimental Techniques*", Elsevier Science, 1st edition, 2007.
7.	Leslie Cromwell, Fred J.Weibell, Erich A.Pfeiffer, "*Bio-Medical Instrumentation and Measurements"*,Pearson Education, PHI Learning Private limited, India, 2nd edition, 2007.
8.	John G.Webster, "*Specifications of Medical Instrumentation Application and Design"*,Wiley India Pvt Ltd, India, 4th edition, 2015.
9.	Diagnostic And Therapeutic Equipment Lab Manual.

Course nature				Theory + Practical			
Assessment Method – Theory Component (Weightage 50%)							
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Cycle Test III	Surprise Test	Quiz	**Total**
	Weightage	**10%**	**15%**	**15%**	**5%**	**5%**	**50%**
End semester examination Weightage :							**50%**
Assessment Method – Practical Component (Weightage 50%)							
In-semester	**Assessment tool**	Experiments	Record	MCQ/Quiz/Viva Voce		Model examination	**Total**
	Weightage	**40%**	**5%**	**5%**		**10%**	**60%**
End semester examination Weightage :							**40%**

15BM402	Neural Networks and Fuzzy Logic Systems in Medicine			L	T	P	C
				3	1	0	4
Co-requisite:	NIL						
Prerequisite:	NIL						
Data Book / Codes/Standards	NIL						
Course Category	P	PROFESSIONAL CORE	SIGNAL AND IMAGE PROCESSING				
Course designed by	Department of Biomedical Engineering						
Approval	32nd Academic Council Meeting held on 23rd July 2016						

PURPOSE	The purpose of studying this course on neural network and fuzzy logic system for biomedical engineering students is to enables the students to understand the basic concepts of Artificial Neural networks and Fuzzy logic systems and provides a pathway for applying the concepts for biomedical application.

INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able to								
1.	Understand the basic concepts of artificial neural networks (ANN)	a	k					
2.	Familiarize about various ANN models	a						
3.	Obtain knowledge about the self organizing maps and competitive networks	a	e	k				
4.	Acquire knowledge on the basic concepts of fuzzy Logic systems	a	e					
5.	Know about the concepts of ANN and Fuzzy Logic in biomedical applications	a	k					

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	UNIT I: Artificial Neural Networks-An Overview	**12**			
1.	Neural networks basics	1	C	1	1,2,5
2.	Biological neuron and their artificial model	1	C,D	1	1,2,5
3.	McCullohpitts model	2	C,D	1	1,2,5
4.	Network parameters-weights, activation, threshold function	1	C,D	1	1,2,5
5.	Hebbrule, delta rule	2	C,D	1	1,2,5
6.	Perception learning algorithm	2	C,D	1	1,2,5
7.	Tutorial: Perceptron convergence theorem, MADALINE, ADALINE Problem	3	C,D	1	1,2,5
	UNIT II: Artificial Neural Network Models	**12**			
8.	Feed forward networks	1	C,D	2	1,2,5
9.	Back propagation network- structure and algorithm, BPN application	2	C	2	1,2,5
10.	Associative memory	1	C	2	1,2,5
11.	Recurrent network - Hopfield network	2	C,D	2	1,2,5
12.	Hopfield -travelling salesman problem, radial basis function network	2	C,D	2	1,2,5
13.	Matlab programming for back propagation neural network	1	D,I	2	1,2,5,6
14.	Tutorial: Boltzman machine, Issues in network design	3	C,D	1	1,2,5
	UNIT III:Self Organizing Maps (SOM)	**12**			
15.	Self organizing maps-pattern clustering	1	C	3	1
16.	SOM-topological mapping, kohonen's SOM	1	C,D	3	1
17.	Learning vector quantization	1	C,D	3	1
18.	Competitive models-min, max net	1	C,D	3	1
19.	Adaptive resonance theory (ART)-introduction, network and processing in art	2	C,D	3	1
20.	Associative memory model	1	D	3	1
21.	Basics of support vector machine (SVM) and radial	2	D	3	1
22.	Tutorial: Self organizing maps in MATLAB, Visualization using U-matrix	3	C,D	3	1,6

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	UNIT IV: Introduction To Fuzzy Logic System	**12**			
23.	Fuzzy logic-basic concepts -fuzzy vs crisp set	2	C,D	4	4
24.	Linguistic variables, membership functions	2	C,D	4	4
25.	Fuzzy if-then rules	2	C,D	4	4
26.	Variable inference techniques, de-fuzzification techniques	2	C	4	4
27.	Basic fuzzy inference algorithm	1	C,D	4	4
28.	Tutorial: Mamdani fuzzy inference system, Comparison of Mamdani and Sugeno systems	3	C,I	5	3
	UNIT V: Neural Network and Fuzzy Logic Applications In Medicine	**12**			
29.	Neural networks in biomedical applications, cardiovascular applications	1	C,I	5	3
30.	Breast tumor analysis using neural networks	2	C,I	5	3
31.	Fuzzy logic applications, fuzzy logic controller	2	C,I	5	3
32.	Neuro fuzzy systems- applications in medicine, recurrent probabilistic neural network for EMG pattern recognition	2	C,I	5	3
33.	Applications of neural network in lung cancer detection	2	C,I	5	3
34.	Tutorial: Genetic Algorithm definition and application	3	C,I	5	3
	Total contact hours	**60 (Exclusive of Assessment hours)**			

LEARNING RESOURCES	
Sl. No.	**TEXT BOOKS**
1.	LaureneFausett, "*Fundamentals of Neural Networks: Architectures, Algorithms, and Applications*", Pearson Education India, 3rd edition, 2008.
2.	Mohamad H. Hassoun, "*Fundamentals of Artificial Neural Network*", Cambridge, The MIT Press, 1stedition,1995.
	REFERENCE BOOKS/OTHER READING MATERIAL
3.	C.M.Bishop, "*Pattern Recognition and Machine Learning*", Springer-Verlag, 1stedition, 2006.
4.	Timothy J. Ross, "*Fuzzy Logic with Engineering Applications*", John Wiley and Sons, 2nd edition, 1995.
5.	B.Yegnanarayana, "*Artificial Neural Networks*", Prentice Hall of India, 3rdedition,2006.
6.	S. N. Sivanandam, S. N Deepa, "*Introduction to Neural Networks Using Matlab 6.0*", Tata McGraw-Hill, 2006.

Course nature				**Theory**			
Assessment Method (Weightage 100%)							
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Cycle Test III	Surprise Test	Quiz	**Total**
	Weightage	**10%**	**15%**	**15%**	**5%**	**5%**	**50%**
End semester examination Weightage :							**50%**

15BM403	Human Assist Devices and Implant Technology			L	T	P	C
				3	0	0	3
Co-requisite:	NIL						
Prerequisite:	NIL						
Data Book / Codes/Standards	NIL						
Course Category	P	PROFESSIONAL CORE	REHABILITATION ENGINEERING				
Course designed by	Department of Biomedical Engineering						
Approval	32nd Academic Council Meeting held on 23rd July 2016						

PURPOSE	The purpose of the course on human assist devices and implant technology for biomedical engineering students is to gain adequate mastery of the various assistive devices available for the challenged people and get an insight of implant design aspects.							
INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able to								
1.	Comprehend the assistive technology (AT) used for mobility	a	c	d	f	g	h	
2.	Summarize the AT for sensory impairment of vision and hearing	a	c	d	f	g	h	
3.	Uncover the assist devices for vital organs and advancements in AT	a	c	d	f	g	h	
4.	Describe the principles of implant design with a case study	a	c	d	f	g	h	
5.	Explain the implant design parameters and solution in use	a	c	d	f	g	h	

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	UNIT I: Assistive Technology For Mobility	**9**			
1.	Basic assessment and evaluation for mobility	2	C	1	1,2
2.	Control systems, navigation in virtual space by wheelchairs	1	C	1	1,2
3.	Wheel chair seating and pressure ulcers.	2	C	1	1,2
4.	Fuzzy logic expert system for automatic tuning of myoelectric prostheses	2	D	1	1,2
5.	Intelligent prosthesis	2	D	1	1,2
	UNIT II:Assistive Technology and Sensory Impairments	**9**			
6.	Visual and auditory impairment, assessment methods	1	C	2	3,4
7.	Libraille, GRAB, mathematical Braille	3	C	2	3,4
8.	Augmentative and alternative methods for hearing impairment	2	D	2	3,4
9.	Use of multimedia technology to help hard of hearing children	2	D	2	3,4
10.	Haptic as a substitute for vision	1	C	2	3,4
	UNIT III:Assist Devices For Vital Organs and Advancements In Technology	**9**			
11.	Cardiac assist devices, Intra-Aortic Balloon Pump (IABP), auxiliary ventricles	2	C	3	2,6, 11
12.	Dialysis for kidneys, Intermittent positive pressure breathing (IPPB) type assistance for lungs	2	C	3	2,6
13.	Latest use of assistive technology for chronic heart diseases and healthcare	2	C	3	2,6
14.	Information technology, telecommunications, new media in assisting healthcare	2	C	3	2,6
15.	Future trends in assistive technology,virtual reality based training system for disabled children	1	C	3	2,6
	UNIT IV:Principles of Implant Design	**9**			
16.	Principles of implant design, cardiac implants	1	C	4	7
17.	Clinical problems requiring implants for solution	2	C	4	7
18.	Permanent versus absorbable devices, the missing organ and its replacement	2	C	4	7
19.	Tissue engineering, scaffolds, cells and regulatorscriteria for materials selection	2	C	4	7
20.	Case study of organ regeneration	2	C	4	7

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	UNIT V: Implant Design Parameters and Its Solution	**9**			
21.	Biocompatibility, local and systemic effects of implants	1	C	5	7
22.	Design specifications for tissue bonding and modulus matching	2	C	5	7
23.	Degradation of devices, natural and synthetic polymers, corrosion, wear and tear	2	C	5	7
24.	Implants for Bone	2	D	5	7
25.	Devices for nerve regeneration, dental and otologic implants	2	C	5	7
	Total contact hours	**45 (Exclusive of Assessment hours)**			

LEARNING RESOURCES	
Sl. No.	**TEXT BOOKS**
1.	Yadin David, Wolf W. von Maltzahn, Michael R. Neuman, Joseph.D, Bronzino, "*Clinical Engineering*", CRC Press, 1st edition,2010.
2.	Kenneth J. Turner, "*Advances in Home Care Technologies: Results of thematch Project*", Springer, 1stedition, 2011.
3.	Gerr . M. Craddock "*Assistive Technology-Shaping the future*", IOS Press, 1st edition, 2003.
4.	Marion. A. Hersh, Michael A. Johnson, "*Assistive Technology for visually impaired and blind*", Springer Science & Business Media, 1st edition, 12-May-2010.
5.	Brownsell, Simon, et al. *"A systematic review of lifestyle monitoring technologies,"* Journal of telemedicine and telecare 17.4 (2011): 185-189.
6.	Yannas, I. V, "Tissue and Organ Regeneration in Adults", New York, NY: Springer, 2001. ISBN: 9780387952147.
	REFERENCE BOOKS/OTHER READING MATERIAL
8.	Levine S.N. *"Advances in Bio-medical engineering and Medical physics",* Vol. I, II, IV, Interuniversity publications, New York, 1st edition, 1968.
9.	Kopff W.J, "*Artificial Organs*", John Wiley and sons, New York, 1st edition, 1976.
10.	Brownsell, Simon, et al. *"A systematic review of lifestyle monitoring technologies,"* Journal of telemedicine and telecare 17.4 (2011): 185-189.
11.	Daniel Goldstein, Mehmet Oz, "*Cardiac assist Devices*", Wiley, 2000.

Course nature				**Theory**			
Assessment Method (Weightage 100%)							
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Cycle Test III	Surprise Test	Quiz	**Total**
	Weightage	**10%**	**15%**	**15%**	**5%**	**5%**	**50%**
					End semester examination Weightage :		**50%**

15BM404	Analog and Digital Communication	L	T	P	C
		3	1	0	4
Co-requisite:	NIL				
Prerequisite:	NIL				
Data Book / Codes/Standards	NIL				
Course Category	P PROFESSIONAL CORE	TELEMEDICINE			
Course designed by	Department of Biomedical Engineering				
Approval	32nd Academic Council Meeting held on 23rd July 2016				

PURPOSE	The purpose of learning this course on analog and digital communication for biomedical engineering students is to attain adequate knowledge about the various electronic communication schemes used to transmit and receive physiological signals.

INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able to								
1.	Explain the concepts of generation and detection of amplitude modulation schemes	a						
2.	Describe the concepts of generation and detection of angle modulation schemes	a						
3.	Illustrate the transmission and reception of signals using digital modulation schemes	a						
4.	Explain the concepts of multiplexing and secured communication schemes	a						
5.	Illustrate the usage of communication modalities to communicate physiological signals	k						

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	UNIT I:Amplitude Modulation	**12**			
1.	Modulation: definition, types, need for modulation	1	C	1	1
2.	Amplitude Modulation(AM): mathematical description, Frequency spectrum – vector representation, power calculations	2	C	1	1
3.	Generation of double side band AM: derivation	1	C	1	1
4.	Generation of double side band-suppressed carrier AM: derivation	1	C	1	1
5.	Generation of single side band modulation: derivation	1	C	1	1
6.	Generation of vestigial side band modulation	1	C	1	1
7.	AM Transmitter and receiver: block diagram description	2	C	1	1
8.	Tutorials: Modulation index, power calculation	3	C	1	1
	UNIT II:Angle Modulation	**12**			
9.	Frequency modulation (FM) and phase modulation (PM): definition, mathematical description, frequency spectrum, phase spectrum	3	C	2	1
10.	FM generators: Reactance and Armstrong modulators	2	C	2	1
11.	FM detector scheme: foster- seeley discriminator, heterodyne receiver	2	C	2	1
12.	FM Transmitter and receiver: block diagram description	2	C	2	1
13.	Tutorials: Modulation index, power calculation	3	C	2	1
	UNIT III: Digital Communication	**12**			
14.	Amplitude shift keying, frequency shift keying, phase shift keying	1	C	3	4
15.	Binary phase-shift keying	2	C	3	4
16.	Differential phase shift keying	2	C	3	4
17.	Quadrature phase shift keying	2	C	3	4
18.	M-aryphase shift keying	1	C	3	4
19.	Comparison over different signaling schemes	1	C	3	4

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
20.	Tutorials: BPSK, QPSK, DPSK	3	C	3	4
	UNIT IV: Multiple Access (MA)Techniques	**12**			
21.	Multiplexing: definition, purpose	1	C	4	5
22.	Frequency division multiple access (FDMA)	1	C	4	5
23.	Time division multiple access (TDMA)	1	C	4	5
24.	Code-division multiple access (CDMA)	1	C	4	5
25.	Comparison of multiple access techniques	1	C	4	5
26.	Differences between multiple access and multiplexing	1	C	4	5
27.	Wireless communication systems	1	C	4	5
28.	Structure of mobile telephone and public switched telephone network	1	C	4	5
29.	Propagation issues in mobile radio	1	C	4	5
30.	Tutorials: FDMA, TDMA, CDMA	3	C	4	5
	UNIT V: Biotelemetry	**12**			
31.	ECG telemetry system	2	C	5	6
32.	Temperature telemetry system	2	C	5	6
33.	Multi-channel wireless telemetry system	2	C	5	6
34.	Transmission of physiological signals over telephone	2	C	5	6
35.	Telemedicine	1	C	5	6
36.	Tutorials: ECG, wireless telemetry	3	C	5	6
	Total contact hours	**60 (Exclusive of Assessment hours)**			

LEARNING RESOURCES	
Sl. No.	**TEXT BOOKS**
1.	J.S. Chitode. *"Principles of Communication",* technical publications, 2nd edition,2009.
2.	Wayne Tomasi, "*Advanced Electronic Communication Systems*", Pearson Education, 6th edition, 2009.
	REFERENCE BOOKS/OTHER READING MATERIAL
3.	Simon Haykin, "*Communication Systems*", John Wiley & Sons, 4thedition,2004.
4.	H.Taub, D L Schilling and G Saha, *"Principles of Communication",* Pearson Education, 3rd edition, 2007.
5.	B. P.Lathi, "*Modern Analog and Digital Communication Systems",* Oxford University Press, 3rd edition, 2007.
6.	R.S.Khandpur, *'Handbook of Bio-Medical instrumentation',* Tata McGraw Hill Publishing Co Ltd., 3rd edition, 2014.

Course nature				**Theory**			
Assessment Method (Weightage 100%)							
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Cycle Test III	Surprise Test	Quiz	**Total**
	Weightage	**10%**	**15%**	**15%**	**5%**	**5%**	**50%**
					End semester examination Weightage :		**50%**

15BM391L	Internship / Industrial Training II	L	T	P	C
		0	0	2	1
Co-requisite:	NIL				
Prerequisite:	NIL				
Data Book / Codes/Standards	NIL				
Course Category	P PROFESSIONAL CORE				
Course designed by	Department of Biomedical Engineering				
Approval	32nd Academic Council Meeting held on 23rd July, 2016				

PURPOSE	To provide short-term work experience in an Industry/ Company/ Organisation							
INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able								
1.	To get an inside view of an industry and organization/company				j			
2.	To gain valuable skills and knowledge				j			
3.	To make professional connections and enhance networking	f	g					
4.	To get experience in a field to allow the student to make a career transition			i				

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	1. It is mandatory for every student to undergo this course. 2. Every student is expected to spend a minimum of 15-days in an Industry/ Company/ Organization, during the summer vacation. 3. The type of industry must be NOT below the Medium Scale category in his / her domain of the degree programme. 4. The student must submit the "Training Completion Certificate" issued by the industry / company / Organisation as well as a technical report not exceeding 15 pages, within the stipulated time to be eligible for making a presentation before the committee constituted by the department. 5. The committee will then assess the student based on the report submitted and the presentation made. 6. Marks will be awarded out of maximum 100. 7. Appropriate grades will be assigned as per the regulations. 8. Only if a student gets a minimum of pass grade, appropriate credit will be transferred towards the degree requirements, as per the regulations. 9. It is solely the responsibility of the individual student to fulfill the above conditions to earn the credits. 10. The attendance for this course, for the purpose of awarding attendance grade, will be considered 100%, if the credits are transferred, after satisfying the above (1) to (8) norms; else if the credits are not transferred or transferable, the attendance will be considered as ZERO. 11. The committee must recommend redoing the course, if it collectively concludes, based on the assessment made from the report and presentations submitted by the student, that either the level of training received or the skill and / or knowledge gained is NOT satisfactory.		D, I,O	1,2,3,4	
	Total contact hours				

Course nature		**Training – 100% internal continuous assessment**		
Assessment Method (Weightage 100%)				
In-semester	**Assessment tool**	**Presentation**	**Report**	**Total**
	Weightage	**80%**	**20%**	**100%**
End semester examination Weightage :				**0%**

15BM496L	Major Project	L	T	P	C
		0	0	24	12
Co-requisite:	NIL				
Prerequisite:	NIL				
Data Book / Codes/Standards	NIL				
Course Category	P PROFESSIONAL CORE				
Course designed by	Department of Biomedical Engineering				
Approval	32nd Academic Council Meeting held on 23rd July, 2016				

PURPOSE	The Major Project experience is the culminating academic endeavor of students who earn a degree in their Undergraduate Programs. The project provides students with the opportunity to explore a problem or issue of particular personal or professional interest and to address that problem or issue through focused study and applied research under the direction of a faculty member. The project demonstrates the student's ability to synthesize and apply the knowledge and skills acquired in his/her academic program to real-world issues and problems. This final project affirms students' ability to think critically and creatively, to solve practical problems, to make reasoned and ethical decisions, and to communicate effectively.

INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able								
1.	To provide students with the opportunity to apply the knowledge and skills acquired in their courses to a specific problem or issue.	a	c		e	f		i
2.	To allow students to extend their academic experience into areas of personal interest, working with new ideas, issues, organizations, and individuals.	a	c		e	f		i
3.	To encourage students to think critically and creatively about academic, professional, or social issues and to further develop their analytical and ethical leadership skills necessary to address and help solve these issues.	a	c		e	f	h	i
4.	To provide students with the opportunity to refine research skills and demonstrate their proficiency in written and/or oral communication skills.	a	c		e	f	g	i
5.	To take on the challenges of teamwork, prepare a presentation in a professional manner, and document all aspects of design work.			d			g	

Session	**Description of Topic**	**Contact hours**	**C-D-I-O**	**IOs**	**Reference**
	1. The Major project is a major component of our engineering curriculum: it is the culmination of the program of study enabling the students to showcase the knowledge and the skills they have acquired during the previous four years, design a product/service of significance, and solve an open-ended problem in engineering. 2. Each student must register to the project course related to his or her program 3. Major Project course consists of one semester and would be allowed to register only during the final year of study. 4. The Major Project may be initiated during the pre-final semester but will be assessed and credits transferred only during the last semester of study, upon completion of all other degree requirements. Generally the undergraduate major project is a team based one. 5. Each team in the major project course will consist of maximum of 5 students. 6. Each project will be assigned a faculty, who will act as the supervisor. 7. The project shall be driven by realistic constraints like that related to economic, environmental, social, political, ethical, health & safety, manufacturability and sustainability.		C,D,I,O	1,2,3,4,5	

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	8. Each group must document and implement a management structure. Group leadership roles must be clearly identified including who has responsibility for monitoring project deliverables and group coordination.				
	9. A group project may be interdisciplinary, with students enrolled in different engineering degrees, or in Engineering plus other faculties such as Management, Medical and Health Sciences, Science and Humanities. 10. Each student team is expected to maintain a log book that would normally be used to serve as a record of the way in which the project progressed during the course of the session. 11. Salient points discussed at meetings with the supervisor (i.e., suggestions for further meetings, changes to experimental procedures) should be recorded by the student in order to provide a basis for subsequent work. 12. The logbook may be formally assessed; 13. The contribution of each individual team member will be clearly identified and the weightage of this component will be explicitly considered while assessing the work done. 14. A project report is to be submitted on the topic which will be evaluated during the final review. 15. Assessment components will be as spelt out in the regulations. 16. The department will announce a marking scheme for awarding marks for the different sections of the report. 17. The project report must possess substantial technical depth and require the students to exercise analytical, evaluation and design skills at the appropriate level.				
	Total contact hours				

Course nature		**Project – 100 % Internal continuous Assessment**			
Assessment Method (Weightage 100%)					
In-semester	**Assessment tool**	Review 1	Review 2	**Review 3**	**Total**
	Weightage	**10%**	**15%**	**20%**	**45%**
End semester examination	**Assessment Tool**	**Project Report**	**Viva Voce**		
	Weightage :	**25%**	**30%**		**55%**

DEPARTMENT ELECTIVE I AND II

15BM221E	Biophotonics			L	T	P	C
				3	0	0	3
Co-requisite:	NIL						
Prerequisite:	NIL						
Data Book / Codes/Standards	NIL						
Course Category	P	PROFESSIONAL ELECTIVE	MEDICAL ELECTRONICS				
Course designed by	Department of Biomedical Engineering						
Approval	32nd Academic Council Meeting held on 23rd July 2016						

PURPOSE	The purpose of learning this course on biophotonics for biomedical engineering students is to provide knowledge about various optical systems used in sensing and imaging of biological systems

INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course on bio photonics, student will be able to								
1.	Differentiate the various working principles of optical imaging systems	a						
2.	Outline the various applications of biosensors in medicine	a						
3.	Analyze the working principle of flow cytometer	a						
4.	Describe the importance of phototherapy in treatment of diseases	a						
5.	Explain about the various nanoparticles and nanorods for bio sensing	a						

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	UNIT I:Bio-Imaging - Principles and Techniques	**9**			
1.	Bioimaging: An Introduction	1	C	1	1,2
2.	Transmission microscopy- simple microscope, compound microscope	1	C	1	1,2
3.	Kohler illumination, numerical aperture and resolution	1	C	1	1,2
4.	Optical aberrations and different types of objectives , phase contrast microscopy	1	C	1	1,2
5.	Dark-field microscopy, differential interference contrast microscopy(DICM)	1	C	1	1,2
6.	Fluorescence microscopy, scanning microscopy	1	C	1	1,2
7.	Inverted and upright microscopes, confocal microscopy, multiphoton microscopy	1	C	1	1,2
8.	Optical coherence tomography, total internal reflection fluorescence microscopy, near-field optical microscopy	1	C	1	1,2
9.	Fluorescence lifetime imaging microscopy (FLIM)	1	C	1	1,2
	UNIT II: Optical Biosensors	**9**			
10.	Biosensors: an introduction	1	C	2	1,2
11.	Principles of optical bio sensing: bio recognition, optical transduction, fluorescence sensing	1	C	2	1,2
12.	Fluorescence energy transfer sensors, molecular beacons, optical geometries of bio sensing	1	C	2	1,2
13.	Immobilization of bio recognition elements	1	C	2	1,2
14.	Fiber-optic biosensors, planar waveguide biosensors	2	C	2	1,2
15.	Evanescent wave biosensors, interferometric biosensors	2	C	2	1,2
16.	Surface Plasmon resonance biosensors	1	C	2	1,2
	UNIT III: Flow Cytometry	**9**			
17.	Basics of flow cytometry	2	C	3	1,2
18.	Basic Steps of flow cytometry	1	C	3	1,2
19.	Components of a flow cytometer	1	C	3	1,2
20.	optical response	1	C	3	1,2
21.	Fluorochromes for flow cytometry	2	C	3	1,2

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
22.	Data manipulation and presentation	2	C	3	1,2
	UNIT IV: Photodynamic Therapy	**9**			
23.	Photodynamic therapy: basic principles	1	C	4	1,2
24.	Photosensitizers for photodynamic therapy	2	C	4	1,2
25.	Light Irradiation for photodynamic therapy: light source, laser dosimetry, light delivery	2	C	4	1,2
26.	Mechanism of photodynamic action	1	C	4	1,2
27.	Two-photon photodynamic therapy	1	C	4	1,2
28.	Applications of photodynamic therapy	2	C	4	1,2
	UNIT V: Bionanophotonics	**9**			
29.	Interface of bioscience, nanotechnology, and photonics, nano chemistry	2	C	5	1,2
30.	Semiconductor quantum dots for bioimaging	1	C	5	1,2
31.	Metallic nanoparticles and nanorods for Bio sensing	1	C	5	1,2
32.	Up-converting nanophores	2	C	5	1,2
33.	Probes encapsulated by biologically localized embedding (PEBBLE)nanosensors for in vitro bioanalysis	1	C	5	1,2
34.	Nanoclinics for optical diagnostics and targeted therapy	2	C	5	1,2
	Total contact hours	**45 (Exclusive of Assessment hours)**			

LEARNING RESOURCES	
Sl. No.	**TEXT BOOKS**
1.	Paras N, Prasad, "*Introduction to Biophotonics*", John Wiley & Sons, 1st edition, 2003.
2.	Jurgen Popp, Valery V, Techin, Arthur Chiou, Stefen Heinemann, "*Handbook of Biophotonics",* Vol 2: Photonics for Health Care, John Wiley & Sons, 1st edition,2012.
	REFERENCE BOOKS/OTHER READING MATERIAL
3.	Harold Sackman, Brian Wilson, ValeriViktorovichTuchin, S. Tanev,Harold Sackman "*Advances in Biophotonics*", IOS Press, 1st edition2005.
4.	Paras N Prasad, "*Nanophotonics*", John Wiley & Sons, 1st edition, 2004.

Course nature				**Theory**			
Assessment Method (Weightage 100%)							
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Cycle Test III	Surprise Test	Quiz	**Total**
	Weightage	**10%**	**15%**	**15%**	**5%**	**5%**	**50%**
					End semester examination Weightage :		**50%**

15BM222E	Applied Optoelectronics in Medicine	L	T	P	C
		3	0	0	3
Co-requisite:	NIL				
Prerequisite:	NIL				
Data Book / Codes/Standards	NIL				
Course Category	P PROFESSIONAL ELECTIVE	MEDICAL ELECTRONICS			
Course designed by	Department of Biomedical Engineering				
Approval	32nd Academic Council Meeting held on 23rd July 2016				

PURPOSE	The purpose of learning this course on applied optoelectronics in medicine for biomedical engineering students is to attain adequate knowledge about light sources, optical detectors, display devices and applications of optoelectronic devices in medicine.

INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able to								
1.	Explain the principles of light emission in LED and LASER	a						
2.	Describe learn the working principles of optoelectronic modulators	a						
3.	Explain the working principles of optoelectronic detectors	a						
4.	Demonstrate the working of display devices	a						
5.	Implement the optoelectronic sensors in medical devices	a						

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	UNIT I: Light Sources	**9**			
1.	LASER: characteristics, population inversion	1	C	1	1,5
2.	Pumping schemes: optical pumping, electrical pumping and direct pumping schemes	2	C	1	1,5
3.	Two level, three level and four level laser principle with energy level diagram	2	C	1	1,5
4.	Optical resonator configuration in laser	1	C	1	1,5
5.	Threshold condition for laser	1	C	1	1,5
6.	LED: construction, working principle, LED materials	2	C	1	1
	UNIT II: Optoelectronic Modulator	**9**			
7.	Basic principles	1	C	2	1
8.	Analog and digital modulation	1	C	2	1
9.	Electro-optic modulators	2	C	2	1
10.	Magneto optic devices	2	C	2	1
11.	Acousto-optic devices	2	C	2	1
12.	Optical switching	1	C	2	1
	UNIT III: Optoelectronic Detection Methods	**9**			
13.	Thermal detectors: bolometer	1	C	3	1
14.	Thermal detectors: pyroelectric detector	1	C	3	1
15.	Photodiode: principle of operation, V-I characteristics	1	C	3	1
16.	Types of photodiode: avalanche photodiode, PIN photodiode: construction, operating principle, applications	2	C	3	1
17.	Phototransistor: construction, operating principle, applications	1	C	3	1
18.	Photomultiplier tube: construction, operating principle, applications	1	C	3	1
19.	Solar cell: construction, operating principle, applications	1	C	3	1
20.	Optocouplers: construction, operating principle	1	C	3	1
	UNIT IV: Display Devices	**9**			
21.	Photo luminescence	1	C	4	1
22.	Cathode luminescence	1	C	4	1
23.	Electro luminescence	1	C	4	1
24.	Numeric displays: common cathode and common anode	1	C	4	1
25.	LCD display: liquid crystals, construction and types	2	C	4	1
26.	Plasma display: construction and working principle	1	C	4	1

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
27.	Colorplasma display: construction and working principle	1	C	4	1
28.	Nixie tube	1	C	4	1
	UNIT V : Medical Applications of Optoelectronic Devices	**9**			
29.	X ray and nuclear radiation sensors	3	C	5	6
30.	Fiber optic blood pressure sensor	2	C	5	7
31.	Optical fiber based respiration sensor for non-invasive respiratory monitoring	2	C	5	8
32.	Non-invasive blood pressure and SPO_2 measurement devices	2	C	5	9
	Total contact hours	**45 (Exclusive of Assessment hours)**			

LEARNING RESOURCES	
Sl. No.	**TEXT BOOKS**
1.	Wilson J and Hawkes J.F.B, "*Optoelectronics – An Introduction*", Prentice Hall of India Pvt. Ltd., New Delhi, 3rd edition, 2003.
	REFERENCE BOOKS/OTHER READING MATERIAL
2.	Safa O Kasap, '*Optoelectronics and Photonics*: *Principles and practices'*, PHI, 1st edition, 2009.
3.	Bhattacharya, "*Semiconductor Optoelectronic Devices*", Prentice Hall of India Pvt., Ltd., New Delhi, 2nd edition, 1997.
4.	Jasprit Singh, "*Optoelectronics – As Introduction to materials and devices*", McGraw-Hill International Edition, 1stedition, 1996.
5.	K Thyagarajan, A K Ghatak, "*Lasers: theory and applications*", Plenum publishing corporation, 2006.
6.	Patranabis D, *"Sensors and transducers"*,PHI, 2nd edition, 2004.
7.	Nan Wu, Ye Tian, XiaotianZou, Yao Zhai, Kurt Barringhaus, Xingwei Wang. "*A miniature fiber optic blood pressure sensor and its application in invivo blood pressure measurements of a swine model"*. Sensors and Actuators B: Chemical Volume 181, May 2013, Pages 172–78:10.1016/j.snb.2013.02.002.
8.	Wook Jae Yoo, Kyoung Won JANG, Jeong Ki Seo, JiYeonHeo, Jin Soo Moon, Jae Hoon Jun, Jang-Yeon Park, Bongsoo Lee. *"Development of Optical Fiber-Based Respiration Sensor for Noninvasive Respiratory Monitoring"*, Optical review Vol. 18, No. 1 (2011) 132–138.
9.	Khandpur R S, *"Handbook of Biomedical Instrumentation"*, McGraw-Hill Professional Publishing, 3rd edition, 2015.

Course nature				**Theory**			
Assessment Method (Weightage 100%)							
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Cycle Test III	Surprise Test	Quiz	**Total**
	Weightage	**10%**	**15%**	**15%**	**5%**	**5%**	**50%**
End semester examination Weightage :							**50%**

15BM223E	Medical Physics			L	T	P	C
				3	0	0	3
Co-requisite:	NIL						
Prerequisite:	NIL						
Data Book / Codes/Standards	NIL						
Course Category	P	PROFESSIONAL ELECTIVE	BIOMEDICAL INSTRUMENTATION				
Course designed by	Department of Biomedical Engineering						
Approval	32nd Academic Council Meeting held on 23rd July 2016						

PURPOSE	The purpose of learning this course on medical physics for biomedical engineering students is to acquire knowledge about the application of principles of physics in biomedical Engineering.							
INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, students will be able to								
1.	Understand the principle of physics used in metabolism and statics of the body	a	c					
2.	Explain the physics behind the working of cardiovascular system	a						
3.	Identify the function and working of the respiratory system	a	c					
4.	Acquire the knowledge in origin of speech and hearing systems	a						
5.	Describe the physics applied in the optical system of the eye and vision	a						

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	UNIT I:Statics and Metabolism of The Body	**9**			
1.	Statics : motion in one plane and levers	1	C	1	1,2
2.	Statics of the body: lower arm, hip problem, and synovial joints	1	C	1	1,2
3.	Statics of the body: three force rule and multi segment modeling	1	C	1	1,2
4.	Metabolism: conservation, energy and heat flow, the energy content of the body flow	2	C	1	1,2
5.	Energy storage molecule, metabolic rates and loss of body heat	2	C	1	1,2
6.	Basal metabolic rates, metabolic rates during common activities	1	C	1	1,2
7.	Heat losses from the body and measurement of pressure in the body	1	C	1	1,2
	UNIT II: Cardiovascular System	**9**			
8.	Introduction to cardiovascular system: circulation, cardiac cycle and valves	1	C,I	2	1,2
9.	Physics of the circulatory system: properties of blood, blood pressure and flow in vessel	2	C,I	2	1,2
10.	Capillaries, osmotic pressure, blood flow rates and speeds	1	C,I	2	1,2
11.	Work done with heart and metabolic needs of the heart	1	C	2	1,2
12.	Strokes and aneurysms	2	C	2	1,2
13.	Physics principle used the circulatory system and heart	2	C, I	2	1,2
	UNIT III: Lung and Breathing	**9**			
14.	Physics of the alveoli, physics of breathing and volume of lungs	2	C	3	1,2
15.	Breathing under usual and unusual condition: flow air during breathing	1	C	3	1,2
16.	Mechanical model of breathing	2	C	3	1,2
17.	Inspiration and expiration cycle	1	C	3	1,2
18.	Breathing with diseased lungs	1	C	3	1,2
19.	Breathing at higher elevation	2	C	3	1,2
	UNIT IV: Sound, Speech and Hearing	**9**			
20.	The physics of sound waves: the speed and properties of sound waves	1	C	4	1,2,3
21.	Intensity of sound waves and resonant cavities	1	C	4	1,2,3

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
22.	Speech production: types of sound, system in speech production	2	C	4	1,2,3
23.	Parameter of the human voice, the enteritis of speaking	1	C	4	1,2,3
24.	Hearing: auditory sensitivity, connection to hearing perception	2	C,I	4	1,2,3
25.	Vibration in the body: cardiac and other source of sounds	2	C	4	1,2,3
	UNIT V: Light, Eye and Vision	**9**			
26.	Focusing and imaging with lenses: image formation, scientific basis for imaging	1	C	5	1.4
27.	Combination of lenses or refractive surfaces	1	C	5	1,4
28.	Imaging and detected by the eye: transmission of the light in the eye, eyeas a compound lens, accommodation	2	C,I	5	1,4
29.	Field of view and binocular vision, adjustment of light level, limitation to visual activity and imperfect vision	2	C,I	5	1,4
30.	Correction of vision by eyeglass, contact lenses and other application	1	C,I	5	1,4
31.	Types of vision impairment, connection to visual perception	2	C,I	5	1,4
	Total contact hours	**45 (Exclusive of Assessment hours)**			

LEARNING RESOURCES	
Sl. No.	**TEXT BOOKS**
1.	Herman I.P, *"Physics of the Human Body"*, Springer Publications, 2nd edition, 2011.
2.	J. R. Cameron & J. G. Skofronick, "*Medical Physics"*, John Wiley and Sons, 2nd edition, 2008.
	REFERENCE BOOKS/OTHER READING MATERIAL
3.	Paul Davidovits, "*Physics in Biology and Medicine*", Academic Press, 4thedition, 2012.
4.	Widmaier, Raff &Strang, "*Vander's Human Physiology- The mechanism of body Function",* McGraw-Hill,12th edition,2010.

Course nature				**Theory**			
Assessment Method (Weightage 100%)							
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Cycle Test III	Surprise Test	Quiz	**Total**
	Weightage	**10%**	**15%**	**15%**	**5%**	**5%**	**50%**
End semester examination Weightage :							**50%**

15BM224E	Biomedical Laser Instruments			L	T	P	C
				3	0	0	3
Co-requisite:	NIL						
Prerequisite:	NIL						
Data Book / Codes/Standards	NIL						
Course Category	P	PROFESSIONAL ELECTIVE	BIOMEDICAL INSTRUMENTATION				
Course designed by	Department of Biomedical Engineering						
Approval	32nd Academic Council Meeting held on 23rd July 2016						

PURPOSE	The purpose of learning this course on biomedical laser instruments for biomedical engineering students is to acquire knowledge about the different types of lasers available, their principle of working and construction and their applications in the field of biomedical engineering.							
INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able to								
1.	Describe the laser radiation characteristics and interaction of lasers with tissues	a						
2.	Explain the types, construction and operation of different laser systems	a						
3.	Associate the role of different types of laser systems used for biomedical applications	a						
4.	Understand the applications of laser in ophthalmology, dermatology, urology, gynecology and neurology	a	h	k				
5.	Attain the knowledge on applications of laser in orthopedic surgery, dentistry and precautionary method in laser safety	a	f					

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	UNIT I: Laser Tissue Interaction	**9**			
1.	Principle and fundamentals of laser	1	C	1	1, 2,3.4
2.	Laser radiation and its characteristics	1	C	1	1, 2,3.4
3.	Mutual interaction process, primary and secondary factors	1	C	1	1, 2,3.4
4.	Biological tissue composition	1	C	1	1
5.	Light penetration and reflectance	1	C	1	1
6.	Laser medicine domains	1	C	1	1
7.	Laser light scattering in tissues	1	C	1	1
8.	Speckle formation, interference and polarization methods of tissue diagnostics	1	C	1	1
9.	Alterations of bio tissue properties during hyperthermal and ablation reactions, photodynamic therapy	1	C	1	1
	UNIT II: Types of Laser Used In Medicine	**9**			
10.	Types of laser, construction and working principle of solid state laser	2	C	2	1, 3, 4
11.	Atomic laser	1	C	2	1, 4
12.	Molecular laser	1	C	2	1, 4
13.	Liquid dye laser	1	C	2	1, 4
14.	Diode laser	2	C	2	1, 3, 4
15.	Solid state dye laser	2	C	2	1, 3, 4
	UNIT III: Laser Applications-I	**9**			
16.	Applications of laser radiation in ophthalmology	1	C	3	1, 2
17.	Laser treatment for eye tissues and diseases	1	C	3	1
18.	Lasers in dermatology- handling of pain	2	C	3	1, 2
19.	Dermatological disorders	2	C	3	1, 2
20.	Lasers in cardiovascular diagnostics	2	C	3	1
21.	Lasers in cardiovascular therapy	1	C	3	1
	UNIT IV: Laser Applications- II	**9**			
22.	Lasers in urology- laser stone disintegration	2	C	4	1

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
23.	Lasers treatment for benign prostatic hyperplasia, bladder neck incision, bladder tumor and upper urinary tract	2	C	4	1
24.	Lasers in gynecology- laser application for the lower genital tract	1	C	4	1, 2
25.	Lasers in laparoscopy	1	C	4	1
26.	Lasers in laryngeal surgery	1	C	4	1
27.	Lasers in otology	1	C	4	1
28.	Lasers in neurology	1	C	4	1, 2
	UNIT V: Laser In Orthopaedic Surgery, Dentistry and Laser Safety	**9**			
29.	Mechanism of bone and cartilage reparation	1	C	5	1, 2
30.	Lasers in orthopaedic surgery	2	C	5	1
31.	Laser techniques used in spinal surgery	1	C	5	1
32.	Lasers in dentistry- lasers in endodontic procedures	1	C	5	1, 2
33.	Caries detection and treatment by laser radiation	2	C	5	1, 2
34.	Laser bleaching	1	C	5	1
35.	Types of laser hazards, laser safety, laser use risk management,	1	C	5	1, 2
	Total contact hours	**45 (Exclusive of Assessment hours)**			

LEARNING RESOURCES	
Sl. No.	**TEXT BOOKS**
1.	Helena Jelinkova, "*Lasers for medical applications: Diagnostics, Therapy and Surgery*", Woodhead Publishing, 1st edition, 2013.
	REFERENCE BOOKS/OTHER READING MATERIAL
2.	MarkolfH.Neimz, "*Laser tissue interactions-Fundamentals and applications*", Springer, 3rd edition, 2014.
3.	Orazio Svelto and David C. Hanna, "*Principles of lasers*", Springer, 5th edition, 2010.
4.	William T. Silfvast, "*Laser fundamentals*", Cambridge University Press, 2nd edition, 2009.

Course nature				**Theory**			
Assessment Method (Weightage 100%)							
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Cycle Test III	Surprise Test	Quiz	**Total**
	Weightage	**10%**	**15%**	**15%**	**5%**	**5%**	**50%**
End semester examination Weightage :							**50%**

15BM225E	Dental Engineering			L	T	P	C
				3	0	0	3
Co-requisite:	NIL						
Prerequisite:	NIL						
Data Book / Codes/Standards	NIL						
Course Category	P	PROFESSIONAL ELECTIVE	BIOMEDICAL INSTRUMENTATION				
Course designed by	Department of Biomedical Engineering						
Approval	32nd Academic Council Meeting held on 23rd July 2016						

PURPOSE	The purpose of learning this course on dental engineering for biomedical engineering students is to provide an adequate knowledge about the basics of oral biology, dental radiography, dental materials and advancements in the dental imaging systems.

INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able to								
1.	Describe the various terminologies associated with oral biology	a						
2.	Explain the various terminologies associated with dental radiology	a						
3.	Understand the various concepts and techniques of dental imaging systems	a						
4.	Attain knowledge of the various biomaterials used in dentistry	a						
5.	Explain the advancements in dental engineering	a						

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	UNIT I: Introduction to Oral Biology	**9**			
1.	Anatomy and physiology of oral cavity: head	2	C	1	1
2.	Anatomy and physiology of oral cavity: neck	2	C	1	1
3.	Structure and functions of oral cavity	1	C	1	1
4.	Tooth: types	1	C	1	1
5.	Tooth: functions	1	C	1	1
6.	Tooth numbering systems	2	C	1	1
	UNIT II: Introduction to Dental Radiology	**9**			
7.	Terms associated with dental radiography and dental radiograph	2	C	2	1
8.	Dental X ray unit: key parts	1	C	2	1
9.	X ray room	1	C	2	1
10.	Infection control, dental radiographs in systemic diseases	1	C	2	1
11.	X ray unit control panel	1	C	2	1
12.	Sequence of activities to expose a radiograph	1	C	2	1
13.	Mounting the radiograph, pictorial guide to recognize errors	1	C	2	1
14.	Radiation safety requirements	1	C	2	1
	UNIT III : Dental X Ray System	**9**			
15.	Dental X ray film: structure and types	1	C	3	1
16.	Dental Xray: working principle	1	C	3	1
17.	Applications of Bite-wing X ray	1	C	3	1
18.	Applications of periapical X ray	1	C	3	1
19.	Applications of occlusal X ray	1	C	3	1
20.	Applications of Panoramic X-rays	1	C	3	1
21.	Tomograms	1	C	3	1
22.	Cephalometric projections, Sialography	1	C	3	1
23.	Extra oral projections in dentistry	1	C	3	1
	UNIT IV: Dental Materials	**9**			
24.	Tooth composition	1	C	4	2
25.	Tooth mechanical properties	1	C	4	2
26.	Impression materials	1	C	4	2
27.	Basers, liners for cavities	1	C	4	2

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
28.	Varnishes for cavities	1	C	4	2
29.	Fillings	1	C	4	2
30.	Restorative materials,	1	C	4	2
31.	Materials for deep cavities	1	C	4	2
32.	Metals in dentistry	1	C	4	2
	UNIT V: Advances in Dental Engineering	**9**			
33.	Oral implants	1	C	5	2
34.	Collagen in dentistry	1	C	5	2
35.	Nano dental implants,digital intraoral imaging	2	C	5	2
36.	Cone beam Computed Tomography	1	C	5	2
37.	Digital panoramic radiography: construction, advantages, applications	1	C	5	1
38.	Panoramic radiography in forensic science	1	C	5	4
39.	Panoramic radiography in age determination	1	C	5	5
40.	Panoramic radiography in osteoporosis diagnosis	1	C	5	6
	Total contact hours	**45 (Exclusive of Assessment hours)**			

LEARNING RESOURCES	
Sl. No.	**TEXT BOOKS**
1.	Olaf E. Langland ,Robert P. Langlais , John Preece,"*Principles of Dental Imaging*", Wolters Kluwer, 2nd edition,2002.
	REFERENCE BOOKS/OTHER READING MATERIAL
2.	Sujata V Bhat, "*Biomaterials"*, Narosa publishing house, 2ndedition, 2010.
3.	Manjunatha BS,*"Textbook of Dental Anatomy and Oral Physiology"*,JP Medical Ltd, 1st edition, 2013.
4.	K.Nicopoulou-Karayianni, A.G.Mitsea, K.Horner.,"*Dental diagnostic radiology in the forensic sciences: sciences: two case presentations"*, J Forensic Odontostomatol 2007;25:12-6.
5.	Kavitha MS, Asano A, Taguchi A, et al., *"Diagnosis of osteoporosis from dental panoramic radiographs using the support vector machine method in a computer-aided system",* BMC Med Img 2012; 12(1): 1–11.
6.	Muramatsu C, Matsumoto T, Hayashi T, et al., "*Automated measurement of mandibular cortical width on dental panoramic radiographs",* Int J Comput Assist RadiolSurg 2013; 8(6): 877–885.
7.	Stuart C. White and Michael J. Pharoah., "*Oral radiology- principles and interpretation"*, Elsevier publications. Parts I and II. Chapters 1-16, 7th edition, 2014.

Course nature				**Theory**			
Assessment Method (Weightage 100%)							
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Cycle Test III	Surprise Test	Quiz	**Total**
	Weightage	**10%**	**15%**	**15%**	**5%**	**5%**	**50%**
					End semester examination Weightage :		**50%**

15BM226E	Medical Simulation in Life Supporting Devices	L	T	P	C
		3	0	0	3
Co-requisite:	NIL				
Prerequisite:	NIL				
Data Book / Codes/Standards	NIL				
Course Category	P PROFESSIONAL ELECTIVE BIOMEDICAL INSTRUMENTATION				
Course designed by	Department of Biomedical Engineering				
Approval	32nd Academic Council Meeting held on 23rd July 2016				

PURPOSE	The purpose of the course on medical simulation and life supporting device for biomedical engineering students is to get practical knowledge in operating basic life supporting devices under emergency condition							
INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able to								
1.	Explain anatomy and physiology of the heart and demonstrate various lifesaving technique used under cardiac arrest	a	h					
2.	Identifying various arrhythmias that can be treated by life supporting device and approach algorithmically towards management of these patients.	e	h					
3.	Describe various techniques available for deployment in patient suffering from respiratory emergency	b						
4.	Learn how to initiate, operate and trouble shoot mechanical ventilator in a patient	b	c					
5.	Explain the use of ultrasound in critical cardiovascular and respiratory diseases and trauma diagnosis	e	i					
6.	Provide hands on training on life supporting devices	a	c					

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	UNIT I: Basic Life Support	**9**			
1.	Anatomy and physiology of heart	1	C	1	1
2.	Cardiogenic shock complicating acute coronary syndrome	1	C	1	2
3.	CPR practice using mannequin	2	I	1	2
4.	AHA BLS guidelines and practice	2	C,I	1	9
5.	Automatic external Defibrillator	1	C	1	4,2
6.	Defibrillator practiceand troubleshooting	2	C,I	1	2
	UNIT II: Analyzing Arrhythmias for Life Support	**9**			
7.	Description of ECG arrythmias-an overview	1	C	2	4
8.	Tachycardia and Bradycardia algorithm and practice	3	C	2	3
9.	ECG arrhythmia simulator and practice	2	C,I	2	4
10.	ACLS guidelines and practice using mannequins	3	C,I	2	10
	UNIT III: Basic Airway Management	**9**			
11.	Ventilation failure and oxygenation failure	1	C	3	3,,8
12.	Inserting airway adjunct (OPA –Oropharyngeal airway and NPA- Nasopharyngeal airway)	2	C,I	3	3,8
13.	Oxygen therapy	1	C	3	3,8
14.	LMA and insertion Technique	2	C,I	3	3,8
15.	AMBUBAG indication and practice	3	C,I	3	3,8
	UNIT IV: Ventilator for Life Support	**9**			
16.	Basic anatomy of lung and mechanism of breathing	1	C	4	1
17.	Mechanical ventilator history and classification	1	C	4	4,5,6
18.	Pressure –volume flow diagram	1	C	4	4, 5,6
19.	Different modes of ventilator	1	C	4	5,6
20.	Ventilator alarm and trouble shooting	2	C	4	5,6
21.	Indication and disease specific ventilation	2	C	4	5,6
22.	Weaning from ventilator	1	C,I		

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	UNIT V: Role of Ultrasound in Life Support	**9**			
23.	Basic principle of ultrasound and different modes of display	2	C	5	4,7
24.	Different transducers used in ultrasound	1	C	5	4,7
25.	Ultrasound doppler blood flow meter	1	C	5	4,7
26.	Ultrasonography in emergency cardiovascular care	2	C	5	2,3
27.	Lung ultrasound	2	C,I	5	7
28.	Fast scan	1	C,I	5	7
	Total contact hours	**45 (Exclusive of Assessment hours)**			

LEARNING RESOURCES	
Sl. No.	**TEXT BOOKS**
1.	Arthur C. Guyton, John Edward Hall, "*Textbook of Medical Physiology*",13th edition ElsevierInc 2016.
2.	John M. Field, Peter J. Kudenchuk, Robert O'Connor, Terry VandenHoek , "*The Textbook of Emergency Cardiovascular Care and CPR*",lippinocot William and wilkins, 1st edition, 2009.
3.	James G. Adams, "*Emergency Medicine: Clinical Essentials*", Saunders an imprint of Elsevier Inc,2nd edition, 2013.
4.	Khandpur R.S, "*Hand-book of Biomedical Instrumentation*", Tata Mc Graw Hill, 2nd Edition, 2003.
	REFERENCE BOOKS/OTHER READING MATERIAL
5.	Peter Papadakos, BurkhardLachmann, "*Mechanical Ventilation: Clinical Applications and Pathophysiology*", sunders an imprint of Elsevier,1stedition 2008.
6.	AshfaqHasan ,"*Understanding Mechanical Ventilation: A Practical Handbook*", Springerverlag London limited, 2ndedition 2010 .
7.	Matthias Hofer, "*Ultrasound Teaching Manual: The Basics of Performing and Interpreting*", thiemenewyork Stuttgart, 3rd edition, 2013.
8.	"*Illustrated Manual of Nursing Practice*", Lippincott Williams & Wilkins, 3rdedtion, 2002.
9.	Gavin D. Perkins, Anthony J. Handley c, Rudolph W. Kosterd,et.al,*"European Resuscitation Council Guidelines for Resuscitation 2015 Adult basic life support and automated external defibrillation"*, Resuscitation, volume95,Pages 81–99, 2015.
10.	Jasmeet Soar, Jerry P. Nolan, Bernd W. Böttigerd, et.al, *"European Resuscitation Council Guidelines for Resuscitation 2015 Section 3. Adult advanced life support"*, Resuscitation,Volume 95,PP 100-147, 2015 **.**

Course nature				**Theory**			
Assessment Method (Weightage 100%)							
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Cycle Test III	Simulation lab practice test	Quiz	**Total**
	Weightage	**5%**	**10%**	**15%**	**15%**	**5%**	**50%**
					End semester examination Weightage :		**50%**

15BM227E	Hospital Information System			L	T	P	C
				3	0	0	3
Co-requisite:	NIL						
Prerequisite:	NIL						
Data Book / Codes/Standards	NIL						
Course Category	P	PROFESSIONAL ELECTIVE	TELEMEDICINE				
Course designed by	Department of Biomedical Engineering						
Approval	32nd Academic Council Meeting held on 23rd July 2016						

PURPOSE	The purpose of learning this course on hospital information system for biomedical engineering students is to acquire knowledge and understand the basic functionalities of hospital services.							
INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able to								
1.	Explain the basic role and designing of hospitals	a	b	c				
2.	Describe the clinical and diagnostic services of hospitals	a	c	d				
3.	Illustrate the basic supportive services and reporting systems in hospitals	a	c	d	f			
4.	Describe the need for staff and safety management	a	c	d	f			
5.	Explain the recent advances in healthcare system	a	c	d	f			

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	UNIT I: Role of Hospitals	**9**			
1.	Evolution of hospitals in India, roles of hospital in healthcare	2	C	1	1
2.	Healthy hospital environment	1	C	1	1
3.	Role of planning and designing in hospital management	2	C	1	1
4.	Creating manpower services	1	C	1	1
5.	Designing disabled friendly hospitals	2	C	1	1
6.	Energy conservation	1	C	1	1
	UNIT II: Clinical and Diagnostic Services	**9**			
7.	Outpatient services, indoor services	2	C	2	1,3
8.	Operation theatre services	1	C	2,3	1,3
9.	Emergency services	1	C	2,3	1,3
10.	Laboratory services	1	C	2,3	1,3
11.	Radiology and imaging services	2	C	2	1,3
12.	Nuclear medicine services	1	C	2	1,3
13.	Experimental medicine services	1	C	2	1
	UNIT III: Supportive Services and Material Management	**9**			
14.	Pharmacy services	1	C	1,3	1,3
15.	Transport services	1	C	1,3	1,3
16.	Engineering services	1	C	1,3	1,3
17.	Medico legal services	1	C	1,3	1
18.	Public relations	1	C	1,3	1
19.	Food safety in hospitals	1	C	1,3	1
20.	Materials management	2	C	1,3	1
21.	Purchase and procurement system.	1	C	1,3	1
	UNIT IV: Staff and Safety Management	**9**			
22.	Human resource management	1	C	1,4	1,3
23.	Nursing management	2	C	1,4	1,3
24.	Biomedical waste management	2	C	1,4	1,3
25.	Quality management	2	C	1,4	1,3
26.	Occupational safety	1	C	1,3,4	1,3
27.	Hospital security	1	C	1,3,4	1,3

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	UNIT V: Reporting System and Recent Advances In Hospital Administration	**9**			
28.	Medical record management	2	C	1,4,5	1,3
29.	Office management	1	C	1,4,5	1,3
30.	Operations research in hospitals	1	C	1,3,4,5	1
31.	Emerging health insurance	1	C	1,3,4,5	1
32.	Telemedicine clinic- mobile health	2	C	1,3,4,5	1
33.	Information and communication technology in healthcare	2	C	1,3,4,5	1
	Total contact hours	**45 (Exclusive of Assessment hours)**			

LEARNING RESOURCES	
Sl. No.	**TEXT BOOKS**
1.	SonuGoel, Anil Kumar Gupta, Amarjeet Singh, "*Hospital administration A problem- solving approach*", Elsevier, 1st edition, 2014.
	REFERENCE BOOKS/OTHER READING MATERIAL
2.	Sakharkar B M, "*Principles of hospital administration and planning*", Jaypee Brothers Medical Publishers Pvt Limited, 2nd edition, 2009
3.	Kunders G D, "*Hospitals: Facilities planning and management*", Tata Mcgraw Hill, 1st edition, 2008.

Course nature				**Theory**			
Assessment Method (Weightage 100%)							
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Cycle Test III	Surprise Test	Quiz	**Total**
	Weightage	**10%**	**15%**	**15%**	**5%**	**5%**	**50%**
End semester examination Weightage :							**50%**

15BM228E	Home Medicare Technology	L	T	P	C
		3	0	0	3
Co-requisite:	NIL				
Prerequisite:	NIL				
Data Book / Codes/Standards	NIL				
Course Category	P PROFESSIONAL ELECTIVE	TELEMEDICINE			
Course designed by	Department of Biomedical Engineering				
Approval	32nd Academic Council Meeting held on 23rd July 2016				

PURPOSE	The purpose of the course on home medicaretechnology for biomedical engineering students is to outline the health care that can be made available at home along with recent digital and tele-health technologies.

INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able to								
1.	Summarize the organization and the need for home medicare system	c	f	h				
2.	Identify the skills required for home medicare for the elderly and the children	c	d	f	h	j		
3.	Review the biomedical instruments that can be used at home	a	c	d	e	h	j	
4.	Associate digital technical advancements with home medicare	a	c	d	e	h	j	
5.	Comprehend the advances in healthcare technologies andwireless technology related to healthcare system	a	d	f	h	j		

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	UNIT I: Introduction to Home Medicare	**9**			
1.	Home health care, purpose, legal and ethical aspects	1	C	1	1
2.	Organization of homecare system	1	C	1	1
3.	Historical development of home care	1	C	1	1
4.	Environmental influences on home care	1	C	1	1
5.	Home care organization	1	C	1	1
6.	Home care nursing practice	1	C	1	1
7.	Role of home care nurse and orientation strategies	1	C	1	1
8.	Infection control in home	1	C	1	1
9.	Patient education in home	1	C	1	1
	UNIT II: Working with Users	**9**			
10.	Basic human needs, communication and interpersonal skills	1	C	2	1
11.	Caregiver observation, recording and reporting, confidentiality	1	C	2	1
12.	Working with elderly, aged	2	C	2	1
13.	Working with children, need for home care	2	C	2	1
14.	Mobility transfers and ambulation, range of motion exercises	2	C	2	1
15.	Skin care and comfort	1	C	2	1
	UNIT III: Medical Instruments and Devices at Home	**9**			
16.	Medical devices at home and its implementation	2	C	3	3
17.	Scope of market for home medical devices	2	C	3	3
18.	Unique challenges to the design & implementation of high-tech home care devices	2	D	3	3
19.	Infant monitors	1	D	3	3
20.	Medical alert services	1	D	3	3
21.	Activity monitors	1	D	3	3
	UNIT IV: Digital Home Care	**9**			
22.	Video communication to support care delivery to independently living seniors	1	C	4	2
23.	Establishing an infrastructure for telecare	2	C	4	2
24.	Implementation of mobile computing in home care programs	2	C	4	2

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
25.	Home medicare management by videophone	2	C	4	2
26.	Continuous home care through wireless bio-signal monitoring system	2	D	4	2
	UNIT V: Advances in Medical Technologies	**9**			
27.	Dynamic configuration of home services	2	C	5	4
28.	Personalized ambient monitoring	2	C	5	4
29.	Support for mental health at home	1	C	5	4
30.	Multi model interaction and technologies for care at home	2	C	5	4
31.	User centered design of technologies to support care at home	2	C	5	4
	Total contact hours	**45 (Exclusive of Assessment hours)**			

LEARNING RESOURCES	
Sl. No.	**TEXT BOOKS**
1.	Robyn Rice, "*Home care nursing practice: Concepts and Application*", Elsevier, 4th edition, 2006.
2.	LodewijkBos, "*Handbook of Digital Homecare: Successes and Failures*", Vol.3, Springer, 2011.
	REFERENCE BOOKS/OTHER READING MATERIAL
3.	Yadin David, Wolf W. von Maltzahn, Michael R. Neuman, Joseph.D,Bronzino, "*Clinical Engineering*", CRC Press, 1st edition,2010.
4.	KenethJ. Tumer, "*Advances in home care technologies*", AT research series,Vol 31,1st edition, IOS press, 2012.

Course nature		**Theory**					
Assessment Method (Weightage 100%)							
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Cycle Test III	Surprise Test	Quiz	**Total**
	Weightage	**10%**	**15%**	**15%**	**5%**	**5%**	**50%**
					End semester examination Weightage :		**50%**

DEPARTMENT ELECTIVE III

15BM321E	Design and Development of Medical Devices	L	T	P	C
		3	0	0	3
Co-requisite:	NIL				
Prerequisite:	NIL				
Data Book / Codes/Standards	NIL				
Course Category	P PROFESSIONAL ELECTIVE	MEDICAL ELECTRONICS			
Course designed by	Department of Biomedical Engineering				
Approval	32nd Academic Council Meeting held on 23rd July 2016				

PURPOSE	The purpose of learning this course on design and development of medical devices for biomedical engineering students is to impart knowledge in the design procedure and design consideration of various medical devices.

INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able to								
1.	Explain the design process and its classification rules	c						
2.	Illustrate the design procedure of medical devices	b	j					
3.	Outline the quality assessment in design	a	d	k				
4.	Describe about the design realization	a	d					
5.	Validation and verification various medical devices	a						

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	UNIT I: Introduction and Classification of Medical Devices	**9**			
1.	Medical devices definition, design life cycle	1	C,D	1	1
2.	Design process versus design control	1	C,D	1	1
3.	FDA regulation and inspection	1	C,D	1	2
4.	Design models-Pahl and Beitz	2	C,D	1	1
5.	Pugh model	1	C,D	1	1
6.	Divergent-convergent model	1	C,D	1	1
7.	Common design management models	1	C,D	1	1
8.	Cross reference with regulatory requirements	1	C	1	1
	UNIT II: Implementing Design Procedure	**9**			
9.	Classification /Product specification procedure	1	C	2	1
10.	Design verification/validation/Evaluation procedure	2	C	2	1
11.	Risk assessment procedure	1	C	2	1
12.	Product design specification	1	C	2	1
13.	Regulatory bodies	1	C	2	1
14.	Generating and selecting concepts and ideas	3	C	2	1
	UNIT III: Quality in Design	**9**			
15.	Optimization	1	C	3	1
16.	Overview of quality function deployment (QFD)	1	C	3	2
17.	QFD process	1	C	3	2
18.	House of quality	2	C,D	3	1
19.	Failure mode and effect of analysis	1	C	3	1
20.	D4X	1	C,D	3	1
21.	Six sigma	2	C,D	3	1
	UNIT IV: Design Realization	**9**			
22.	The process to design realization	1	C	4	1
23.	Design calculation	1	C,D	4	1
24.	Material selection and standards	2	C	4	1
25.	Design for usability	2	C,D	4	1
26.	Fundamental safety and effectiveness principle	1	C	4	2
27.	FDA'S interest in standards	1	C	4	2
28.	Intellectual property	1	C	4	2

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	UNIT V: Evaluation	**9**			
22.	Risk analysis	1	C	5	1
23.	Criteria based evaluation- Invitro/Invivo	1	C	5	1
24.	Value to health care analysis	1	C	5	2
25.	Clinical trials and clinical studies	1	C	5	1
26.	Synthetic crafts, total hip prosthesis	2	C	5	1
27.	Hazard analysis and quality control	2	C	5	2
28	Analyzing the outcomes and limits to analysis	1	C	5	2
	Total contact hours	**45 (Exclusive of Assessment hours)**			

LEARNING RESOURCES	
Sl. No.	**TEXT BOOKS**
1.	Peter Ogrodnik, "*Medical Device Design Innovation from Concept to Market*", Elsevier, 2013.
2.	Richard C. Fries, "*Handbook of Medical Device Design*", Marcel Dekker AG, 2nd edition, 2005.
	REFERENCE BOOKS/OTHER READING MATERIAL
3.	Gail Baura, "*Medical Device Technologies: A Systems Based Overview Using Engineering*", Elsevier science, 2012.
4.	Matthew B.Weinger, Michael E, Wiklund, DaryleJ. Gardner-Bonneau, "*Handbook of Human factors in Medical Device Design*", Taylor and Francis group, 2010.

Course nature				**Theory**			
Assessment Method (Weightage 100%)							
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Cycle Test III	Surprise Test	Quiz	**Total**
	Weightage	**10%**	**15%**	**15%**	**5%**	**5%**	**50%**
					End semester examination Weightage :		**50%**

15BM322E	Embedded Systems in Medical Devices	L	T	P	C
		3	0	0	3
Co-requisite:	NIL				
Prerequisite:	NIL				
Data Book / Codes/Standards	NIL				
Course Category	P PROFESSIONAL ELECTIVE	MEDICAL ELECTRONICS			
Course designed by	Biomedical engineering				
Approval	32nd Academic Council Meeting held on 23rd July 2016				

PURPOSE	The purpose of learning this course on embedded systems in medical devices for biomedical engineering students is to impart knowledge in the design of embedded system for various medical devices.

INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**
At the end of the course, student will be able to		
1.	Attain knowledge on the basic concepts and the building blocks for embedded system	a
2.	Understand the hardware and software partitioning in embedded systems	e
3.	Gain knowledge about timers and memory organization of embedded systems	c
4.	Design a pulse oximeter using embedded tool	i
5.	Design a pacemaker using embedded tool	e

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	UNIT I: Embedded Design with Microcontrollers	**9**			
1.	Product specification – hardware / software partitioning	2	C	1	1
2.	Detailed hardware and software design – integration, product testing	2	C	1	1
3.	Microprocessor Vsmicro controller	1	C	1	1,2
4.	Performance tools, bench marking processors.	2	D	1	1
5.	RTOS micro controller -issues in selection of processors	2	D	1	1
	UNIT II: Partitioning Decision	**9**			
6.	Hardware / software duality	2	C	2	2
7.	Hardware-software portioning, coding for hardware/software development, ASIC revolution	2	C	2	2
8.	Managing the risk,co-verification, execution environment	2	C	2	2
9.	Memory organization of controller, memory enhancement	1	C	2	2
10.	Firmware, speed and code density, system startup	2	D	2	2
	UNIT III: Functionalities for System Design	**9**			
11.	Timers, watch dog timers	2	C	3	2
12.	RAM, flash memory, basic toolset, integration of hardware & firmware	2	C	3	2
13.	Application programming, IDE, target configuration	2	C	3	2
14.	Hostbased debugginganalyser	1	D	3	1,2
15.	Remote debugging, ROM emulators, logic	2	D	3	1,2
	UNIT IV: Design of Patient Monitoring Devices	**9**			
16.	Design consideration of patient monitoring systems	3	D	4	2,3
17.	Basic block diagram of pulse oximeter, design requirement of device	2	D	4	3
18.	Circuit implementation of interfacing of oximeter sensors with microcontoller	2	D	4	3
19.	Software coding and implementation	2	D	4	2,3
	UNIT V Designing of Pacemaker	**9**			
20.	System description of pacemaker	3	D	5	3
21.	Design requirement and basic block diagram of pacemaker	2	D	5	3

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
22.	Interfacing of pacemaker elements with processors	2	D	5	3
23.	Software coding of pacemaker and implementation	2	D	5	3
	Total contact hours	**45(Exclusive of assessment hours)**			

LEARNING RESOURCES	
Sl. No.	**TEXT BOOKS**
1.	James K. Peckol, *"Embedded system Design"*, John Wiley & Sons, 1st edition, 2010.
	REFERENCE BOOKS/OTHER READING MATERIAL
2.	Elicia White, "M*aking Embedded Systems"*, O'Reilly Series, SPD, 1st edition, 2011.
3.	G. Baura, *"A Biosystems Approach to Industrial Patient Monitoring and Diagnostic Devices"*, Morgan& Claypool, IEEE, 2008.

Course nature				**Theory**			
Assessment Method (Weightage 100%)							
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Cycle Test III	Simulation lab practice test	Quiz	**Total**
	Weightage	**10%**	**15%**	**15%**	**5%**	**5%**	**50%**
					End semester examination Weightage :		**50%**

15BM323E	Machine Vision in Medical Technology	L	T	P	C
		3	0	0	3
Co-requisite:	NIL				
Prerequisite:	NIL				
Data Book / Codes/Standards	NIL				
Course Category	P PROFESSIONAL ELECTIVE SIGNAL AND IMAGE PROCESSING				
Course designed by	Department of Biomedical Engineering				
Approval	32nd Academic Council Meeting held on 23rd July 2016				

PURPOSE	The purpose of this course on machine vision in medical technology for biomedical engineering students is to impart fundamental machine vision concepts and their application in the field of medicine

INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able to								
1.	Familiarize with the machine vision and its problems	a						
2.	Explain the applications of differential vision and motion analysis	a	c					
3.	Describe and understand the concept of three dimensional reconstruction	a						
4.	Use stereo vision techniques and optical flow methods to study motion	a						
5.	Use contemporary numerical and simulation tools to implement methods and algorithms	a	j	k				

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	UNIT I: Machine Learning for Machine Vision	**9**			
1.	Learning and inference in vision	2	C	1,4	2,1
2.	Geometric primitives and transformations, photometric image formation, digital camera-usage	2	C	1	2
3.	Global optimization, geometric intrinsic calibration	3	C,D	1	2
4.	Regression model, graphical model	2	C,D	1	2
	UNIT II: Visualizing of Objects in Motion	**9**			
5.	Two-frame structure from motion, factorization	2	C	5	1,2,4
6.	Constrained structure and motion	2	C,D	5	1,2,4
7.	Dense motion estimation- parametric motion	3	D,I	5	1,2,4
8.	Motion models, image stitching	2	C,D	5	1,2
	UNIT III: 3d Reconstruction –Basics and Methods	**9**			
9.	2D and 3D feature-based alignment, shape from X, active range finding	1	C	5	1,2
10.	Point-based representations, surface representations	2	C,D	5	1,2
11.	Volumetric representations, model-based reconstruction	2	C,D	5	1,2
12.	Recovering texture maps and albedos	2	C	5	1,2
13.	Rendering- Layered depth images, light fields and lumigraphs– 3D	2	C	4	1,2
	UNIT IV: Photogrammetry and Stereo Methods	**9**			
14.	Photometric calibration, High dynamic range imaging, Super-resolution and blur removal	3	C	2	2,3
15.	Image matting and compositing, texture analysis and synthesis	3	C,D	2	2,3
16.	Epipolar geometry, sparse correspondence, dense correspondence, multi-view stereo	3	C,D	2	2,3
	UNIT V: Applying Computational Vision	**9**			
17.	Automated visual inspection	2	C,D	4	2
18.	Computer vision in interventional cardiology	2	C	4	2
19.	Fusion of three dimensional quantitative coronary angiography and intracoronary imaging for coronary interventions	3	C	4	3
20.	Feature centric lesion detection and retrieval in thoracic images	2	C	4	3
	Total contact hours	**45(Exclusive of assessment hours)**			

LEARNING RESOURCES	
Sl. No.	**TEXT BOOKS**
1.	Richard Szeliski , "*Computer Vision: Algorithms and Applications*", Springer, 1st edition, 2010.
2.	E R Davies, "*Computer & Machine Vision: Theory, Algorithms, Practicalities*", Elsevier, 4thedition, 2012.
3.	Chi Hau Chen , "*Computer Vision in Medical Imaging*", Series in Computer Vision – Vol 2, World Scientific Publishing Co Ltd, 2014.
4.	Simon J.D. Prince, "*Computer vision: models, learning and inference*", Cambridge University Press, 1st edition, 2012.
	REFERENCE BOOKS/OTHER READING MATERIAL
5.	Herwig Unger, PhayungMeesad, Sirapat , "*Recent Advances in Information and Communication Technology 2015*", Springer, 1st edition, 2015.
6.	Xuegong Zhang, Image and Graphics: 8th International Conference, ICIG 2015, Springer.
7.	Horn, Berthold K. P, "Robot Vision", Cambridge, MA: MIT Press /McGraw-Hill, March 1986.

Course nature				**Theory**			
Assessment Method (Weightage 100%)							
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Cycle Test III	Surprise Test	Quiz	**Total**
	Weightage	**10%**	**15%**	**15%**	**5%**	**5%**	**50%**
					End semester examination Weightage :		**50%**

15BM325E	Medical Simulation in Cardiology	L	T	P	C
		3	0	0	3
Co-requisite:	NIL				
Prerequisite:	NIL				
Data Book / Codes/Standards	NIL				
Course Category	P PROFESSIONAL ELECTIVE	BIOMEDICAL INSTRUMENTATION			
Course designed by	Department of biomedical Engineering				
Approval	32nd Academic Council Meeting held on 23rd July 2016				

PURPOSE	The purpose of the course on medical simulation in cardiology for biomedical engineering students is to identify the cardiac disease using various simulation techniques and to demonstrate how to treat disease under emergency condition.

INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able to								
1.	Explain the basic structure and function of heart and disease associated with it	h	i					
2.	Distinguish various types of arrhythmias	b	e					
3.	Describe imaging technique for cardiac disease diagnosis	e	k					
4.	Apply intervention cardiology to diagnose and treat disease	c	h					
5.	Work with basic cardiac equipment under emergency condition	h	k					

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	UNIT I: Basic Cardiology	**9**			
1.	Anatomy of heart	1	C	1	1
2.	Cardiac function in physiology and pathophysiology	1	C	1	1
3.	Coronary circulation in physiology	1	C	1	1
4.	Cardiogenic shock complicating acute coronary syndrome	1	C	1	9
5.	Disease of pericardium	1	C	1	3
6.	Mitral and aortic valve disease	1	C	1	3
7.	Pulmonary hypertension	1	C	1	1
8.	Advanced cardiac life support (ACLS) Guidelines and practice	2	C,I	1	10
	UNIT II: Cardiac Arrhythmias	**9**			
9.	Mechanism of cardiac arrhythmias	1	C	2	3
10.	Atrial arrhythmias	2	C	2	6
11.	Ventricular arrhythmias	1	C	2	3
12.	Atrio-ventricular arrhythmias	1	C	2	3
13.	Junctional arrhythmias	1	C	2	3
14.	Heart blocks	1	C	2	3
15.	ECG arrhythmia simulator practice	2	C,I	2	6
	UNIT III: Cardiovascular Imaging	**9**			
16.	Principle of imaging, Plain film examination of chest	1	C	3	1,3
17.	Trans thoracic echocardiograph	1	C	3	1,3
18.	Stress echocardiography	1	C	3	1,3
19.	Imaging technique in nuclear cardiology	1	C	3	1,3
20.	Cardio vascular MRI	1	C	3	1,3
21.	Computer tomography of Heart	1	C	3	1,3
22.	Clinical application of intra-aortic balloon pump	1	C,I	3	4
23.	Intravascular coronary ultrasound	1	C	3	1
24.	Real time 3D echocardiography	1	C	3	1
	UNIT IV: Intervention Cardiology	**9**			
25.	Coronary angiography	1	C	4	3,4
26.	Coronary artery bypass surgery	1	C	4	3,4
27.	Intervention in cardiogenic shock	1	C	4	3,4
28.	Percutaneous intervention for congenital heart disease	2	C,I	4	3,4

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
29.	Venous intervention	2	C,I	4	3,4
30.	Aortic vascular intervention	2	C,I	4	3,4
	UNIT V: Emergency Cardiology	**9**			
31.	External cardiac pacemaker	1	C	5	6
32.	Implantable cardiac pacemaker	1	C	5	6
33.	Cardiac pacemaker simulator	2	C,I	5	6
34.	DC Defibrillator	1	C	5	6
35.	Implantable cardioverter defibrillator	1	C	5	6
36.	Defibrillator practice	2	C,I	5	6
37.	Cardiac resynchronization therapy	1	C,I	5	3
	Total contact hours	**45 (Exclusive of Assessment hours)**			

LEARNING RESOURCES	
Sl. No.	**TEXT BOOKS**
1.	Kanu Chatterjee, "*Cardiology: An Illustrated Textbook, Volume 1*", Jaypee brother medical publisher, 1st edition, 2012.
2.	Navin C. Nanda, "*Comprehensive Textbook of Echocardiography (Vols 1 & 2), Volume 1",* Jaypee brothers medical publishers, 2014.
3.	Eric J. Topol, Robert M. Califf, "*Textbook of Cardiovascular Medicine",* Lippinocot William and Wilkins, 3rd edition, 2007.
4.	Eric J. Topol, PaulS. Teirstein, "*Textbook of Interventional Cardiology*",Elsevier,1st edition, 2016.
	REFERENCE BOOKS/OTHER READING MATERIAL
5.	PetrWidimsky, Harry Suryapranata, Alec Vahanian, *"Catheterization and Interventional Cardiology in Adult Patients*", Oxford university press,1st edition,2010.
6.	Khandpur R.S, "*Hand-book of Biomedical Instrumentation*", Tata McGraw Hill,3rd edition, 2014.
7.	Leslie Cromwell, Fred J, Weibell, Erich A, Pfeiffer, "*Biomedical Instrumentation and Measurements*", Prentice-Hall India, 2nd edition,2011.
8.	John G. Webster, "*Medical Instrumentation application and design*", John Wiley, 4th edition, 2010.
9.	John M. Field, Peter J. Kudenchuk, Robert O'Connor, Terry Vanden Hoek, "*The Textbook of Emergency Cardiovascular Care and CPR*" ,lippinocot William and wilkins, 1st edition, 2009.
10.	Jasmeet Soar, Jerry P. Nolan, Bernd W. Böttigerd, Gavin D. Perkins, Carsten Lott G, Pierre Carlih, Tommaso Pellisi, Claudio Sandronij, Markus B. Skrifvarsk, Gary B. Smith l, KjetilSundem N, Charles D. Deakino, "*European Resuscitation Council Guidelines for Resuscitation 2015. Section 3 Adult advanced life support",* 2015, Resuscitation 2015, vol 95, pp 100-147.

Course nature		**Theory**					
Assessment Method (Weightage 100%)							
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Cycle Test III	Simulation lab practice test	Quiz	**Total**
	Weightage	**5%**	**10%**	**15%**	**15%**	**5%**	**50%**
					End semester examination Weightage :		**50%**

15BM326E	Radiotherapeutic Equipments	L	T	P	C
		3	0	0	3
Co-requisite:	NIL				
Prerequisite:	NIL				
Data Book / Codes/Standards	NIL				
Course Category	P PROFESSIONAL ELECTIVE	BIOMEDICAL INSTRUMENTATION			
Course designed by	Department of Biomedical engineering				
Approval	32nd Academic Council Meeting held on 23rd July 2016				

PURPOSE	The purpose of learning this course on radiotherapeutic equipment for biomedical engineering students is to acquire knowledge on different radiotherapy techniques, radiotherapy planning and components of radiotherapy equipment and its functioning.

INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able to								
1.	Overview the different radiotherapy techniques and procedures	a	b					
2.	Describe the basic working principle of mega voltage and kilo voltage equipment and dosimetry	a	b					
3.	Apply the different types of immobilization devices available	a	b					
4.	Describe the radiotherapy planning procedure	a	b	c				
5.	Explain the advanced technique of proton and carbon ion therapeutic principles and procedures	a	b					

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	UNIT: I Radiation Therapy	**9**			
1.	External beam radiation therapy: 3D conformal radiation therapy	2	C	1	1,2
2.	Intensity modulated radiation therapy	1	C	1	1,2
3.	Image guided RT	1	C	1	1,2
4.	Tomo therapy, stereotactic radio surgery	2	C	1	1,2
5.	Internal beam radiation therapy: brachytherapy	1	C	1	1,2
6.	Systemic radiation therapy, radioactive iodine therapy.	2	C	1	1,2
	UNIT: II Mega Voltage and Kilo Voltage Equipments and Dosimetry	**9**			
7.	Cobalt units, gamma knife	1	C	2	1,2
8.	Linear accelerators	1	C	2	1,2
9.	Helical tomo therapy, ancillary equipments	1	C	2	1,2
10.	Superficial and ortho voltage equipment, kilo voltage unit	1	C	2	1,2
11.	Colorimetry, free air ionization chamber,	1	C	2	1,2
12.	Cavity chamber, parallel plate chamber, dosimetry for mega voltage photons	1	C	2	1,2
13.	Radiation detection and measurement: semiconductor detectors	1	C	2	1,2
14.	Thermo luminescent dosimeters, detector design	2	C	2	1,2
	UNIT:III Immobilization Equipments	**9**			
15.	Immobilisation equipment for head and neck treatment: head supports, facial mask, base plate systems; bite blocks	2	C	3	1,2
16.	Immobilisation equipment for breast treatment	1	C	3	1,2
17.	Thorax immobilization, Immobilisation equipment for pelvic treatment	2	C	3	1,2
18.	Organ immobilization: Rectal catheters, respiratory movements	2	C	3	1,2
19.	Immobilisation equipment for treatment of extremities and superficial radiotherapy	2	C	3	1,2
	UNIT:IV Radiation Treatment Planning	**9**			
20.	Patient positioning, Immobilization	1	C	4	1,2
21.	Localization and verification techniques	1	C	4	1,2

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
22.	Principles and practice of radiation treatment planning	1	C	4	1,2
23.	Data measurements for treatment planning systems	1	C	4	1,2
24.	Intensity-Modulated Radiation Therapy (IMRT) planning, electron beam planning	2	C	4	1,2
25.	4D CT planning, Stereotactic radiosurgery planning	2	C	4	1,2
26.	Brachytherapy planning	1	C	4	1,2
	UNIT:V Introduction To Proton and Carbon Ion Therapy	**9**			
27.	Accelerators for proton and carbon ion therapy	2	C	5	5
28.	Beam delivery systems for particle therapy	1	C	5	5
29.	Dosimetry for proton and carbon ion therapy	2	C	5	5
30.	Image guided proton and carbon ion therapy	2	C	5	5
31.	Treatment planning for scanned particle beams, conformal proton therapy.	2	C	5	5
	Total contact hours	**45 (Exclusive of Assessment hours)**			

LEARNING RESOURCES	
Sl. No.	**TEXT BOOKS**
1.	Symonds, Deehan, Meredith & Mills Walter and Miller, *"Textbook of Radiotherapy: Radiation Physics, Therapy and Oncology",* Churchill Livingstone, 7th edition,2012.
2.	Pam Cherry, Angela Duxbury, *"Practical Radiotherapy-Physics and Equipment",* John Wiley & Sons, 2nd edition, 2009.
	REFERENCE BOOKS/OTHER READING MATERIAL
3.	Subramania Jayaraman, Lawrence H. Lanzl, *"Clinical Radiotherapy Physics",* CRC Press, 2nd edition, 1996.
4.	*Edward C. Halperin, Luther W. Brady, Carlos A. Perez and David E. Wazer,* "Perez & Brady's Principles and Practice of Radiation Oncology", Lippincott Williams & Wilkins, 6th edition, *2013.*
5.	C-M Charlie Ma, Tony Lomax, *"Proton and Carbon Ion Therapy",* CRC Press, 2012.
6.	Todd Powliki, Peter B. Dunscombe, Arno J. Mundt, Pierre Scalliet, *"Quality and safety in radiotherapy",* CRC Press, 1st edition, 2010.

Course nature				**Theory**			
Assessment Method (Weightage 100%)							
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Cycle Test III	Surprise Test	Quiz	**Total**
	Weightage	**10%**	**15%**	**15%**	**5%**	**5%**	**50%**
					End semester examination Weightage :		**50%**

15BM327E	Biomedical Nanotechnology	L	T	P	C
		3	0	0	3
Co-requisite:	NIL				
Prerequisite:	NIL				
Data Book / Codes/Standards	NIL				
Course Category	P PROFESSIONAL ELECTIVE	REHABILITATION ENGINEERING			
Course designed by	Department of Biomedical Engineering				
Approval	32nd Academic Council Meeting held on 23rd July 2016				

PURPOSE	To enable the students to acquire knowledge about the principles & application of nanomaterial and nanotechnology in biomedical industry							
INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able to								
1.	Learn the different synthesis method and application of nano material	a	d					
2.	Apply the various characterization techniques used in nano biomaterial	a	d	k				
3.	Know the importance of nanotechnology based biomedical diagnostics	a	d	j				
4.	Familiarize with biological system, prosthetic and medical implants in nanotechnology	a	d	j				
5.	Gain the knowledge about nano material used in biomedical application	a	d	j				

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	UNIT I:Synthesis and Application of Nano Material	**9**			
1.	Bulk synthesis: Top down and bottom up approaches	1	C	1	1,2,3
2.	Inert gas condensation technique	1	C	1	1,2,3
3.	Arc plasma and laser ablation	1	C	1	1,2,3
4.	Chemical synthesis: sol gel processing, hydrothermal, precipitation, spray pyrolysis	3	C	1	1,2,3
5.	Electro spraying and spin coating routes	2	C	1	1,2,3
6.	Pulsed electrochemical deposition	1	C	1	1,2,3
	UNIT II: Nano Material Characterization Technique	**9**			
7.	Introduction to Nano scale phenomena	1	C	2	1,3
8.	Nanoparticles determination and carbon nano tube (CNT)	2	C	2	1,3
9.	Nanomaterial characterization: Scanning electron microscope (SEM) and Energy-dispersive X-ray spectroscopy (EDS) analysis	2	C	2	1,3
10.	Transmission electron microscopy (TEM)analysis and Atomic-force microscopy (AFM) analysis	2	C	2	1,3
11.	Scanning probe microscopy (SPM) technique and Small-angle X-ray scattering (SAXS)	1	C	2	1,3
12.	Nano indentation technique	1	C	2	1,3
	UNIT III: Nanotechnology Based Medical Diagnostics	**9**			
13.	Introduction to Improved diagnosis by in vivo imaging	2	C	3	4,5
14.	Detection of tumors, plaque and genetic defects	3	C	3	4,5
15.	Nanobot medical devices	2	C	3	4,5
16.	Cantilever Sensors used in biomedical application	2	C	3	4,5
	UNIT IV: Prosthetic and Medical Implants in Nanotechnology	**9**			
17.	Introduction to prosthesis and implants: Neural implant	2	C	4	5,6
18.	Ocular, cochlear and dental implants	2	C	4	5,6
19.	Implants and prosthesis of skin, limb and bone	2	C	4	5,6
20.	Artificial organ and organ transplant	1	C	4	5,6
21.	Nanofiber scaffold technology	2	C	4	5,6
	UNIT V:Biomedical Applications of Nanotechnology	**9**			
22.	Nano-bio conjugates and their significance	2	C	5	5,6

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
23.	Nanoscaffolds and application	2	C	5	5,6
24.	Magnetic nanoparticles synthesis and application	1	C	5	5,6
25.	Multifunctional inorganic and CNT nano particle and its application	2	C	5	5,6
26.	Organic nanoparticles and their biomedical applications	2	C	5	5,6
	Total contact hours	**45 (Exclusive of Assessment hours)**			

LEARNING RESOURCES	
Sl. No.	**TEXT BOOKS**
1.	W.Gaddand, D.Brenner, S.Lysherski and G.J.Infrate(Eds.), "*Handbook of Nano Science Engineering and Technology"*, CRC Press, 2013.
2.	K. Barriham, D.D. Vvedensky, "*Low dimensional semiconductor structure fundamental and device applications"*, Cambridge University Press, 2010.
	REFERENCE BOOKS/OTHER READING MATERIAL
3.	Cao,G,*Nanostructures & Nanomaterials Synthesis: Properties &Applications"*, Imperial College Press, 2011. Brian, R Eggins; Wiley; New York, Chichester, 3rd edition,2012
4.	Allen J Bard and Larry R Faulkner; Wiley, "*Electrochemical Methods: Fundamentals and Applications",* New York Chichester, 4th edition, 2009
5.	David Wild; *"The Immunoassay Handbook",* Elsevier, 4th edition, 2013.

Course nature		**Theory**					
Assessment Method (Weightage 100%)							
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Cycle Test III	Surprise Test	Quiz	**Total**
	Weightage	**10%**	**15%**	**15%**	**5%**	**5%**	**50%**
					End semester examination Weightage :		**50%**

15BM328E	Rehabilitation Robotics	L	T	P	C
		3	0	0	3
Co-requisite:	NIL				
Prerequisite:	NIL				
Data Book / Codes/Standards	NIL				
Course Category	P PROFESSIONAL ELECTIVE	REHABILITATION ENGINEERING			
Course designed by	Department of Biomedical Engineering				
Approval	32nd Academic Council Meeting held on 23rd July 2016				

PURPOSE	The purpose of learning this course on rehabilitation robotics for biomedical engineering students is to acquire knowledge on the working concepts of various rehabilitation equipments for human movements

INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able to								
1.	Understand the biomechanics of mobility and universal design	a	b					
2.	Gain knowledge about different hearing aids	a	b					
3.	Learn about personal transportation, manual and powered wheelchairs	e	i					
4.	Follow the working of prosthetics, orthotics and rehabilitation robotics	c						
5.	Design various rehabilitation devices	a						

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	UNIT I:Introduction, Biomechanics of Mobility and Universal Design	**9**			
1.	Rehabilitation engineering and assistive technology:concepts and terminologies	1	C	1	1
2.	Design, considerations, approaches to rehabilitation	2	C	1	1,2
3.	Biomechanics of mobility and universal design	2	C	1	1
4.	Gait analysis-Biomechanics of wheel chair propulsion	2	C	1	1
5.	Barrier free design- design for people with disabilities	2	C	1	1,2
	UNIT II: Intelligent Techniques in Hearing Rehabilitation	**9**			
6.	Hearing aid, design of electronic hearing aid	3	D	2	2
7.	Normal hearing aids, bone integrated vibrator, middle ear aids	3	D	2	2
8.	Cochlear implants, materials design	3	D	2	2
	UNIT III: Intelligent Mobility Aids	**9**			
9.	Smart power wheelchair	3	C	3	2
10.	Smart wheeled walker, input methods, sensors	3	C	3	2,3
11.	Control integrator, control modes and control interface	3	C	3	3
	UNIT IV: Therapeutic Robotics	**9**			
12.	Therapeutic robots for upper limb movements	3	C	4	2
13.	Therapeutic robots for lower limb movements	3	C	4	2
14.	Comparison between conventional and robotic therapy	3	C	4	2
	UNIT V: Computerized Obstacle Avoidance Systems	**9**			
15.	Mobile robot obstacle avoidance sensors	3	D	5	3
16.	Knee –ankle foot orthosis design	3	D	5	3
17.	Advance concept in ortho-robotic design	3	D	5	3
	Total contact hours	**45 (Exclusive of Assessment hours)**			

LEARNING RESOURCES	
Sl. No.	**TEXT BOOKS**
1.	Reswick. J., *"What is Rehabilitation Engineering?, Annual review of rehabilitation"*,Vol.2 Springer - Verlag, Newyork, 1982.

	REFERENCE BOOKS/OTHER READING MATERIAL
2.	Horia-Nicolai L Teodorescu, Lakhmi C. Jain *"Intelligent Systems and Technologies in Rehabilitation Engineering"* CRC Press, 2000.
3.	Rory A Cooper, Hisaichi Ohnabe, Douglas A. Hobson "An Introduction to Rehabilitation Engineering", CRC Press, 2006.

Course nature				**Theory**			
Assessment Method (Weightage 100%)							
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Cycle Test III	Simulation lab practice test	Quiz	**Total**
	Weightage	**10%**	**15%**	**15%**	**5%**	**5%**	**50%**
End semester examination Weightage :							**50%**

15BM329E	Biomechanics	L	T	P	C
		3	0	0	3
Co-requisite:	NIL				
Prerequisite:	NIL				
Data Book / Codes/Standards	NIL				
Course Category	P PROFESSIONAL ELECTIVE	REHABILITATION ENGINEERING			
Course designed by	Department of Biomedical Engineering				
Approval	32nd Academic Council Meeting held on 23rd July 2016				

PURPOSE	The purpose of learning this course on biomechanics for biomedical engineering students is to acquire knowledge and understand the basic mechanical concepts involved in human movement							
INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able to								
1.	Illustrate the fundamental concepts of kinematics and kinetics of human motion	a	b	c				
2.	Explain the functions of bone and its skeletal articulations	a	d					
3.	Describe the structure, movements, and various loads applied on the shoulder, elbow and hand	a	b	e				
4.	Describe the structure, movements and various loads applied on the hip, knee, ankle and spine	a	b	e				
5.	Explain the principles of mechanics in various applications	a	b	c	d	e		

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	UNIT I:Kinematic and Kinetic Concepts of Human Motion	**9**			
1.	Introduction, forms of motion, standard reference terminology, joint movement terminology	1	C	1	1
2.	Spatial reference systems, qualitative analysis of human movement, tools for measuring kinematic quantities	2	C	1	1
3.	Basic concepts related to kinetics, mechanical loads on the human body	3	C,D	1	1
4.	Effects of loading, tools for measuring kinetic quantities, vector algebra	3	C,D	1	1,3
	UNIT II: Biomechanics of Bone Growth and Skeletal Muscle	**9**			
5.	Composition and structure of bone tissue, bone growth and development, bone response to stress-osteoporosis	3	C	2	1,4
6.	Joint Architecture, joint stability, joint flexibility, techniques for increasing joint flexibility, common joint injuries	3	C	1,2	1
7.	Structural organization of skeletal muscle, skeletal muscle function, factors affecting muscular force generation, common muscle injuries	3	C	1,2	1,4
	UNIT III: Biomechanics of the Human Upper Extremity	**9**			
8.	Structure of the shoulder, movements of the shoulder, loads on the shoulder, common injuries of the shoulder	2	C,D	1,2,3	1
9.	Joint-Articulating surface motion of shoulder	1	C,D	1,2,3	2
10.	Structure of the elbow, movements at the elbow, loads on the elbow, common injuries of the elbow	2	C,D	1,2,3	1,3
11.	Joint-articulating surface motion of elbow	1	C,D	1,2,3	2
12.	Structure of the wrist, movements of the wrist, structure of the joints of the hand, movements of the hand, common injuries of the wrist and hand	2	C	1,2,3	1
13.	Joint-Articulating surface motion of Wrist	1	C,D	1,2,3	2

	UNIT IV: Biomechanics of the Human Lower Extremity and Spine	**9**			
14.	Structure of the hip, movements at the hip, loads on the hip, common injuries of the hip	2	C,D	1,2,4	1
15.	Joint-Articulating surface motion of hip	1	C,D	1,2,4	2
16.	Structure of the knee and ankle, movements at the knee and ankle loads on the knee and ankle, common injuries of the knee and ankle	2	C,D	1,2,4	1
17.	Joint-articulating surface motion of knee	1	C,D	1,2,3	2
18.	Structure of the spine, movements of the spine, muscles of the spine, loads on the spine, common injuries of the back and neck	3	C,D	1,2,4	1,3
	UNIT V: Application of Biomechanics	**9**			
19.	Biomechanics in physical education	2	C	5	2,3
20.	Biomechanics in strength and conditioning	3	C	5	2,3
21.	Gait analysis, biomechanics in sports medicine and rehabilitation	4	C,D	5	2,3
	Total contact hours	**45 (Exclusive of Assessment hours)**			

LEARNING RESOURCES	
Sl. No.	**TEXT BOOKS**
1.	Susan J Hall, "*Basic Biomechanics*", McGraw-Hill Higher Education, 7th edition, 2014.
	REFERENCE BOOKS/OTHER READING MATERIAL
2.	Donald R. Peterson and Joseph D. Bronzino, "*Biomechanics- Principles and Applications*", CRC Press, 2nd edition, 2008.
3.	Duane Knudson, "*Fundamental of biomechanics*", Springer, 2nd edition, 2007.
4.	Fung Y C, Biomechanics: "*Mechanical Properties of Living Tissues*", Springer, 2nd edition, 1993.

Course nature				**Theory**			
Assessment Method (Weightage 100%)							
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Cycle Test III	Surprise Test	Quiz	**Total**
	Weightage	**10%**	**15%**	**15%**	**5%**	**5%**	**50%**
End semester examination Weightage :							**50%**

DEPARTMENT ELECTIVE IV AND V

15BM330E	Troubleshooting and Quality Control in Medical Equipments	L	T	P	C
		3	0	0	3
Co-requisite:	NIL				
Prerequisite:	NIL				
Data Book / Codes/Standards	NIL				
Course Category	P PROFESSIONAL ELECTIVE	MEDICAL ELECTRONICS			
Course designed by	Department of Biomedical Engineering				
Approval	32nd Academic Council Meeting held on 23rd July 2016				

PURPOSE	The purpose of learning this course on troubleshooting and quality control in medical equipments for biomedical engineering students is to provide knowledge about the troubleshooting of various equipments used in hospitals and quality standard of medical equipment.

INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able to								
1.	Apply the common troubleshooting procedures in electronic equipment	e	k					
2.	Outline the testing procedures of active and passive components	e						
3.	Analyze the fault diagnosis in analog circuits and digital ICs	e						
4.	Identify the problems in common biomedical equipment in hospitals when it is not working and provide a suitable solution	e	k					
5.	Describe the various quality measures & standards adapted for medical systems	c						

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	UNIT I: Fundamental Troubleshooting Testing Procedures	**9**			
1.	Equipment failure and its causes	1	C	1	1
2.	Functional block diagram of a troubleshooting system	1	C	1	1
3.	Troubleshooting process & fault finding aids	2	C	1	1
4.	Troubleshooting techniques and their correction action	3	C,D	1	1,4
5.	Testing of active and passive components: resistor, capacitor, inductor, BJT, JFET, & MOSFET	2	C,O	1,2	1,3,4
	UNIT II: Fault Diagnosis in Analog & Digital Integrated Circuits	**9**			
6.	Characteristics of ideal op-amps, typical op-amp based medical circuits	2	C,I	3	1,3
7.	Fault diagnosis in op-amp circuits	2	C	3	1,3
8.	Digital troubleshooting methods	2	C	3	1
9.	Digital IC Troubleshooters, logic clip, logic probe, logic pulser, logic current tracer, logic comparator	2	C	3	1
10.	Circuit board Troubleshooting	1	C	3	1,3,4
	UNIT III: Biomedical Equipment Troubleshooting	**9**			
11.	Troubleshooting- ECG Machine, EEG Machine	2	C	4	1,5,7
12.	Troubleshooting- defibrillator, electrosurgical unit	2	C	4	5,7
13.	Troubleshooting- anesthesia machine, autoclaves & sterilizers	2	C	4	5,7
14.	Troubleshooting- endoscope, incubators, nebulizer	1	C	4	5,7
15.	Troubleshooting- oxygen concentrators, sphygmomanometers, suction machine	1	C	4	5,7
16.	Troubleshooting- X-ray machine	1	C	4	5,6,7,8
	UNIT IV: Medical Device Design Quality	**9**			
17.	Definition of quality, essence of quality	2	C	5	2,13
18.	Quality operating system and the device life cycle	3	C	5	2,13
19.	Evolution of quality	1	C	5	2

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
20.	Business excellence: a value proposition	2	C	5	2
21.	Health care quality	1	C	5	9
	UNIT V: Design for Six Sigma and Medical Device Regulation	**9**			
22.	Global Perspective on medical device regulations, medical device classification (USA, Europe & GHTF)	3	C	5	2,10,11,12
23.	Medical device safety, medical device quality management systems requirements	2	C	5	2,13
24.	Medical device regulation throughout the product development life cycle	3	C,D	5	2,13
25.	Purpose of ISO 9001:2001&ISO 13485	1	C	5	9
	Total contact hours	**45(Exclusive of assessment hours)**			

LEARNING RESOURCES	
Sl. No.	**TEXT BOOKS**
1.	KhandpurR S, "*Troubleshooting Electronic Equipment- Includes Repair & Maintenance"*, Tata McGraw-Hill, 2nd edition, 2009.
2.	Basem S EL-Haik& Khalid S Mekki, "*Medical Device Design for Six Sigma: A Road Map for Safety and Effectiveness*", John Wiley & Sons, 1st edition, 2008.
	REFERENCE BOOKS/OTHER READING MATERIAL
3.	Nicholas Cram & Selby Holder, "*Basic Electronic Troubleshooting for Biomedical Technicians",* TSTC Publishing, 2nd edition, 2010.
4.	Dan Tomal& Neal Widmer, "*Electronic Troubleshooting",* McGraw Hill, 3rd edition, 2004.
5.	World Health Organisation, "*Maintenance & Repair of Laboratory, Diagnostic imaging & Hospital Equipment"*, Geneva,1994.
6.	Ian R McClelland, "*X-ray Equipment maintenance & repairs workbook for Radiographers & Radiological Technologists*", World Health Organisation, Geneva, 2004.
7.	Ministry of Health &Family Welfare, "*Medical Equipment Maintenance Manual- A first line maintenance guide for end users"*, New Delhi, 2010.
8.	Joseph J Panichello, "*X-Ray Repair: A Comprehensive Guide to the Installation & Servicing of Radiographic Equipment"*, Charles C Thomas Publisher Ltd, 2nd edition, 2005.
9.	Joseph Dyro, "*The Clinical Engineering Handbook*", Elsevier, 1st edition, 2004.
10.	Joseph D Bronzino& Donald R Peterson, "*Medical Devices and Human Engineering*", CRC Press, 4th edition, 2015.
11.	Myer Kutz, "*Biomedical Engineering and Design Handbook- Volume 2: Applications*", McGraw-Hill, 2nd edition,2009.
12.	Richard Fries, "*Reliable Design of Medical Devices*", CRC Press, 2nd edition, 2006.
13.	Jose Justiniano & Venky Gopalaswamy, "*Six Sigma for Medical Device Design*", CRC Press, 1st edition, 2005.

Course nature				**Theory**			
Assessment Method (Weightage 100%)							
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Cycle Test III	Surprise Test	Quiz	**Total**
	Weightage	**10%**	**15%**	**15%**	**5%**	**5%**	**50%**
					End semester examination Weightage :		**50%**

15BM331E	Computational Fluid Dynamics in Biomedical Systems			L	T	P	C
				3	0	0	3
Co-requisite:	NIL						
Prerequisite:	15MA104, 15MA204						
Data Book / Codes/Standards	NIL						
Course Category	P	PROFESSIONAL ELECTIVE	SIGNAL AND IMAGE PROCESSING				
Course designed by	Department of Biomedical Engineering						
Approval	32nd Academic Council Meeting held on 23rd July 2016						

PURPOSE	The purpose of learning this course on computational fluid dynamics in biomedical systems for biomedical engineering students is to acquire knowledge about computational fluid dynamics which is useful in analysis & design of various fluid flow medical devices.

INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able to								
1.	Explain the fundamentals of fluid dynamics	a						
2.	Describe the mechanics of biofluid	a						
3.	Analyze the discretization principles and explain the importance of CFD in general	a						
4.	Differentiate the FEM, FDM & FVM	b						
5.	Illustrate the application of CFD in biomedical domain	c	e					

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	UNIT I:Fundamentals of Fluid Dynamics	**9**			
1.	Definition & properties of fluids and classification of fluids, Introduction to fluid statics & kinematics	3	C	1	1,2,6
2.	Governing Equations of fluid motion: Lagrangianand Eulerian description, Reynolds transport theorem	2	C	1	1,2,6
3.	Integral & differential forms of governing equations: mass, momentum & energy conservation equations	1	C	1	1,2,6
4.	Euler's equation, Bernoulli's equation, Navier-Stokes equations	3	C	1	1,2,6
	UNIT II: Biofluid Mechanics	**9**			
5.	Viscoelastic fluids, viscoelastic models	2	C	2	16
6.	Bioviscoelastic fluids: Protoplasm, Mucus, Saliva, Synovial fluids	2	C	2	16
7.	Blood rheology	2	C	2	11
8.	Blood vessel mechanics	2	C	2	11
9.	Fahraeus - Lindquist effect	1	C	2	15
	UNIT III: Discretization Fundamentals &CFD Introduction	**9**			
10.	Discretization principles: pre-processing, solution, post-processing	2	C	3	3,4,13
11.	Structured mesh systems and its properties	2	C	3	5
12.	Unstructured mesh Systems and its properties	2	C	3	5
13.	Computational Fluid Dynamics: what, when &why, CFD applications	3	C	3	3,4,7,13
	UNIT IV: Introduction to FEM, FDM and FVM	**9**			
14.	Finite Element Method (FEM) – principle and application	3	C	4	3,12
15.	Finite Difference method (FDM) – principle and application	3	C	4	3,14
16.	Finite Volume method (FVM) – principle and application	3	C	4	3,9
	UNIT V:Biomedical Case Study Approaches In CFD	**9**			
17.	Examples of biomedical CFD applications:case Study 1: CFD analysis of the human circulation	3	C	5	11
18.	Case Study 2: CFD analysis of blood pump	3	C	5	11,14
19.	Case Studies in the human respiratory system	3	C	5	5
	Total contact hours	**45 (Exclusive of assessment hours)**			

LEARNING RESOURCES	
Sl. No.	**TEXT BOOKS**
1.	Philip J Pritchard and John W Mitchell, "*Fox and McDonald's Introduction to fluid Mechanics"*, John Wiley, 9th edition, 2012.
2.	Goldstein J. Richard, "*Fluid Mechanics Measurements"*, Taylor & Francis Publication, 2nd edition, 1996.
3.	T.J. Chung, "*Computational Fluid Dynamics",* Cambridge University Press, 2nd edition,2010.
4.	J.Blazek, "*Computational Fluid Dynamics: Principles & Applications",* Elsevier, 1st edition, 2001.
5.	JiyuanTu, KiaoInthavong & Goodarz Ahmadi, "*Computational Fluid and Particle Dynamics in the Human Respiratory System*", Springer, 1st edition, 2013.
	REFERENCE BOOKS/OTHER READING MATERIAL
6.	Frank M. White, "*Fluid Mechanics*", McGraw-Hill, 8th edition, 2015.
7.	John D. Anderson, Jr, "*Computational Fluid Dynamics: The Basics with Applications*", McGraw Hill, 1st edition, 1995.
8.	J.H. Ferziger& M. Peric, "*Computational Methods for Fluid Dynamics*", Springer, 3rd edition, 2002.
9.	Versteeg H. K &Malalasekera W, "*Introduction to Computational Fluid Dynamics: The Finite Volume Method*", Pearson Education, 2nd edition,2008.
10.	C.T. Shaw, "*Using Computational Fluid Dynamics*", Prentice Hall, 1st edition, 1992.
11.	Krishnan B Chandran, Stanley ERittgers&Ajit P Yoganathan, "*Biofluid Mechanics: The Human Circulation*", CRC Press, 2nd edition, 2012.
12.	RainaldLohner, "*Applied CFD Techniques: An Introduction based on Finite Element Methods*", John Wiley & Sons, 2nd edition, 2008.
13.	John F Wendt, "*Computational Fluid Dynamics: An Introduction*", Springer, 3rd edition, 2009.
14.	JiyuanTu, KiaoInthavong and Kelvin KianLoong Wong, "*Computational Hemodynamics- Theory, Modelling and Applications*", 1st edition, Springer, 2015.
15.	David A Rubenstein, Wei Yin and Mary D Frame, "*Biofluid Mechanics: An Introduction to Fluid Mechanics, Macrocirculation and Microcirculation*", Academic Press, 2nd edition, 2015.
16.	Y.C Fung, "*Biomechanics: Mechanical properties of living tissues*", Springer, 2nd edition, 1993.

Course nature				**Theory**			
Assessment Method (Weightage 100%)							
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Cycle Test III	Surprise Test	Quiz	**Total**
	Weightage	**10%**	**15%**	**15%**	**5%**	**5%**	**50%**
End semester examination Weightage :							**50%**

15BM332E	Machine Learning Techniques in Medicine			L	T	P	C
				3	0	0	3
Co-requisite:	NIL						
Prerequisite:	NIL						
Data Book / Codes/Standards	NIL						
Course Category	P	PROFESSIONAL ELECTIVE	SIGNAL AND IMAGE PROCESSING				
Course designed by	Department of Biomedical Engineering						
Approval	32nd Academic Council Meeting held on 23rd July 2016						

PURPOSE	The purpose of learning this course on machine learning techniques in medicine for biomedical engineering students is to provide an understanding of different machine learning techniques and to enable the students in solving problems in medicine

INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able to								
1.	Explain the history, algorithm types, languages for machine learning	a						
2.	Describe machine learning cycle with different data parameters	a	c	d				
3.	Outline the decision trees and Bayesian networks	a	c	d				
4.	Investigate the knowledge of machine learning in radiotherapy	a	c	d				
5.	Summarize the methods to detect, classify and measure objects in hematological cytology	a	c	d				

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	UNIT I: Machine Learning Basics	**9**			
1.	Introduction – What is learning	1	C	1	2,7
2.	History of machine learning	2	C	1	2,7
3.	Algorithm types for machine learning, the human touch	2	C	1	2,7
4.	Uses for machine learning	2	C	1	2,7
5.	Languages for machine learning	2	C	1	2,7
	UNIT II: Planning for Machine Learning	**9**			
6.	Machine learning cycle	2	C	2	2,4
7.	Defining the process, building a data team	2	C	2	2,4
8.	Data processing, data storage	3	C	2	2,4
9.	Data privacy, data quality and cleaning	2	C	2	2,4
	UNIT III: Working with Decision Trees and Bayesian Networks	**9**			
10.	Basics of decision trees – uses, advantages and limitations	3	C	3	2,6
11.	Different algorithm types and working of decision trees	2	C	3	2,6
12.	Bayesian networks – little graph theory, little probability theory	2	C	3	2,6
13.	Bayes theorem, working of Bayesian networks	2	C	3	2,6
	UNIT IV: Machine Learning Delivery and Motion Management in Radiotheraphy	**9**			
14.	Method to emulate and compensate breathing motion during radiation therapy	3	C	4	1,4
15.	Image-based motion correction	2	C	4	1,4
16.	Detection and prediction of radiotherapy errors	2	C	4	1,4
17.	Treatment delivery validation - recent advancements in radiotherapy application through machine learning	2	C,I	4	1,4
	UNIT V: Hematological Cytology Applications through Machine Learning	**9**			
18.	Automatic analysis of microscopic images in hematological cytology applications	2	C,I	5	3

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
19.	Methods to detect, classify and measure objects in hematological cytology	2	C,I	5	3
20.	Fully automated blood smear analysis system	2	C,I	5	3
21.	Recent advances of main automated analysis steps in hematological cytology applications	3	C,I	5	3
	Total contact hours	**45(Exclusive of assessment hours)**			

LEARNING RESOURCES	
Sl. No.	**TEXT BOOKS**
1.	Issam E I Naqa., "*Machine Learning in Radiation Oncology - Theory and Applications*", Springer, 1st edition, 2015.
2.	Jason Bell, "*Machine Learning for Big Data: Hands on for Developers and Technical Professionals*", John Wiley & Sons, 1st edition,2014.
3.	Cyran KA, Kawulok J, Kawulok M, Stawarz M, Michalak M, Pietrowska M, Polańska J., "*Support Vector Machines in Biomedical and Biometrical Applications. In Emerging Paradigms in Machine Learning"*, Vol.13, Springer, 2013.
	REFERENCE BOOKS/OTHER READING MATERIAL
4.	Kenneth R Foster, Robert Koprowski, Joseph D Skufca.,"*Machine learning, medical diagnosis, and biomedical engineering research – commentary"*, Journal of Biomedical Engineering, 2014.
5.	Koprowski R, Zieleźnik W, Wróbel Z, Małyszek J, Stepien B, Wójcik W., "*Assessment of significance of features acquired from thyroid ultrasonograms in Hashimoto's disease"*, Journal of Biomedical Engineering Online, 2012.
6.	David A. Rubenstein, Wei Yin, Mary D. Frame., "*Machine Learning and Data mining: Introduction to Principles and Algorithms*", Horwood Publishing Ltd, 1st edition, 2007.
7.	Tom M Mitchell., "*Machine Learning"*,Mcgraw Hill Education, 1st edition, 2007.
8.	Igor Konenenko, MatzajKukar., "*Machine Learning and Data mining: Introduction to Principles and Algorithms*", Horwood Publishing Ltd, 1st edition,2007.

Course nature		**Theory**					
Assessment Method (Weightage 100%)							
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Cycle Test III	Surprise Test	Quiz	**Total**
	Weightage	**10%**	**15%**	**15%**	**5%**	**5%**	**50%**
End semester examination Weightage :							**50%**

15BM333E	Physiological Modeling and Simulation			L	T	P	C
				3	0	0	3
Co-requisite:	NIL						
Prerequisite:	15BM303						
Data Book / Codes/Standards	NIL						
Course Category	P	PROFESSIONAL ELECTIVE	SIGNAL AND IMAGE PROCESSING				
Course designed by	Department of Biomedical Engineering						
Approval	32nd Academic Council Meeting held on 23rd July 2016						

PURPOSE	The purpose of learning this course on physiological modeling and simulation for biomedical engineering students is to break down a complex physiological system into the function of its component subsystems, and then build an engineering model based on subsystems.

INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able to								
1.	Develop a more in-depth level of understanding of physiology to that will enable engineering analysis of physiological systems.	a	b					
2.	Perform static analysis of a system.	a						
3.	Perform transient and stability analysis of a system.	a	c					
4.	Able to do frequency analysis of the system	c	k					
5.	Understand and implement system identification techniques	e						
6.	Practically implement the techniques in SIMULINK and MATLAB	c						

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	UNIT I: Linear Model	**9**			
1.	Introduction to modeling methodology, need for models, approaches to modeling, simulation, model identification, model validation	2	C	1	2
2.	Engineering control system versus physiological control system generalized system properties	2	C,D	1	1
3.	Models with combinations of system elements, distributed versus lumped parameter model	2	D,I	1	1
4.	Linear Models of Physiological systems: lung mechanics	3	D,I	6	1
	UNIT II: Static Analysis	**9**			
5.	Open loop versus closed loop	2	C,D	2	1
6.	Determination of steady state operating point for simple model of muscle stretch reflex	2	D,I	2	1
7.	Regulation of glucose-insulin	1	D,I	2	1
8.	Chemical regulation of ventilation	2	D,I	2	1
9.	SIMULINK implementation for static analysis	2	D,I	6	1
10.	**UNIT III: Time Domain Analysis**	**9**			
11.	Linearized respiratory mechanics, open loop and closed loop first order model	2	C	3	1
12.	Transient response descriptors	2	C	3	1
13.	Model of neuromuscular reflex motion	1	C,D	3	1
14.	Stability analysis, root locus plots, Routh-hurwitz stability criterion, Nyquist criterion for stability review	2	C,D	3	1
15.	Stability analysis of the pupillary light reflex	2	D,I	6	1
16.	**UNIT IV: Frequency Domain Analysis**	**9**			
17.	Steady-state responses to sinusoidal inputs	2	C	4	1
18.	Graphical representations of frequency response	2	C,D	4	1
19.	Frequency response of glucose-insulin regulation	2	D,I	6	1
20.	Frequency response of circulatory control	2	D,I	6	1
21.	Frequency response using SIMULINK	2	I	6	1
22.	**UNIT V: System Identification**	**9**			
23.	Problems in system identification, identification methods	3	C	5	1

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
24.	Identifiability and input design	1	C	5	1
25.	Identification of closed loop systems (case studies)	2	C	5	1
26.	Adaptive control of physiological variables	3	C	5	1
	Total contact hours	**45(Exclusive of assessment hours)**			

LEARNING RESOURCES	
Sl. No.	**TEXT BOOKS**
1.	Michael C.K. Khoo, "*Physiological Control Systems - Analysis, Simulation and Estimation"*, Prentice Hall of India Private Ltd., 2nd edition, New Delhi, 2001.
2.	Ewart Carson, Claudio Cobelli, "*Modeling Methodology for Physiology and Medicine*", Newnes, 2nd edition, 2013.
	REFERENCE BOOKS/OTHER READING MATERIAL
3.	Dorf, "*Modern Control Systems"*,Pearson Education India, 1st edition, 2008.
4.	Jerry J. Batzel, MostafaBachar, Franz Kappel, "*Mathematical Modeling and Validation in Physiology: Applications to the Cardiovascular and Respiratory Systems Volume 2064 of Lecture Notes in Mathematics*, *Mathematical Biosciences Subseries"*, Springer, 2012.
5.	V.Z. Marmarelis,*"Advanced Methods of Physiological System Modeling"*, Vol.3, Springer Science and Business Media, 2013.
6.	Johnny T. Ottesen, Mette S. Olufsen, Jesper K. Larsen, "*Applied Mathematical Models in Human Physiology",* Vol.9,SIAM, 2004.
7.	Vincent G. Duffy, "*Advances in Applied Human Modeling and Simulation",* CRC Press, 2012.

Course nature				**Theory**			
Assessment Method (Weightage 100%)							
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Cycle Test III	Surprise Test	Quiz	**Total**
	Weightage	**10%**	**15%**	**15%**	**5%**	**5%**	**50%**
					End semester examination Weightage :		**50%**

15BM334E	Electrocardiogram	L	T	P	C
		3	0	0	3
Co-requisite:	NIL				
Prerequisite:	NIL				
Data Book / Codes/Standards	NIL				
Course Category	P PROFESSIONAL ELECTIVE	SIGNAL AND IMAGE PROCESSING			
Course designed by	Department of Biomedical Engineering				
Approval	32nd Academic Council Meeting held on 23rd July 2016				

PURPOSE	To enable students to interpret the resting normal and abnormal ECG with an overview of heart anatomy and function.

INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**
At the end of the course, student will be able to		
1.	Understand cardiac physiology and electrocardiography	a
2.	Understand the action potential and its propagation in cardiac muscles	a
3.	Understand lead system , placement of electrodes and components of normal ECG	a
4.	Understand the pathology behind the various abnormalities and interpret common ECG abnormalities from the recording	a
5.	Design an automated classification techniques for cardiac abnormalities	e
6.	Understand cardiac physiology and electrocardiography	k

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	UNIT I: Cardiac System	**9**			
1.	Structure and function of heart, heart surfaces, heart wall	2	C	1	1,3
2.	Circulatory system, heart chambers, heart valves, coronary circulation, cardiac innervation	3	C	2	1,3
3.	Cardiac cells, depolarization and repolarization, electrical conduction of the heart, cardiac cycle, waveforms and current flow	2	C	1,2	1,3
4.	Refractory and supernormal periods of cardiac cycle	2	C	2	1,3
	UNIT II: ECG Interpretation	**9**			
5.	ECG lead system, Einthoven's triangle, 12-lead system	2	C	3	2
6.	Determination of frontal plane axis, genesis of normal ECG wave	2	C,D	3	2
7.	Analyzing ECG wave: normal P wave, PR interval, QRS Complex	2	C,D	3	1
8.	ST segment, T wave, QT interval, U wave	3	C,D	3	1
	UNIT III: Arrhythmias	**9**			
9.	Mechanisms of arrhythmias	2	C,D	4	2
10.	Determination of electrical axis	2	C,D	4	2
11.	Measurement of heart rate and intervals	1	C,D	4	2
12.	Arrhythmias from sinus node	2	C,D	4	2
13.	Atrial tachycardia and fibrillation	2	C,D	4	2
	UNIT IV: Other Disorders and 3D ECG	**9**			
14.	Wolff-Parkinson-White Syndrome, Wellens syndrome	2	C	5	2
15.	Bundle branch and hemiblock	2	C	5	2
16.	Acute myocardial infarction	3	C	5	2
17.	3D ECG: QRS vector loop, vectorcardiogram	2	C	4	3
	UNIT V: Basic ECG Signal Processing	**9**			
18.	Expert ECG Evaluation, cardiac monitoring	2	C,D	6	4
19.	Signal averaged ECG and fast fourier transform analysis of tachycardia	2	C,D	6	4
20.	ECG processing for exercise test	3	C,D	6	4
21.	Feature extraction and automated classification of arrhythmias using neural networks	2	C,D	6	4
	Total contact hours	**45 (Exclusive of assessment hours)**			

LEARNING RESOURCES	
Sl. No.	**TEXT BOOKS**
1.	Jane Huff, "*ECG Workout: Exercises in Arrhythmia Interpretation"*, Lippincott Williams and Wilkins, 6th edition, 2011.
2.	Mary Boudreau Conover, *"Understanding Electrocardiography"*, illustrated, Elsevier Health Sciences, 2003.
3.	Galen S Wagner, David G. Strauss, "*Marriott's Practical Electrocardiography",* Lippincott Williams and Wilkins, 12th edition, 2013.
4.	Adam Gacek, WitoldPedrycz, "*ECG Signal Processing, Classification and Interpretation: A Comprehensive Framework of Computational Intelligence"*, Springer Science and Business Media, 1st edition, 2012.
	REFERENCE BOOKS/OTHER READING MATERIAL
5.	Hans-Holger Ebert, Georg Thieme, *"Easy ECG: Interpretation, Differential Diagnoses",* illustrated, Verlag, 2005.
6.	HN Sarker, Harendra Nath Sarker, "*An Aid to Electrocardiogram"*, JP Medical Ltd, 1st edition, 2014.

Course nature				**Theory**			
Assessment Method (Weightage 100%)							
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Cycle Test III	Surprise Test	Quiz	**Total**
	Weightage	**10%**	**15%**	**15%**	**5%**	**5%**	**50%**
End semester examination Weightage :							**50%**

15BM335E	Medical Radiation Safety	L	T	P	C
		3	0	0	3
Co-requisite:	NIL				
Prerequisite:	NIL				
Data Book / Codes/Standards	NIL				
Course Category	P PROFESSIONAL ELECTIVE BIOMEDICAL INSTRUMENTATION				
Course designed by	Department of Biomedical Engineering				
Approval	32nd Academic Council Meeting held on 23rd July 2016				

PURPOSE	The purpose of this course on medical radiation safety for biomedical engineering students is to acquire knowledge in concepts related to safe usage of radiation in medical field.							
INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able to								
1.	Understand the concepts of radiation and its characteristics	a						
2.	Describe mechanisms of different types of biological effects following exposure to radiation	a	d					
3.	Familiarize different types of radiation protection in nuclear medicine and oncology	a						
4.	Explain radiation protection in diagnostic radiology	a	f					
5.	Understand the concepts of radiation hazards and protective measures in medical diagnosis	a	k					

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	UNIT I: Radiation Basics	**9**			
1.	Atomic structure, characteristics of radiations, types of ionizing & non-ionizing radiations	2	C	1	1
2.	Radioactive decay constant – half-life period, units of radiation and radioactivity	2	C	1	1
3.	Units of radiation risk, Relative Biological Effectiveness (RBE)	1	C,D	1	1
4.	Motion of electron in a crossed electric and magnetic fields, nuclear forces, nuclear model	2	C,D	1	1
5.	Radiation shielding principles , use of pocket dosimeters	2	C	1	1
	UNIT II: Biological Effects	**9**			
6.	Acute biological effects of ionizing radiations, long term biological effects of ionizing radiations	2	C	2	2
7.	Typical radiation doses – background, medicine, and industry; dose limits for occupationally exposed individuals	2	C	2	1,2
8.	Techniques for limiting radiation doses to personnel	2	C	2	1,2,3
9.	Spontaneous mutation rate , effect of radiation on skin and blood forming organs, digestive tract – sterility and cataract formation	2	C	2	1,2
10.	Effects of chronic exposure to radiation	1	C	2	1,2
	UNIT III: Radiation Protection in Nuclear Medicine and Oncology	**9**			
11.	Nuclear medicine, diagnostic & therapeutic nuclear medicine	2	C	3	2
12.	Positron Emission Tomography (PET), special considerations for handling PET, intensity modulated radiation therapy	2	C	3	1,2
13.	Facility design, radiation protection of nuclear medicine staff	2	C,D	3	1,2,3
14.	Radiation oncology, external beam shielding, brachytherapy, low-dose-rate brachytherapy	2	C	3	1,2
15.	Radiation hazards in brachytherapy departments and teletherapy departments and radioisotope laboratories – Particle accelerators	1	C	3	1,2

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	UNIT IV: Radiation Protection in Diagnostic Radiology	**9**			
16.	Definition of free radicals and G-value, kinetics of radiation chemical transformations , LET and dose-rate effects	1	C	4	2,3
17.	Safety assessment, facility design and shielding-BIR shielding method	3	C	4	3
18.	Teletherapy machines: reference conditions for measurement, Type of ion chambers, phantom, waterproof sleeve	3	C	4	2,3
19.	Unintended and accidental medical exposures, pregnancy procedures, Magnetic Resonance Imaging safety issues	1	C	4	2,3
20.	Derivation of an expression for machine timing error, procedure for evaluation of temperature and pressure correction	2	C	4	1,2,3
	UNIT V: Radiation Hazards and Protective Measures	**9**			
21.	Planning of medical radiation installations - general considerations, design of diagnostic, deep therapy, telegamma and accelerator installations, brachytherapy facilities and medical radioisotope laboratories	2	C	5	2,3
22.	Evaluation of radiation hazards in medical diagnostic, therapeutic installations	2	C	5	2,3
23.	Radiation monitoring procedures – protective measures to reduce radiation , exposure to staff and patients, protective equipment – Handling of patients	2	C	5	2,3
24.	Radiation accidents in medicine , the role of recommendations and regulations	2	C	5	2,3
25.	Waste disposal facilities , radiation safety during source transfer operations, special safety features in accelerators, reactors	1	C	5	2,3
	Total contact hours	**45 (Exclusive of assessment hours)**			

LEARNING RESOURCES	
Sl.No.	**TEXT BOOKS**
1.	Mary Alice StatkiewiczSherer, Paula J. Visconti, E. Russell Ritenour, Kelli Haynes, "*Radiation Protection in Medical Radiography*", CRC Press, 7th edition, 2008.
2.	Richard J. Vetter,Magdalena S. Stoeva, *"Radiation protection in Medical imaging and Radiation oncology"*, CRC Press,Taylor and franics group, 1st edition, 2016.
3.	GopalB.Saha, "*Physics and Radiobiology of Nuclear Medicine"*, Springer, 3rdedition, 2006.
	REFERENCE BOOKS/OTHER READING MATERIAL
4.	Max H Lombardi, "*Radiation Safety in Nuclear Medicine"*, CRC Press, 2ndedition, 2007.
5.	DanielFarb, Bruce Gordan, "*Occupational Radiation Safety Guidebook"*, University of Health Care, 2005.
6.	Robert J. Emery and Janelle Rios, "*Operational Radiation Safety"*, Vol. 110, No. 2, February 2016.
7.	B.H Brown , PV Law ford, R H Small wood , D R Hose , D C Barber , "*Medical Physics and Biomedical Engineering*", CRC Press, 1999 .
8.	Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards, IAEA Standards, http://www-pub.iaea.org/MTCD/publications/PDF/Pub1578_web-57265295.pdf.

Course nature				**Theory**			
Assessment Method (Weightage 100%)							
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Cycle Test III	Surprise Test	Quiz	**Total**
	Weightage	**10%**	**15%**	**15%**	**5%**	**5%**	**50%**
					End semester examination Weightage :		**50%**

15BM336E	X-Ray Imaging and Computed Tomography	L	T	P	C
		3	0	0	3
Co-requisite:	NIL				
Prerequisite:	NIL				
Data Book / Codes/Standards	NIL				
Course Category	P PROFESSIONAL ELECTIVE	BIOMEDICAL INSTRUMENTATION			
Course designed by	Department of Biomedical Engineering				
Approval	32nd Academic Council Meeting held on 23rd July 2016				

PURPOSE	The purpose of learning this course on x-ray and computed tomography for biomedical engineering students is to acquire in-depth knowledge in the X-ray and computed tomographic techniques and instrumentation

INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able to								
1.	Acquire knowledge in advanced techniques in X-ray imaging	a	k					
2.	Understand the performance of mammography and its imaging techniques	a	k					
3.	Describe the modern developments in the field of radiology	a	k					
4.	Illustrate the advancements in tomographic imaging	a	k					
5.	Apply associated imaging techniques in X-ray computed tomography	a	b					

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	UNIT I: X-Ray	**9**			
1.	Projection radiography	3	C	1	1
2.	Screen film radiography	2	C	1	1
3.	Computed radiography, digital radiography	2	C	1	1
4.	Dual energy radiography, X-ray contrast agents	2	C	1	1
	UNIT II: Mammography	**9**			
5.	Mammography: X-ray tube, beam filtration	2	C	2	1
6.	X-ray generator and photo timer system	2	C	2	1
7.	compression, scattered radiation and magnification	2	C	2	1
8.	Digital mammography, colour X-ray imaging	3	C	2	1
	UNIT III: Specialized X-Ray Techniques	**9**			
9.	Fluoroscopy: Imaging chain components, detector systems	2	C	3	1
10.	Modes of operation and automatic exposure control	2	C	3	1
11.	Digital subtraction angiography	2	C	3	1
12.	Single photon counting x-ray detectors in medical imaging	2	C	3	1
13.	Image quality and artifacts	1	C	3	1
	UNIT IV: Advanced CT	**9**			
14.	Slip ring technology, Helical CT-instrumentation	2	C	4	2,3
15.	Multislice CT, detector configuration, multislice helical configuration	3	C	4	2,3
16.	Cone beam CT, isotropic imaging	2	C	4	2,3
17.	Dual source and dual energy CT	2	C	4	2,3
	UNIT V: Special Applications	**9**			
18.	Quantitative CT, phase selective imaging of heart	2	C	5	2,3
19.	3D reconstruction: technical aspects, rendering techniques	3	C	5	3
20.	Features of dedicated breast CT scanner	2	C	5	2
21.	Quality control of CT scanners, future of CT	2	C	5	2,3
	Total contact hours	**45 (Exclusive of assessment hours)**			

LEARNING RESOURCES	
Sl. No.	**TEXT BOOKS**
1.	Jerrold T. Bushberg, John M. Boone, Lippincott Williams & Wilkins, "*The Essential Physics of Medical Imaging*", Lippincott Williams and Wilkins, 3rd edition, 2011.
2.	Willi A. Kalender, '*Computed Tomography: Fundamentals, System Technology, Image Quality, Applications*', John Wiley & Sons, 3rd edition, 2011.
3.	Euclid Seeram, "*Computed Tomography: Physical Principles, Clinical Applications, and Quality Control"*,Elsevier Health Sciences, 4th edition,2015.
	REFERENCE BOOKS/OTHER READING MATERIAL
4.	Nadine Barrie Smith, Andrew Webb, "*Introduction to Medical Imaging: Physics, Engineering and Clinical Applications*", Cambridge University press, 1st edition, 2011.
5.	Peter Morris, "*Biomedical Imaging: Applications and Advances"*, Wood head, 1st edition, 2014

Course nature				**Theory**			
Assessment Method (Weightage 100%)							
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Cycle Test III	Surprise Test	Quiz	**Total**
	Weightage	**10%**	**15%**	**15%**	**5%**	**5%**	**50%**
					End semester examination Weightage :		**50%**

15BM337E	Bone Densitometry	L	T	P	C
		3	0	0	3
Co-requisite:	NIL				
Prerequisite:	NIL				
Data Book / Codes/Standards	NIL				
Course Category	P PROFESSIONAL ELECTIVE	BIOMEDICAL INSTRUMENTATION			
Course designed by	Department of Biomedical Engineering				
Approval	32nd Academic Council Meeting held on 23rd July 2016				

PURPOSE	The purpose of learning this course on bone densitometry for biomedical engineering students is to acquire knowledge in various techniques in bone densitometry and the management of osteoporosis

INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able to								
1.	Explain the basic densitometry techniques	a						
2.	Describe the functions and effects of skeletal anatomy and performance of DXA	a	c					
3.	Explain the basic functions of various densitometer devices	a	c	e				
4.	Illustrate the analysis of morphometry and imaging techniques	a	e	k				
5.	Understand the guidelines and the management of osteoporosis	a	f					

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	UNIT I: Densitometry Techniques	**9**			
1.	Introduction, qualitative morphometry, quantitative morphometric techniques	2	C	1	1,2
2.	Radiographic absorptiometry	1	C	1	1,2
3.	Photon absorptiometry techniques	4	C	1	1,2
4.	Quantitative ultrasound bone densitometry	2	C	1	1,2
	UNIT II: Skeletal Anatomy and Performance of DXA in Densitometry	**9**			
5.	The spine in densitometry, PA lumbar spine study	3	C	2	1,2
6.	Proximal femur in densitometry, proximal femur study	3	C	2	1,2
7.	Forearm in densitometry, forearm study metacarpals, phalanges and calcaneus	3	C	2	1,2
	UNIT III: Densitometers	**9**			
8.	Computer enhanced radiographic absorptiometry	1	C	3	2,3
9.	Central X-ray densitometers	4	C	3	2,3
10.	Peripheral X-ray densitometers	2	C	3	2,3
11.	Ultrasound bone densitometers	2	C	3	2,3
	UNIT IV: Morphometry, Hip and Body Composition Analysis	**9**			
12.	Vertebral fracture imaging, diagnosis of vertebral fractures, spine imaging with DXA	2	C,D	4	1
13.	Proximal femur morphometry, fracture risk assessment tool	2	C,D	4	1
14.	Hip structural analysis	2	C,D	4	1
15.	Body composition methods , two compartment and three compartment measurement techniques	3	C,D	4	1
	UNIT V: Management of Osteoporosis	**9**			
16.	Evaluation of postmenopausal osteoporosis	2	C	5	4
17.	Role of biochemical markers	1	C	5	4
18.	Guidelines in the management of postmenopausal osteoporosis	2	C	5	4
19.	Surgical management of spine and hip	4	C	5	4
	Total contact hours	**45 (Exclusive of assessment hours)**			

LEARNING RESOURCES	
Sl. No.	**TEXT BOOKS**
1.	Sydney Lou Bonnick, Lori Ann Lewis, "*Bone Densitometry for Technologists*", Springer, 3rd edition, 2013.
	REFERENCE BOOKS/OTHER READING MATERIAL
2.	Dale W Stovall, "*Osteoporosis: Diagnosis and Management*", Wiley Blackwell, 1st edition, 2013.
3.	Sydney Lou Bonnick, Lori Ann Lewis, "*Bone Densitometry for Technologists"*, Humana Press, 2nd edition,2006.
4.	Meeta, "*Post Menopausal Osteoporosis: Basic and Clinical Concepts*", Jaypee Brothers Medical Publishers (p) Ltd, 1st edition,2013.

Course nature				**Theory**			
Assessment Method (Weightage 100%)							
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Cycle Test III	Surprise Test	Quiz	**Total**
	Weightage	**10%**	**15%**	**15%**	**5%**	**5%**	**50%**
					End semester examination Weightage :		**50%**

15BM338E	MRI and its Clinical Applications	L	T	P	C
		3	0	0	3
Co-requisite:	NIL				
Prerequisite:	NIL				
Data Book / Codes/Standards	NIL				
Course Category	P PROFESSIONAL ELECTIVE	BIOMEDICAL INSTRUMENTATION			
Course designed by	Department of Biomedical Engineering				
Approval	32nd Academic Council Meeting held on 23rd July 2016				

PURPOSE	The purpose of learning this course on MRI and its clinical applications for biomedical engineering students is to provide the fundamental concepts of the equipment, various measurement parameters and its application in medical diagnostics

INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able to								
1.	Explain the basic concepts of Magnetic resonance(MR)	a						
2.	Illustrate various types of MR equipments design and its process	a	c					
3.	Summarize various measurement parameters and contrast agents	a	e					
4.	Analyze the topics on suppression ,artifacts and its reduction techniques	a	e	f	g			
5.	Explain various application of MRI on different parts of body and latest add on technology, functional MRI	a	k					

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	UNIT I: Physics of Magnetic Resonance	**9**			
1.	Concepts of magnetic resonance	2	C	1	1,2,3
2.	Principles of magnetic resonance imaging	2	C	1	1,2,3
3.	Production of net magnetization	2	C	1	1,2,3
4.	Relaxation, pulse sequences	3	C	1	1,2,3
	UNIT II: MRI System	**9**			
5.	Magnet systems, gradient systems, radiofrequency systems, computer systems	3	C,D	2	1,2,3
6.	Types of MRI system: closed, open, wide portable, standing or sitting and installation	3	C,D	2	1,2,3
7.	Data acquisition: K-space, image reconstruction	3	C,D	2	1,2,3
	UNIT III: Measurement Parameters and Image Contrast	**9**			
8.	Intrinsic parameters, extrinsic parameters	2	C,D	3	1,2,3
9.	Magnetic Resonance Imaging tissue parameters, molecular spin relaxation	3	C,D	3	1,2,3
10.	Parameter trade offs	2	C,D	3	1,2,3
11.	Intravenous agents, oral agents	2	C,D	3	1,2,3
	UNIT IV: Signal Suppression Techniques, Artifacts and Motion Artifact Reduction Techniques	**9**			
12.	Spatial pre-saturation, magnetization transfer suppression,	2	C,D	4	1,2,3,8
13.	Frequency-selective saturation, non-saturation methods	2	C,D	4	1,2,3,8
14.	Motion artifacts, sequence/protocol-related artifacts, external artifacts	2	C,D	4	1,2,3,8
15.	Acquisition parameter modification, triggering	2	C,D	4	1,2,3,8
16.	Flow compensation, radial-based motion compensation	1	C,D	4	1,2,3,8
	UNIT V: Current Technology and Applications	**9**			
17.	Magnetic resonance angiography :time-of-flight, phase contrast	2	C,D,I	5	4,10
18.	Magnetic resonance spectroscopy, ultra-high field spectroscopy	2	C,D,I	5	4,10
19.	Review applications of MRI in medicine: neurology, musculoskeletal, cardiology	2	C,I	5	4,6,7,10
20.	Application of MRI in gastrointestinal tract, peritoneal cavity, liver	1	C,I	5	5,8,9

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
21.	Functional magnetic resonance imaging and its application	2	C,I	5	12
	Total contact hours	**45 ((Exclusive of assessment hours)**			

LEARNING RESOURCES	
Sl. No.	**TEXT BOOKS**
1.	Brian M. Dale, Mark A. Brown, Richard C. Semelka,"*MRI: Basic Principles and Applications*", Wiley-Blackwell, 5th edition, 2015.
2.	Christakis Constantinides, "*Magnetic Resonance Imaging: The Basics*", CRC Press,2014.
3.	Rakesh K. Gupta, Sunil Kumar, "*Magnetic Resonance Imaging of Neurological Diseases in Tropics*", Wiley-Blackwell, 1stedition, 2013.
	REFERENCE BOOKS/OTHER READING MATERIAL
4.	Richard C. Semelka, Michele A. Brown, ErsanAltun, "*Abdominal-Pelvic MRI*", Wiley-Blackwell, 4thedition, 2015.
5.	ImanBeheshti,HasanDemirel, "*Feature-ranking-based Alzheimer's disease classification from structural MRI*", Journal of Magnetic Resonance Imaging,Elsevier, 2016.
6.	Peter Rinck, *"Magnetic Resonance in Medicine*",Wiley-Blackwell,4threvised edition, 2001.
7.	Dwight G Nishimura, "*Principles of Magnetic Resonance Imaging*", 1stedition, Stanford Univ.,2010.
8.	Catherine Westbrook, "Handbook of MRI Technique", Wiley-Blackwell,4th edition,2014.
9.	Markus Rokitta, Eberhard Rommel, Ulrich Zimmermann ,Axel Haase**, "***Portable nuclear magnetic resonance imaging system*", Rev. Sci. Instrum.,2000.
10.	Scott A. Huettel, Allen W. Song, Gregory McCarthy, *"Functional Magnetic Resonance Imaging"*, 2ndedition, Sinauer Associates,2014.

Course nature				**Theory**			
Assessment Method (Weightage 100%)							
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Cycle Test III	Surprise Test	Quiz	**Total**
	Weightage	**10%**	**15%**	**15%**	**5%**	**5%**	**50%**
					End semester examination Weightage :		**50%**

15BM339E	Neurorehabilitation and Human Machine Interface	L	T	P	C
		3	0	0	3
Co-requisite:	NIL				
Prerequisite:	NIL				
Data Book / Codes/Standards	NIL				
Course Category	P PROFESSIONAL ELECTIVE	REHABILITATION ENGINEERING			
Course designed by	Department of Biomedical Engineering				
Approval	32nd Academic Council Meeting held on 23rd July 2016				

PURPOSE	The purpose of learning this course on Neurorehabilitation and Human Machine Interfacefor biomedical engineering students is to provide knowledge of several advanced concepts and topics in the rapidly evolving field of neurorehabilitation and human machine interface

INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able to								
1.	Explain the basic growth responses of neurons with cellular and molecular mechanism	a						
2.	Analyze the plasticity of cerebral motor function	a	c					
3.	Summarize the role of inflammatory response in central nervous system	a						
4.	Illustrate the future perspective of human machine interface (HMI)	a	d	e				
5.	Explain the motor recovery and compensation in neurorehabilitation	a	d	e				

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	UNIT I: Neural Plasticity: Cellular and Molecular Mechanisms	**9**			
1.	Learning and memory: basic principles and model systems	3	C	1	1,2,6
2.	Cellular and molecular mechanisms of associative and non-associative learning	3	C	1	1,2,6
3.	Degenerative changes and reactive growth responses of neurons following denervation and axotomy	3	C	1	1,2,6
	UNIT II: Functional Plasticity in the Central Nervous System	**9**			
4.	Plasticity of mature and developing somatosensory systems	3	C	2	1,2
5.	Activity-dependent plasticity in the intact spinal cord	3	C	2	1,2
6.	Plasticity of cerebral motor functions: Implications for repair and rehabilitation	3	C	2	1,2
	UNIT III: Determination of Regeneration in the Injured Nervous System	**9**			
7.	Non-mammalian models of nerve regeneration	3	C	3	1,2,6
8.	Myelin-associated axon growth inhibitors, Inhibitors of axonal regeneration	3	C	3	1,2,6
9.	Role of the inflammatory response in central nervous system injury and regeneration	3	C	3	1,2,6
	UNIT IV: Ambient Intelligence and Ubiquitous Computing Scenario	**9**			
10.	The advanced human machine interface (HMI) framework	2	C	4	1,5
11.	Human machine interface systems – structure, protocols, applications	2	C,I	4	1,5
12.	The next-generation advanced HMI	2	C,I	4	1,5
13.	A future perspective for next-generation HMI: fNIRS-EEG Multi-Modal HMI.	3	C,I	4	1,5
	UNIT V: Translational Research: Application in Human Machine Interface	**9**			
14.	Biomimetic design of neural prosthesis	2	C,D	5	1,7
15.	Brain responses to neural prosthesis	2	C	5	1,7

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
16.	Intracranial human machine interfaces for communication and control	2	C,I	5	1,7
17.	Understanding motor recovery and compensation in neurorehabilitation	3	C,I	5	1,7
	Total contact hours	**45 (Exclusive of assessment hours)**			

LEARNING RESOURCES	
Sl. No.	**TEXT BOOKS**
1.	Michael E. Seizer, Stephanie Clarke, Lenardo G. Cohen. GertKwakkel, Robert H. Miller., "*Textbook of Neural repair and rehabilitation",* Volume 1-Neural repair and Plasticity", Cambridge university press, 2nd edition, 2014.
2.	Jose L Pons, Diego Torricelli,"*Textbook of Neural repair and rehabilitation",* Springer, 1stedition,2014.
	REFERENCE BOOKS/OTHER READING MATERIAL
3.	Surjo R. Soekadar, NielsBirbaumer, Marc W. Slutzky, Leonardo G. Cohen., "*Brain- machine interfaces in neurorehabilitation of stroke*', Neurobiology of disease, 2015.
4.	F. Nijboer, "*Technology transfer of brain-computer interfaces as assistive techno logy: Barriers and opportunities*", Annals of physical and Rehabilitation Medicine, 2015.
5.	U.Chaudhary, N. Birbaumer, M.R.Curado., *"Brain-machine interface (BMI) in paralysis*", Annals of physical and rehabilitation medicine, 2015.
6.	D.D. Franks and J.H. Turner., "*Handbook of Neurosociology"*, Springer, 1stedition, 2013.
7.	Jose L Pons, Diego Torricelli, Marta Pajaro., "*Converging clinical and engineering research on neurorehabilitation*", Springer, 1stedition, 2013.

Course nature				**Theory**			
Assessment Method (Weightage 100%)							
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Cycle Test III	Surprise Test	Quiz	**Total**
	Weightage	**10%**	**15%**	**15%**	**5%**	**5%**	**50%**
					End semester examination Weightage :		**50%**

15BM340E	Introduction to Telemedicine	L	T	P	C
		3	0	0	3
Co-requisite:	NIL				
Prerequisite:	NIL				
Data Book / Codes/Standards	NIL				
Course Category	P PROFESIONAL ELECTIVE TELEMEDICINE				
Course designed by	Department of Biomedical Engineering				
Approval	32nd Academic Council Meeting held on 23rd July 2016				

PURPOSE	The purpose of learning this course on introduction to telemedicine for biomedical engineering students is to acquire knowledge on the basic concepts of telemedicine and the technology used in healthcare system

INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able to								
1.	Explain the development and transmission techniques used in telemedicine	a						
2.	Describe thetypes of communication and network systems	a						
3.	Explain the technologies used in data exchange and privacy of telemedicine	a	c	f				
4.	Illustrate the current system of tele-health and mobile health	a	f	g				
5.	Describe the currents and futures perspective of telemedicine	b	h	i	k			

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	UNIT I: Background of Telemedicine	**9**			
1.	Introduction ,definitions of telemedicine, telehealth and telecare	1	C	1	1,2,3
2.	Origins and development of telemedicine: from beginning to modern times, modern telemedicine and telecare	2	C	1	1,2,3
3.	Drivers of telemedicine and telecare: technology drivers, non technological drivers, the funding dilemma	2	C	1	1,2,3
4.	Telemedicine in developed and underdeveloped countries ,benefits and limitations of telemedicine	2	C	1	1,2,3
5.	Types of information and transmission in telemedicine: audio, video, still images, text and data, Fax	2	C	1	1,2,3
	UNIT II: Communication and Network Systems in Telemedicine	**9**			
6.	Types of communication and network: public switched telephone network, plain old telephone service, integrated services digital network, internet, asynchronous transfer mode	2	C	2	1,2,3,5
7.	Wireless communications basics and its types	2	C	2	1,2,3,5
8.	Wireless sensor standards and homecare concerns, medical sensors for mobile communication devices	2	C	2	1,2,3,5
9.	Development of disposable adhesive wearable human monitoring system	1	C	2	1,2,3,5
10.	Implantable systems: implantable system architecture	1	C,D	2	1,2,3,5
11.	Signal Processing in implantable neural recording microsystems, electronic health signal processing	1	C,D	2	1,2,3,5
	UNIT III: Technologies for Safeguarding Medical Data and Privacy	**9**			
12.	Data Exchanges: Network configuration, circuit and packet switching, H.320 series	2	C	3	1,2,3
13.	Data security and standards: Encryption, cryptography, mechanisms of encryption, phases of encryption	3	C	3	1,2,3
14.	Cryptography, safeguarding patient medical history	2	C	3	1,2,3
15.	Anonymous data collection and processing, biometric security and identification	2	C	3	1,2,3

	UNIT IV: Telehealth and Mobile Health	**9**			
16.	Medical robotics: surgical robots, rehabilitation robots	2	C	4	1,2,3
17.	Modern devices for tele-surgery: Main component and functionalities of a robotics tele-surgery System, design guidelines and methodology	2	C,D	4	1,2,3
18.	Microsurgery Systems: Robot-assisted microsurgery system,miniaturization, microsurgical tools, visualization methods and systems	3	C,D	4	1,2,3
19.	Image-guided microsurgery: Image guidance component and workflow, image guidance by surgical domain	2	C,D	4	1,2,3
	UNIT V: Implementation of Telemedicine and Future Trends in Technology	**9**			
20.	Telecardiology: Tools and devices	2	C	5	1,2,4,6
21.	Teleradiology and Tele-audiology	2	C	5	1,2,4,6
22.	Telepathologysystem development and implementation	2	C	5	1,2,4,6
23.	Acute care telemedicine and monitoring for elderly care	1	C	5	1,2,4,6
24.	Virtual doctor systems for medical practices, wireless electrical impedance tomography	1	C	5	1,2,4,6
25.	Synthetic biometrics in biomedical systems, bio-kinematics for mobility	1	C	5	1,2,4,6
	Total contact hours	**45(Exclusive of assessment hours)**			

LEARNING RESOURCES	
Sl. No.	**TEXT BOOKS**
1.	Bernard Fong, A.C.M. Fong, C.K. Li, "*Telemedicine Technologies: Information Technologies in Medicine and Telehealth",* Wiley, 1st edition, 2010.
2.	HalitEren, John G. Webster, *"The E-Medicine, E-Health, M-Health, Telemedicine, and Telehealth Handbook*", CRC Press,1st edition, 2015.
3.	Olga Ferrer-Roca, M.SosaLudicissa, "*Handbook of Telemedicine"*, IOS press,1st edition, 2002.
	REFERENCE BOOKS/OTHER READING MATERIAL
4.	GeorgiGraschew, Stefan Rakowsky, *"Telemedicine Techniques and Applications*", In Tech, 1st edition, 2011.
5.	A.C.Norris, "*Essentials of Telemedicine and Telecare*", John Wiley & Sons, 1st edition**,** 2002.
6.	Richard W. Carlson, "*Telemedicine in the ICU, An Issue of Critical Care Clinics, (The Clinics: Internal Medicine)"*, Elsevier, 1st edition, 2015.

Course nature				**Theory**			
Assessment Method (Weightage 100%)							
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Cycle Test III	Surprise Test	Quiz	**Total**
	Weightage	**10%**	**15%**	**15%**	**5%**	**5%**	**50%**
End semester examination Weightage :							**50%**

DEPARTMENT ELECTIVE VI

15BM422E	BioMEMS	L	T	P	C
		3	0	0	3
Co-requisite:	NIL				
Prerequisite:	NIL				
Data Book / Codes/Standards	NIL				
Course Category	P PROFESSIONAL ELECTIVE	MEDICAL ELETRONICS			
Course designed by	Department of Biomedical Engineering				
Approval	32nd Academic Council Meeting held on 23rd July 2016				

PURPOSE	The purpose of learning this course on BioMEMS for Biomedical Engineering students is to acquire knowledge about the principles & applications of MEMS in medical device miniaturization.

INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able to								
1.	Analyze the working principle of MEMS & Microsystems in healthcare domain	a						
2.	Explain the micro system fabrication processes and materials used for MEMS	a						
3.	Differentiate the various Micro manufacturing techniques	c						
4.	Analyze the working principle of Micro fluidic Systems	c						
5.	Illustrate the concepts ofBioMEMS with suitable examples	c	d					

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	UNIT I: MEMS and Microsystem	**9**			
1.	MEMS and microsystems- Introduction	1	C	1	1
2.	Typical MEMS and microsystem products - application of Microsystems in healthcare industry	1	C	1	1
3.	Working principles of microsystems: microsensors and microactuators	3	C	1	1
4.	MEMS with microactuators - application	2	C	1	1
5.	Micro-accelerators, examples of biomedical microsensors and microactuators	2	C	1	1,15
	UNIT II: MEMS Materials and Fabrication Processes	**9**			
6.	Substrates and wafers, silicon as a substrate material	2	C	2	1
7.	Silicon compounds, silicon piezoresistor, gallium arsenide, quartz, piezoelectric crystals, polymers, packaging materials	3	C	2	1
8.	Photolithography, ion implantation	1	C	2	1
9.	Diffusion, oxidation	1	C	2	1
10.	Chemical vapor deposition (CVD), Physical vapor deposition (PVD), epitaxy, etching	2	C	2	1
	UNIT III: Overview of Micromanufacturing	**9**			
11.	Bulk micro manufacturing -isotropic and anisotropic etching	2	C	3	1,8
12.	Dry and wet etching techniques	3	C	3	1,8
13.	Surface micromachining description	2	C	3	1,8
14.	LIGA process description	2	C	3	1
	UNIT IV: Microfluidic Systems	**9**			
15.	Microfluidics- fluid Properties, applications of microfluidic systems in biomedical domain	2	C	4	2
16.	Fluid actuation methods	3	C	4	2,3,4,8,13
17.	Microfluidic channel, microdispenser	1	C	4	2,12,13
18.	Microneedle, microfilter	1	C	4	10,12
19.	Microseparator, microreactor, micromixer	2	C	4	12,13
	UNIT V: BioMEMS	**9**			
20.	Introduction to BioMEMS, BioMEMS for clinical monitoring	1	C	5	3,6,7,9

21.	DNA Sensors, Lab on a chip, Micro total analysis systems	3	C	5	2,3,4,6
22.	Microarrays, microsystem approaches to PCR	2	C	5	5,6
23.	MEMS based implantable drug delivery system, mobile point of care monitors	2	C	5	4,6,10,11
24.	Current point of care technology	1	C	5	14
	Total contact hours	**45(Exclusive of assessment hours)**			

LEARNING RESOURCES	
Sl. No.	**TEXT BOOKS**
1.	Tai-Ran Hsu, "*MEMS & Microsystems- Design, Manufacture and Nanoscale Engineering*", John Wiley & Sons, 2nd edition 2008.
2.	Nitaigour PremchandMahalik, "MEMS", Tata McGraw Hill, 2nd reprint, 2008.
3.	Steven S.Saliterman, "*Fundamentals of BioMEMS & Medical Microdevices*", International Society for Optical Engineering, 1st edition, 2006.
	REFERENCE BOOKS/OTHER READING MATERIAL
4.	Ellis Meng, "*Biomedical Microsystems"*, CRC Press, 1st edition 2011.
5.	Simona Badilescu and Muthukumaran Packirisamy, "*BioMEMS Science and Engineering Perspectives"*, CRC Press, 1st edition 2011.
6.	Albert Folch, "*Introduction to BioMEMS"*, CRC Press, 1st edition 2013.
7.	Gerald A Urban, "BioMEMS", Springer, 1st edition 2006.
8.	Chang Liu, "*Foundations of MEMS"*, Prentice Hall, 2nd edition 2012.
9.	Abraham P. Lee and James L. Lee, "*BioMEMS and Biomedical Nanotechnology"*, Volume I, Springer, 1st edition 2006.
10.	Wanjun Wang & Steven A.Soper, "*BioMEMS- Technologies and applications"*, CRC Press, 1st edition 2007.
11.	Walter Karlen and Krzysztof Iniewski, "*Mobile Point-of-Care Monitors and Diagnostic Device Design"*, CRC Press, 1st edition 2015.
12.	Nam-Trung Nguyen & Steven T Wereley, "*Fundamentals and Applications of Microfluidics*", Artech House, 2nd edition, 2006.
13.	Dongqing Li, "*Encyclopedia of Microfluidics and Nanofluidics*", Springer, 1st edition, 2008.
14.	Chao-Min Cheng, Chen-MengKuan & Chien-Fu Chen, "*In-Vitro Diagnostic Devices: Introduction to Current Point of Care Diagnostic Devices*", Springer, 1st edition, 2016.
15.	Mel L. Mendelson, "*Learning Bio-Micro-Nanotechnology"*, CRC Press, 1st edition 2013.

Course nature				**Theory**			
Assessment Method (Weightage 100%)							
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Cycle Test III	Surprise Test	Quiz	**Total**
	Weightage	**10%**	**15%**	**15%**	**5%**	**5%**	**50%**
					End semester examination Weightage :		**50%**

15BM423E	Pattern Recognition and Expert Systems in Medicine	L	T	P	C
		3	0	0	3
Co-requisite:	NIL				
Prerequisite:	NIL				
Data Book / Codes/Standards	NIL				
Course Category	P PROFESSIONAL ELECTIVE	SIGNAL AND IMAGE PROCESSING			
Course designed by	Department of Biomedical Engineering				
Approval	32nd Academic Council Meeting held on 23rd July 2016				

PURPOSE	The purpose of this course on pattern recognition and expert systems in medicine for biomedical engineering students is to provide an adequate mastery of technical current trends in Artificial Intelligence and pattern recognition							
INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able to								
1.	Give an insight knowledge about the different types of pattern classification techniques	a	j					
2.	Explain concepts of structures, strategies and searching techniques in artificial intelligence	a	h					
3.	Describe and use the concepts of knowledge representation and reasoning in AI application	a	h					
4.	Describe about types and methods of learning	a						
5.	Analyze about the application of AI in medical field and use feature extraction based on clustering	e	d					

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	UNIT I: Classification of Patterns	**9**			
1.	Classes, patterns and features, pattern similarity and PR tasks, pattern discrimination	1	C	1	3,4
2.	Feature space metrics and covariance matrix, feature selection and extraction-methods	2	C,D	1	3,4
3.	Statistical, syntactic and descriptive approaches	2	C	1	3
4.	Bayesian classification, Bayes rule for minimum risk, minimum error rate classification	2	C	1	3
5.	Discriminant functions and decision surfaces, linear discriminant functions	2	C	1	3,4
	UNIT II: Intelligence and Searching	**9**			
6.	Artificial Intelligence components, problem definition, problem solving agents, state space search	2	C	2	1,2
7.	Uninformed search - depth first and breadth first search, DFS with iterative deepening	2	C	2	1,2
8.	Informed /heuristic search- best first search, A* Algorithm, AND – OR graphs	2	C,D	2	1,2
9.	Searching with partial information-online search agents and unknown environments	2	C,D	2	1,2
10.	Constraint satisfaction problems	1	C	2	1,2
	UNIT III: Knowledge and Reasoning	**9**			
11.	Logical agents, propositional calculus, syntax and semantics of first order logic, forward and backward chaining	2	C	3	1,2
12.	Resolution – theorem proving problems using resolution	1	C,D	3	1,2
13.	AI Representational schemes- semantic nets, conceptual graphs, using frames, using scripts	3	C,D	3	1,2
14.	Production system	1	C	3	1,2
15.	Rule based expert system	2	C,D	3	1,2
	UNIT IV: Learning Types and Methods	**9**			
16.	Classes, forms of learning, inductive learning	1	C	4	1,2

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
17.	Decision trees, learning using relevance information	2	C, D	4	1,2
18.	Statistical learning methods-EM algorithm	2	C	4	1,2
19.	Intelligence using neural networks	2	C,D,	4	1,2
20.	Reinforcement learning – passive and active reinforcement	2	C	4	1,2,5
	UNIT V: Applications in Medicine	**9**			
21.	Unsupervised clustering ,K means clustering ,Fuzzy C means clustering	1	C,D	5	3,4
22.	AI in diagnosis-ELISA model	2	C	5	3,4
23.	Biometrics in e-health security, face recognition	2	C	5	3,4
24.	Gene matching, automated drug delivery systems	2	C	5	3,4
25.	Mining of electronic health record, tumor boundary detection	2	C	5	3,4
	Total contact hours	**45(Exclusive of assessment hours)**			

LEARNING RESOURCES	
Sl. No.	**TEXT BOOKS**
1.	Stuart Jonathan Russell, Peter Norvig, "*Artificial Intelligence: A Modern Approach"*, Pearson, 3rd edition,2013.
2.	George.F.Luger, "*Artificial Intelligence- Structures and Strategies for Complex Problem Solving"*, Pearson, 4th edition, 2002.
3.	Anke Meyer-Bäse , "*Pattern Recognition for Medical Imaging"*, Elsevier, 1st edition, 2004.
	REFERENCE BOOKS/OTHER READING MATERIAL
4.	Rochard O. Duda and Hart P.E, and David G Stork, '*Pattern classification'*, John Wiley and Sons Inc., 2nd edition, 2001.
5.	Carlo Combi, Yuval Shahar; "*Artificial Intelligence in Medicine – 12th Conference"*, Springer, 2001.
6.	Svetlana N Yanushkevich , et al., "*Image Pattern Recognition Synthesis and Analysis in Biometrics*" Volume 67, World Scientific, 2007.

Course nature				**Theory**			
Assessment Method (Weightage 100%)							
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Cycle Test III	Surprise Test	Quiz	**Total**
	Weightage	**10%**	**15%**	**15%**	**5%**	**5%**	**50%**
End semester examination Weightage :							**50%**

15BM424E	Computational Methods for Signal and Image Processing			L	T	P	C
				3	0	0	3
Co-requisite:	NIL						
Prerequisite:	15BM304J, 15BM306J						
Data Book / Codes/Standards	NIL						
Course Category	P	PROFESSIONAL ELECTIVE	SIGNAL AND IMAGE PROCESSING				
Course designed by	Department of Biomedical Engineering						
Approval	32nd Academic Council Meeting held on 23rd July 2016						

PURPOSE	The purpose of learning this course on computational methods for signal and image processing for biomedical engineering students is to attain knowledge on the advanced methods in signal and image processing and understand how to apply these techniques for various medical images.

INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able to								
1.	Understand the fundamentals of time –frequency domain analysis and the concepts of wavelets	a	e	k				
2.	Acquire knowledge on the concepts of PCA and ICA	a	b	e	k			
3.	Illustrate the concept of morphological operations and algorithms used in medical images	a	b	k				
4.	Explain the image registration and image visualization algorithms	a	b	c	k			
5.	Describe the advanced signal and image processing techniques in medical imaging applications	a	b	c	k			

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	UNIT I: Introduction to Time - Frequency Domain Analysis	**9**			
1.	Introduction to wavelets, time frequency representation	2	C	1	1
2.	Short time Fourier transform: spectrogram, wigner-ville distribution	2	C	1	1
3.	Discrete wavelet transform, pyramid algorithm, comparison of Fourier transform and wavelet transform	2	C,D	1	1
4.	Dual tree complex wavelet transform, filter banks, wavelet packets	3	C	1	1
	UNIT II:PCA and ICA	**9**			
5.	Principal component analysis (PCA)-Introduction	2	C,D	2	1
6.	Order selection, data rotation, PCA evaluation	3	C	2	1
7.	Independent component analysis (ICA)	4	C	2	1
	UNIT III: Morphological Operations	**9**			
8.	Erosion and dilations, opening and closing, hit or miss transformations	2	C,D	3	1,5
9.	Some basic morphological algorithms- boundary extraction, hole filling, thinning ,thickening ,skeletons, pruning	3	C	3	1,5
10.	Morphological reconstructions, gray scale morphology	4	C	3	1,5
	UNIT IV: Image Registration and Visualization Algorithms	**9**			
11.	Registration-rigid registration and non rigid registration algorithms	3	C	4	3
12.	Registration of MRI and PET images, registration of MRI and CT images for clinical applications	5	C,D	4	3,4
13.	Image visualization-2D visualization, 3D visualization- surface and volume based display methods	1	C,D	4	3,4
	UNIT V: Advances in Medical Imaging Applications	**9**			
14.	Medical imaging in diagnosis of osteoporosis and estimation of individual bone fracture risk	2	C	5	2
15.	Diagnosis of diabetic retinopathy, diagnosis and treatment of spinal deformity	2	C	5	2

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
16.	Detecting and analyzing linear structures in biomedical images: A case study of corneal nerve fibres	2	C	5	2
17.	A case study approach in mammography image analysis	2	C	5	4,6
18.	Image fusion-pixel based methods	1	C	5	4
	Total contact hours	**45(Exclusive of assessment hours)**			

LEARNING RESOURCES	
Sl. No.	**TEXT BOOKS**
1.	John L.Semmlow, Benjamin griffel, "*Biosignal and medical image processing"*, CRC press, Taylor and francis group, 3rd edition 2014.
2.	G. Dougherty., "*Medical Image Processing-Techniques and Applications"*, Springer-Verlag, 1st edition, 2011.
	REFERENCE BOOKS/OTHER READING MATERIAL
3.	J. Hanjal, D. Hawkes, and D. Hill, "*Medical Image Registration"*, CRC press Taylor and francis group, 1st edition, 2001.
4.	M. A. Haidekker , "*Advanced Biomedical Image Analysis"*, Wiley, 1st edition, 2010.
5.	Rafael C, Gonzalez and Richard E. Woods, "*Digital Image Processing*", Pearson Education Asia, 3rd edition, 2007.
6.	Thomas M. Deserna, "*Biomedical image processing"*, springer berlin Heidelberg, 1st edition, 2011.

Course nature				**Theory**			
Assessment Method (Weightage 100%)							
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Cycle Test III	Surprise Test	Quiz	**Total**
	Weightage	**10%**	**15%**	**15%**	**5%**	**5%**	**50%**
End semester examination Weightage :							**50%**

15BM425E	Modeling and Designing of Bone and Dental Implants			L	T	P	C
				3	0	0	3
Co-requisite:	NIL						
Prerequisite:	NIL						
Data Book / Codes/Standards	NIL						
Course Category	P	PROFESSIONAL ELECTIVE	SIGNAL AND IMAGE PROCESSING				
Course designed by	Department of Biomedical Engineering						
Approval	32nd Academic Council Meeting held on 23rd July 2016						

PURPOSE	The purpose of learning this course on modeling and designing of bone and dental implants for biomedical engineering students is to acquire knowledge and apply modeling and designing concepts in bone and its implants.							
INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able to								
1.	Explain the basic of Finite element analysis	a	b	c				
2.	Describe the types of elements and apply in different conditions	a	b	c				
3.	Explain the modeling of bone	a	b	c	e			
4.	Illustrate the modeling properties and design the various implants	a	b	c	d	e		
5.	Apply the processing steps and operations involved in finite element modeling	a	b	c	e	g	h	

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	UNIT I: Basics of Finite Element Analysis	**9**			
1.	Introduction, basic equations in elasticity, matrix displacement formulation	3	C,D	1	1
2.	Element shapes, nodes, nodal unknowns and coordinate systems	4	C,D	1	1
3.	Shape functions, one dimensional, two dimensional, three dimensional polynomial shape functions	2	C,D	1	1
	UNIT II: Types of Elements in FEA	**9**			
4.	Strain displacement matrix , bar element, constant strain triangle element	3	C,D	1,2	1,3
5.	Linear elements, quadratic elements, analysis of one dimensional problem	3	C,D	1,2	1,3
6.	Rectangular elements, linear triangular elements, quadratic triangular elements	3	C,D	1,2	1,3
	UNIT III: Modeling of Bone Implants	**9**			
7.	Basic segmentation, advanced segmentation of lower and upper extremity bone	3	C,D	1,2,3	1,3
8.	3D modeling of shoulder, 3D modeling of Spine	3	C,D	1,2,3	1
9.	Segmentation and meshing of femur	3	C,D	1,2,3	1
	UNIT IV: Modeling and Designing of Dental Implants	**9**			
10.	Modeling and designing of dental implants	3	C,D,I	1-4	1-3
11.	Modeling and designing of hip implants	3	C,D,I	1-4	1-3
12.	Modeling and designing of knee implants	3	C,D,I	1-4	1-3
	UNIT V: Finite Element Modeling	**9**			
13.	Introduction, modeling operations, boolean operations, additional operations	3	C,D,I	1-5	1-3
14.	Preprocessing and post processing steps in Finite element analysis	2	C,D,I,O	1-5	1
15.	Finite element modeling of femur bone and spine	4	C,D,I,O	1-5	1
	Total contact hours	**45(Exclusive of assessment hours)**			

LEARNING RESOURCES	
Sl. No.	**TEXT BOOKS**
1.	S.S. Bhavikati, "*Finite element analysis"*, New Age International Ltd, 1st edition, 2005.
	REFERENCE BOOKS/OTHER READING MATERIAL
2.	Mimics Student edition Course book, 2010.
3.	Saeedmoaveni, "*Finite element analysis theory and application with ANSYS"*, Prentice hall, 3rd edition, 2007.
4.	Erdogan Madenci, Ibrahim Guven, "*The finite element method and applications in engineering using Ansys*", Springer, 1st edition, 2006.

Course nature				**Theory**			
Assessment Method (Weightage 100%)							
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Cycle Test III	Surprise Test	Quiz	**Total**
	Weightage	**10%**	**15%**	**15%**	**5%**	**5%**	**50%**
					End semester examination Weightage :		**50%**

15BM426E	Nuclear Imaging	L	T	P	C
		3	0	0	3
Co-requisite:	NIL				
Prerequisite:	NIL				
Data Book / Codes/Standards	NIL				
Course Category	P PROFESSIONAL ELECTIVE	BIOMEDICAL INSTRUMENTATION			
Course designed by	Department of Biomedical Engineering				
Approval	32nd Academic Council Meeting held on 23rd July 2016				

PURPOSE	The purpose learning this course on nuclear imaging for biomedical engineering students is to enable the students to learn the basic principles of different imaging modalities used in nuclear medicine.

INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able to								
1.	Understand the basic science of nuclear medicine, operating principles and quality control aspects of various nuclear medicine equipment	a						
2.	Gain knowledge about various detectors and nuclear imaging technique used in nuclear medicine	a	c					
3.	Study the basic principle of imaging modalities in nuclear imaging medicine	a	c					
4.	Understand the principle and design of emission tomography ,tomography used in clinical application	a						
5.	Study the radiation safety and usage of radiopharmaceuticals in nuclear medicine	a						

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	UNITI: Introduction to Nuclear Medicine	**9**			
1.	Radioactive decay : radioactive law, radioactive process	1	C	1	1,2,3
2.	Decay process : units of radioactivity measurement and successive decay equations	2	C	1	1,2,3
3.	Statistics of counting and interaction of radiation with matter	1	C	1	1,2,3
4.	Methods of radionuclide production: nuclear reactor, medical cyclotron and radionuclide generators	3	C	1	1,2,3
5.	Spectra of commonly used radio nuclides and problems in radiation measurements	2	C	1	1,2,3
	UNIT II: Detector and Application	**9**			
6.	Types detector : pulse current mode operation	1	C	3	1,2,3,4
7.	Gas Filled detector: basics principle and ionizing chamber	1	C	3	1,2,3,4
8.	Scintillation Detectors: Inorganic crystalline scintillator in radiology	2	C	3	1,2,3,4
9.	Solid state detector and scintillation counting system	1	C	3	1,2,3,4
10.	Gamma Ray Spectrometry and radionuclide dose calibrator, Properties of detectors	2	C	3	1,2,3,4
11.	In Vitro techniques: Introduction, single and double isotope method, radioimmunoassay and RIA counting system	1	C	3	1,2,3,4
12.	In vivo techniques: general principle, uptake monitoring system, rectilinear, computer interface and performance parameter	1	C	3	1,2,3,4
	UNITIII: Nuclear Medicine in Imaging	**9**			
13.	Planar nuclear imaging: introduction to anger scintillation camera	1	C	4	1,2,5
14.	Design and principles of operation: anger scintillation camera and principle of image formation	2	C	4	1,2,5
15.	Design factors determining performance	2	C	4	1,2,5
16.	Effect of scatter and attenuation on projection image, operation and routine quality controls	1	C	4	1,2,5

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
17.	System spatial resolution and efficiency	1	C	4	1,2,5
18.	Computer in nuclear imaging :Image acquisition, frame mode acquisition and list mode acquisition	2	C	4	1,2,5
	UNITIV: Emission Tomography Techniques and Clinical Applications	**9**			
19.	Introduction, principles and applications of SPECT	2	C	5	1,4,5
20.	Principles and applications of PET	1	C	5	1,4,5
21.	System performance parameters and quality control functions	1	C	5	1,4,5
22.	Introduction to hybrid modalities: PET/CT, SPECT/CT	3	C	5	1,4,5
23.	Clinical applications**:** clinical applications of PET, SPECT and hybrid modalities in cardiology, neurology and oncology	2	C	5	1,4,5
	UNIT-V Radio Radiopharmaceuticals and Radiation Safety	**9**			
24.	Introduction to ideal radiopharmaceuticals and methods of radio labeling	1	C	2	1,2,3
25.	Internal radiation dosimetry: absorbed dose calculations to target and non-target tissues	2	C	2	1,2,3
26.	Medical Internal Radiation Dose (MIRD) methodology	1	C	2	1,2,3
27.	Radiation safety**:** natural and artificial radiation exposure	1	C	2	1,2,3
28.	External and internal radiation hazard and methods of minimizing external and internal exposure	2	C	2	1,2,3
29.	Evaluation of external and internal hazard	1	C	2	1,2,3
30.	Radioactive management and radioactive waste management and ethics in nuclear medicine	1	C	2	1,2,3
	Total contact hours	**45(Exclusive of assessment hours)**			

LEARNING RESOURCES	
Sl. No.	**TEXT BOOKS**
1.	Jerold T. Bushhery, J. Antony Siebert, Edwin M. Leidholdt, John M Boone, "*The Essential Physics of Medical Imaging*", Lippincott Williams and Wilkins, 4th edition 2014.
2.	M.A. Flower, "*Webb's Physics of Medical Imaging",* Taylor and Francis, 3rd edition, 2013.
	REFERENCE BOOKS/OTHER READING MATERIAL
3.	J. Harbert and A.F.G. Rocha, Lea and Fibiger, "*Textbook of Nuclear medicine"*,2nd edition, 2009.
4.	B.R. Bairi, Balvinder Singh, N.C. Rathod and P.V. Narurkar" *Handbook of Nuclear medicine Instruments",* Tata McGraw – Hill, 2nd edition,2010.
5.	Ramesh Chandra, Lea and Febiger, "*Introductory Physics of Nuclear* Medicine", American Association of physicists in medicine- Medical Physics,3rd edition, 2008.

Course nature				**Theory**			
Assessment Method (Weightage 100%)							
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Cycle Test III	Surprise Test	Quiz	**Total**
	Weightage	**10%**	**15%**	**15%**	**5%**	**5%**	**50%**
End semester examination Weightage :							**50%**

15BM427E	Acoustics and Optical Imaging			L	T	P	C
				3	0	0	3
Co-requisite:	NIL						
Prerequisite:	NIL						
Data Book / Codes/Standards	NIL						
Course Category	P	PROFESSIONAL ELECTIVE	BIOMEDICAL INSTRUMENTATION				
Course designed by	Department of Biomedical Engineering						
Approval	32nd Academic Council Meeting held on 23rd July 2016						

PURPOSE	The purpose of learning this course on acoustic and optical imaging for biomedical engineering students is to provide knowledge about various microscopic imaging systems to analyze biological system

INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course on acoustics and optical imaging, student will be able to								
1.	Analyze the various principles of physics used in acoustic imaging	a						
2.	Explain about the acoustic imaging modalities	a						
3.	Differentiate the various image capturing techniques	a						
4.	Illustrate the special techniques used in optical microscopy	a	k					
5.	Explain about the working principles of fluorescence imaging	a						

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	UNIT I: Physics of Acoustics	**9**			
1.	The sine wave, sound in media-particle motion, propagation of sound	1	C	1	1
2.	Speed of sound - wavelength and frequency, complex waves-harmonics	1	C	1	1
3.	Phase, partials, octaves, spectrum, electrical, mechanical and acoustic analogs	1	C	1	1
4.	Wave phenomenon : wavefronts, Interference, reflection, scattering, diffraction, refraction, doppler effect, convection	3	C	1	1
5.	Sound levels and decibel: ratios versus differences, logarithms, decibels, reference levels	1	C	1	1
6.	Comparison of Logarithmic and exponential forms, acoustic power	1	C	1	1
7.	Measuring sound pressure level, sine wave measurement	1	C	1	1
	UNIT II: Acoustic Imaging	**9**			
8.	Fundamentals of photo acoustic tomography : photo acoustic effect, image reconstruction methods, instrumentation	3	C	2	2,4
9.	Transducer array-based photoacoustic tomography: array-based PAT system and 2D imaging, 3D imaging,4D imaging	3	C	2	2,4
10.	Photoacoustic microscopy and computed microscopy: optical-resolution, acoustic-resolution,C-scan photoacousticmicroscopy, photoacoustic computed microscopy	2	C	2	2,4
11.	Photoacoustic microscopy based on acoustic lens with variable focal length, confocal photoacoustic microscopy using a single multifunctional Lens	1	C	2	2,4
	UNIT III: Image Capture	**9**			
12.	Optical contrasting techniques: dark field, phase contrast, polarization, differential interference contrast, hoffman modulation contrast	2	C	3	3
13.	Filter sets: excitation filter, dichroic mirror, and barrier filter	2	C	3	3
14.	Optical layout for image capture, color recording, additive color model, subtractive color model	2	C	3	3

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
15.	CCD cameras, frame-transfer array, interline-transfer array	1	C	3	3
16.	Back illumination, binning, capturing color, filter wheels, filter mosaics	1	C	3	3
17.	Three CCD elements with dichronic beam splitters, boosting the signal	1	C	3	3
	UNIT IV: Microscopy and Three Dimensional Imaging	**9**			
18.	Nonlinear microscopy: multiphoton microscopy, principles of two -photon fluorescence, lasers for nonlinear microscop, advantages of two-photon excitation	1	C	4	3
19.	Construction of a multiphoton microscope, fluorochromes for multiphoton microscopy, second harmonic microscopy	1	C	4	3
20.	High-speed confocal microscopy: tandem scanning (spinning disk) microscopes, petràn system, one-sided tandem scanning microscopes (OTSMS)	1	C	4	3
21.	Microlensarray: the Yokogawa system, slit-scanning microscopes, multipoint-array scanners, structured illumination	1	C	4	3
22.	Surfaces: two-and-a-half dimensions, perception of the 3D world, motion parallax, convergence and focus of our eye	2	C	4	3
23.	Perspective, concealment of one object by another, light and shade, limitations of confocal microscopy	1	C	4	3
24.	Stereoscopy : three-dimensional reconstruction, techniques that require identification of objects, techniques that create views directly from intensity data	1	C	4	3
25.	Simple projections, weighted projection (alpha blending)	1	C	4	3
	UNIT V:Fluorescence and its Advanced Techniques	**9**			
26.	Fluorescent staining: immuno labeling, types of antibody, raising antibodies, labeling, fluorescent stains for cell components and compartments	1	C	5	3
27.	Quantitative fluorescence: fluorescence intensity measurements, linearity calibration, measurement, co-localization, ratio imaging	1	C	5	3
28.	Cell loading, membrane potential, fast-response dyes, slow-response dyes, fluorescence recovery after photo bleaching	2	C	5	3
29.	Fluorescence lifetime Microscopy(FLIM), Practical Lifetime Microscopy, frequency domain, time domain	1	C	5	3
30.	Fluorescence Resonant Energy Transfer (FRET), identifying and quantifying fret, increase in brightness of acceptor emission, quenching of emission from the donor	2	C	5	3
31.	Lifetime of donor emission, protection from bleaching of donor, Fluorescence Correlation Spectroscopy (FCS), raster image correlation spectroscopy	2	C	5	3
	Total contact hours	**45(Exclusive of Assessment hours)**			

LEARNING RESOURCES	
Sl. No.	**TEXT BOOKS**
1.	F. Alton Everest, Ken Pohlmann, "*Master Handbook of Acoustics"*, McGraw-Hill, 6th edition,2014.
2.	Huabei Jiang, "*Photoacoustic Tomography*" CRC press, Taylor & Francis Group, 1st edition, 2015.
3.	Guy cox, "*Optical Imaging Techniques in Cell Biology*", CRC press, Taylor & Francis Group, 2nd edition, 2012.
4.	Jose Luís del Cura, Pedro Seguí, Carlos Nicolau, "*Learning Ultrasound Imaging"*, Springer, 1st edition 2012.
5.	Peter R. Hoskins, Kevin Martin, Abigail Thrush, "*Diagnostic Ultrasound: Physics and Equipment"*, Cambridge university press, 2nd edition, 2010.

6.	Gerhard K. Ackermann, Jürgen Eichler, "*Holography: A Practical Approach"*, WILEY-VCH Verlag GmbH & Co, 1st edition, 2008.
7.	Tuan Vo Dirh, "*Biomedical photonics – Handbook"*, CRC Press, 2nd edition, 2003.
	REFERENCE BOOKS/OTHER READING MATERIAL
8.	Frank J. Fahy, "*Foundations of Engineering Acoustics"*, academic press, 1st edition, 2005.

Course nature				**Theory**			
Assessment Method (Weightage 100%)							
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Cycle Test III	Surprise Test	Quiz	**Total**
	Weightage	**10%**	**15%**	**15%**	**5%**	**5%**	**50%**
End semester examination Weightage :							**50%**

15BM428E	Picture Archiving and Communication Systems	L	T	P	C
		3	0	0	3
Co-requisite:	NIL				
Prerequisite:	NIL				
Data Book / Codes/Standards	NIL				
Course Category	P PROFESSIONAL ELECTIVE TELEMEDICINE				
Course designed by	Department of Biomedical Engineering				
Approval	32nd Academic Council Meeting held on 23rd July 2016				

PURPOSE	The purpose of learning this course on Picture Archiving and communication systems for biomedical engineering students is to acquire knowledge on the fundamental concepts, networking technology and its broad application in healthcare system

INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able to								
1.	Explain the basic fundamental concepts of picture archiving and communication system	a						
2.	Describe the types of workstations and image display devices	a	c					
3.	Impart knowledge on the networking technologies used in PACS	a	c					
4.	Describe the data storage process of PACS	a	c					
5.	Illustrate the healthcare integration, implementation and its applications	b	e	k				

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	UNIT I: PACS: the Transition to Medicine and Servers	**9**			
1.	History of Picture archiving and communication system (PACS): Computer network development and data storage technology history	1	C	1	1,2
2.	Establishment of standards for image exchange in medicine	1	C	1	1,2
3.	Imaging modality digitization, defining PACS: from mini to enterprise	1	C	1	1,2
4.	Advantages and benefits, work flow changes after implementation of PACS	2	C	1	1,2
5.	Prerequisites for PACS implementation	1	C	1	1,2
6.	PACS server	3	C	1	1,2
	UNIT II: Image Display Devices and Workstations	**9**			
7.	Softcopy image display system, quality standards for display devices	2	C	2	1,2
8.	Types of image display workstations	2	C	2	1,2
9.	Workstation architecture, environment for PACS workstations	2	C	2	1,2
10.	Radiology workflow	1	C	2	1,2
11.	Speech recognition for report dictation	2	C	2	1,2
	UNIT III: Networking Technologies	**9**			
12.	Ethernet local area network	2	C	3	1,2,3
13.	Wide area network	2	C	3	1,2,3
14.	Network topology	2	C	3	1,2,3
15.	Wi-Fi and wireless local area network	2	C	3	1,2,3
16.	Network security	1	C	3	1,2,3
	UNIT IV: Data Storage	**9**			
17.	Data storage media types	2	C	4	1,2,3
18.	Digital storage device interface	2	C	4	
19.	Image data compression, content-addressed storage	3	C	4	1,2,3
20.	Short-term and long-term storage	2	C	4	1,2,3
	UNIT V: Healthcare Information Integration, Practical PACS Implementation and Applications	**9**			
21.	Health Level 7: HL7 Version 2.X, 3.X, DICOM	2	C	5	1,2,3
22.	Integrating the healthcare enterprise technical frameworks	2	C	5	1,2,3

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
23.	PACS equipment selection and contract preparation	1	C	5	1,2,3
24.	Application review on : cardiology PACS, pathology PACS	2	C	5	3,4,5
25.	Radiation oncology PACS, endoscopy PACS	1	C	5	3,4,5
26.	Other applications of PACS	1	C	5	3,4,5
	Total contact hours	**45(Exclusive of assessment hours)**			

LEARNING RESOURCES	
Sl. No.	**TEXT BOOKS**
1.	Yu Liu, Jihong Wang, "*PACS and Digital Medicine: Essential Principles and Modern Practice*", CRC Press, 1st edition,2010.
2.	Keith J, Dreyer D "*PACS A Guide to the Digital Revolution"*, Springer, 2nd edition, 2006.
	REFERENCE BOOKS/OTHER READING MATERIAL
3.	H.K.Huang, Wiley-Blackwell "*PACS and Imaging Informatics: Basic Principles and Applications"*, Wiley-Blackwell, 2nd edition, 2004.
4.	Thomas D. Vreugdenburg , Cameron D. Willis, Linda Mundy, Janet E. Hiller, "*A systematic review of elastography, electrical impedance scanning, and digital infrared thermography for breast cancer screening and diagnosis*", Breast Cancer Research and Treatment,Springer**,**2013.
5.	Yupeng Cun , Holger Fröhlich, "*Prognostic gene signatures for patient stratification in breast cancer - accuracy, stability and interpretability of gene selection approaches using prior knowledge on protein-protein interactions*", BMC Bioinformatics, May 2012.

Course nature				**Theory**			
Assessment Method (Weightage 100%)							
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Cycle Test III	Surprise Test	Quiz	**Total**
	Weightage	**10%**	**15%**	**15%**	**5%**	**5%**	**50%**
					End semester examination Weightage :		**50%**

15BM429E	Body Area Networks and Mobile Healthcare	L	T	P	C
		3	0	0	3
Co-requisite:	NIL				
Prerequisite:	NIL				
Data Book / Codes/Standards	NIL				
Course Category	P PROFESSIONAL ELECTIVE	TELEMEDICINE			
Course designed by	Department of Biomedical Engineering				
Approval	32nd Academic Council Meeting held on 23rd July 2016				

PURPOSE	The purpose of the course on body area network and mobile healthcare for biomedical engineering students is to provide an overview of the technical background of Body Area Networks (BAN) and its application in health care using mobile technology

INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able to								
1.	Comprehend technical information and challenges in body area networks (BAN)	a	c	d	e	f	k	
2.	Describe the hardware requirements of BAN	a	c	d	e	h	k	
3.	Review the wearable sensors and standards for BAN	a	c	d	e	h	k	
4.	Describe the medical devices that are available for health care	a	c	d	e	f	k	
5.	Summarize the possible and latest applications of mobile healthcare	a	c	d	e	f	k	

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	UNIT I: BAN Inception	**9**			
1.	BAN and healthcare	1	C	1	1,7,8
2.	Technical challenges- sensor design	2	C	1	1,2
3.	Biocompatibility, energy supply, energy scavenging methods	2	C	1	1,2
4.	Optimal node placement, number of nodes, networks for BAN	2	C	1	1,2
5.	System security and reliability, standards	1	C	1	1,2
6.	BAN Architecture	1	C	1	1,2
	UNIT II: Hardware for BAN	**9**			
7.	Processor-Low Power MCUs, mobile computing MCUs	2	C	2	1,7
8.	Integrated processor with radio transceiver, memory types and ranges	2	C	2	1,3
9.	Antenna types , PCB antenna, wire antenna, ceramic antenna, external antenna	3	D	2	1,3
10.	Sensor interface, power sources- batteries and fuel cells for sensor nodes.	2	C	2	1,3
	UNIT III: Wearable Sensors and Standards for BAN	**9**			
11.	Wearables fundamentals and role of wearable sensors	1	C	3	9
12.	Attributes of wearables, flexible electronics, meta-wearables	2	C	3	9
13.	Future of wearables, research road map	2	D	3	9
14.	Wireless personal area network technologies-IEEE 802.15.1,IEEEP802.15.13, IEEE 802.15.14	2	C	3	3
15.	Zigbee, coexistence issues with BAN.	2	C	3	3
	UNIT IV:Mobile Devices for Healthcare	**9**			
16.	Wearable system for ECG monitoring	1	C	4	2,6
17.	Evaluation of night time performance, smart phone based health care monitoring system	2	C	4	2,6
18.	Phone based fall risk prediction	2	C	4	2,6
19.	RFID based personal mobile medical assistance	2	C	4	2,6
20.	Secure medical sensor network	2	C	4	2,6
	UNIT V:Mobilehealth Technologies and Applications	**9**			
21.	Mobile nutrition tracking -case study	2	C,I	5	2,6
22.	Accessing existing virtual electronic patient record, mobile personal health records	2	C	5	2,6

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
23.	Monitoring hospital patients, sensing vital signs and transmission using wireless networks	2	C	5	2,6
24.	Context aware healthcare applications with case study	3	C,I	5	2,6
	Total contact hours	**45 (Exclusive of assessment hours)**			

LEARNING RESOURCES	
Sl. No.	**TEXT BOOKS**
1.	Annalisa Bonfiglio, Danilo De Rossi, "*Wearable Monitoring Systems"*, Springer, 1st edition, 2011.
2.	Philip Olla, Joseph Tan, "*Mobile Health solutions for Biomedical applications"*, Medical Information science reference, Hershey New York, IGI Global 2009.
3.	Mehmet R. Yuce,JamilY.Khan, "*Wireless Body Area Networks Technology, Implementation, and applications*", Pan Stanford Publishing Pvt.Ltd, Singapore, 1st edition, 2012.
	REFERENCE BOOKS/OTHER READING MATERIAL
4.	Zhang, Yuan-Ting, "*Wearable Medical Sensors andSystems"*, Springer, 1st edition, 2013.
5.	Guang-ZhongYang(Ed.), "*Body Sensor Networks"*, Springer, 1st edition, 2006.
6.	KonstantinaS.Nikita, James C. Lin, Dimitrios, Maria Teresa, "*Wireless mobile communication and healthcare*", Second International ICST conference, Mobihealth 2011, Springer, 1st edition, 2011.
7.	Ullah, Sana, et al. *"A review of wireless body area networks for medical applications"*, Int'l J. of Communications, Network and System Sciences2.08 (2009): 797.
8.	Patel, Shyamal, et al. "*A review of wearable sensors and systems with application in rehabilitation",* Journal of Neuroengineering Rehabilitation. 9.12 (2012): 1-17.
9.	Edward Sazonov, Michael R Neuman, "*Wearable sensors: Fundamentals, Implementations and applications"* Elsevier, 1st edition, 2014.

Course nature				**Theory**			
Assessment Method (Weightage 100%)							
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Cycle Test III	Surprise Test	Quiz	**Total**
	Weightage	**10%**	**15%**	**15%**	**5%**	**5%**	**50%**
End semester examination Weightage :							**50%**

COURSES CUSTOMIZED TO OTHER DEPARTMENT

15BM324E	Principles of Biomedical Instrumentation	L	T	P	C
		3	0	0	3
Co-requisite:	NIL				
Prerequisite:	NIL				
Data Book / Codes/Standards	NIL				
Course Category	P PROFESSIONAL ELECTIVE	BIOMEDICAL INSTRUMENTATION			
Course designed by	Department of Biomedical engineering				
Approval	32nd Academic Council Meeting held on 23rd July 2016				

PURPOSE	The purpose of learning this course on principles of biomedical instrumentation is to provide knowledge to students to understand about the different components of various biomedical equipment and its working principle.

INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able to								
1.	Understand the origin of bioelectric potential and their measurements using appropriate electrode sand transducers	a	c					
2.	Understand how to measure various biochemical and non-electrical parameters of human system	a	c					
3.	Understand the Electrophysiology of various systems and recording of the bioelectric signals	d	f					
4.	Understand the working principles of various imaging techniques	d						
5.	Understand the design aspects of various assist and therapeutic devices	f	h					

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	UNIT I: Biopotential Electrodes and Transducers	**9**			
1.	Electrode theory- Electrode electrolyte interface, half-cell potential, Hydrogen, Calomel, Ag-AgCl electrode	1	C	1	1,2
2.	Needle and wire electrode	1	C	1	1,2
3.	Surface electrodes, microelectrode	1	C	1	1,2
4.	Metal micropipette electrodes	2	C	1	1,2
5.	Physiological transducers: resistive transducers: thermistor, strain gauge	1	C	1	1,2
6.	Inductive transducers, capacitive transducers	1	C	1	1,2
7.	Photoelectric transducers, piezoelectric transducers	1	C	1	1,2
8.	Biochemical Transducers-pH, pCo2 and pO2 electrodes	1	C	2	1,2
	UNIT II: Bio Electric Potentials and Measurements	**9**			
9.	Origin of bioelectric potentials: resting and action potential, propagation of action potential	1	C	3	1,2,3
10.	Electrophysiology of heart, origin of ECG, ECG waveforms and characteristics, electrodes and lead configurations, 12 lead ECG system	2	C	3	1,2,3
11.	Vector cardiograph, magneto cardiograph	1	C	3	1
12.	EEG waveforms and characteristics, 10-20 electrode placement system, EEG machine, evoked potential study	2	C	3	1,2
13.	Recoding of EMG, measurement of conduction velocity	1	C	3	1,2,3
14.	Recording of EOG, ERG	1	C	3	1,2,3
15.	Heart sounds: origin, PCG	1	C	3	1,2
	UNIT III: Non-Electrical Parameter Measurements	**9**			
16.	Measurement of blood pressure: direct and indirect methods	2	C	2	1,2
17.	Blood flow measurement: electromagnetic blood flow meter, ultrasound blood flow meter, laser doppler blood flow meter	2	C	2	1

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
18.	Cardiac output measuring techniques: dye dilution method; thermal dilution method	1	C	2	1,2
19.	Heart rate measurement	1	C	2	1
20.	Ultrasonic blood flow meter, NMR blood flow meter, laser doppler blood blow meter	1	C	2	1,2
21.	InvitroOximetry, ínvivooximetry: ear oximeter, pulse oximeter	1	C	2	1,2
22.	Respiratory volumes and capacities, spirometry, Pneumotachometers: different types , Measurement of lung volume	1	C	2	1
	UNIT IV: Medical Imaging Techniques	**9**			
23.	X-ray machine	2	C	4	1
24.	Computer Tomography, different generations	1	C	4	1
25.	Ultrasonography: A, B and M Mode scans	1	C	4	1
26.	Magnetic Resonance Imaging System	2	C	4	1
27.	PET, SPECT	2	C	4	1
28.	Thermography	1	C	4	1
	UNIT V: Telemetry, Therapeutic and Assist Devices	**9**			
29.	Biotelemetry: basics components, and its different types.	1	C	5	1,2
30.	Patient monitoring system	1	C	5	1
31.	Assist and therapeutic devices: cardiac pacemakers	1	C	5	1
32.	Defibrillators	1	C	5	1
33.	Heart Lung machine, different types of oxygenators	1	C	5	1,2
34.	Hemodialysis and Peritoneal dialysis	1	C	5	1
35.	Respiratory therapy equipments: ventilators, anesthesia machine	2	C	5	1,2
36.	Artificial heart valves and types	1	C	5	1,2
	Total contact hours	**45 (Exclusive of Assessment hours)**			

LEARNING RESOURCES	
Sl. No.	**TEXT BOOKS**
1.	R. S. Khandpur, '*Handbook of Bio-Medical instrumentation'*, Tata McGraw Hill Publishing Co Ltd., 3rd edition, 2014.
2.	John G. Webster, "*Specifications of Medical Instrumentation Application and Design",* Wiley India Pvt Ltd India, 4th edition, 2015.
	REFERENCE BOOKS/OTHER READING MATERIAL
3.	Joseph J Carr and John m Brown, "*Introduction to Biomedical equipment Technology*", Pearson Education New Delhi, 4thedition, 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.

Course nature				**Theory**			
Assessment Method (Weightage 100%)							
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Cycle Test III	Surprise Test	Quiz	**Total**
	Weightage	**10%**	**15%**	**15%**	**5%**	**5%**	**50%**
End semester examination Weightage :							**50%**

15BM421E	Medical Electronics			L	T	P	C
				3	0	0	3
Co-requisite:	NIL						
Prerequisite:	NIL						
Data Book / Codes/Standards	NIL						
Course Category	P	PROFESSIONAL ELECTIVE	MEDICAL ELECTRONICS				
Course designed by	Department of Biomedical Engineering						
Approval	32nd Academic Council Meeting held on 23rd July 2016						

PURPOSE	The purpose of learning this course on Medical Electronics is to acquire the knowledge related to bio-electric potentials and the design of bio-amplifiers and to study the physiological functions of the human body

INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able to								
1.	Describe the functioning of the major physiological systems of the human body	a						
2.	Examine the various sources of bioelectric signals and the type of electrodes to be used for signal pick up	a	b					
3.	Discuss on various electrical / electronic components used in therapeutic equipments	b	c					
4.	Demonstrate about the various imaging systems and telemetry system for vital parameters	b	d					
5.	Evaluate the maximum safe current that a subject could encounter in ICU/surgery through any biomedical device	b	d					

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	UNIT I: Physiological Signals and its Characteristics	**9**			
1.	Physiological systems of the body: cardiovascular system, respiratory system and nervous system	1	C	1	1,2,3
2.	Sources of biomedical signals, medical instrumentation system	1	C	2	1,2
3.	Origin of bioelectric signals: ECG, EEG and EMG	2	C	2	1,2,3
4.	Electrode-tissue interface	1	C	1,2	1,2
5.	Electrodes for ECG: Limb, floating, disposable, EEG, EMG	1	C	2	1,2,3
6.	Pressure transducer, thermistor, photoelectric transducer , optical fibre sensors	2	C	2	1
7.	Biosensor and smart sensor	1	C	2,3	1
	UNIT II: Cardiac Pacemakers and Defibrillators	**9**			
8.	Basics of cardiac pacemaker, external pacemaker	2	C	3	1
9.	Implantable pacemaker : types, programmable pacemaker, power sources	2	C	3	1
10.	DC Defibrillator	1	C	3	1
11.	DC Defibrillator with synchronizer	1	C	3	1
12.	Automatic external defibrillator	1	C	3	1
13.	Implantable defibrillator and pacer-cardioverter-defibrillator	2	C	3	1
	UNIT III: Medical Imaging Systems and Biomedical Telemetry	**9**			
14.	Nature of X-rays, stationary anode tube and X-ray machine	2	C	3,4	1
15.	Digital Radiography and computed tomography	2	C	3,4	1
16.	Emission computed tomography	2	C	3,4	1
17.	Principle of NMR and its imaging system	1	C	3,4	1
18.	Single channel ECG telemetry system, obstetrical telemetry system	2	C	3,4	1,2
	UNIT IV: Therapeutic Equipments	**9**			
19.	Basic principle of lasers and its application in medicine	1	C	3	1

20.	Helium neon laser and ruby laser	2	C	3	1
21.	CO_2 laser, Nd:YAG laser and Excimer laser	3	C	3	1
22.	Electrotherapy equipments: short wave diathermy and microwave diathermy	2	C	3	1
23.	Electro-diagnostic therapeutic stimulator	1	C	3	1
	UNIT V: Instruments for Surgery and Patient Safety	**9**			
24.	Principle of surgical diathermy machine and safety aspects in ESU	3	C	3,5	1
25.	Surgical diathermy analyzer	1	C	5	1
26.	Electric shock hazards, micro and macro shock	2	C	5	1
27.	Leakage current and its types	1	C	5	1
28.	Safety codes for electro medical equipment and electrical safety analyzer	1	C	5	1
29.	Testing of biomedical equipment	1	C	5	1
	Total contact hours	**45(Exclusive of assessment hours)**			

LEARNING RESOURCES	
Sl. No.	**TEXT BOOKS**
1.	Khandpur R.S, *"Hand-book of Biomedical Instrumentation"*, McGraw Hill Education, 3rd edition, 2014.
2.	Leslie Cromwell, Fred J. Weibell, Erich A. Pfeiffer, *"Biomedical Instrumentation and Measurements"*, Prentice-Hall India, 2nd edition, 2007.
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3.	Joseph J Carr and John M Brown., "*Introduction to Biomedical equipment technology*", Pearson education, New Delhi, 4th edition, 2004.

Course nature					**Theory**		
Assessment Method (Weightage 100%)							
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Cycle Test III	Surprise Test	Quiz	**Total**
	Weightage	**10%**	**15%**	**15%**	**5%**	**5%**	**50%**
					End semester examination Weightage :		**50%**