KALASALINGAM
ACADEMY OF RESEARCH AND EDUCATION
(DEEMED TO BE UNIVERSITY)
Under sec. 3 of UGC Act 1956.
Anand Nagar, Krishnankoil - 626126. Srivilliputtur (Via), Virudhunagar (Dt), Tamil Nadu | info@kalasalingam.ac.in | www.kalasalingam.ac.in

SCHOOL OF BIO AND CHEMICAL ENGINEERING

DEPARTMENT OF BIOMEDICAL ENGINEERING

B.Tech.

in

BIOMEDICAL ENGINEERING

2021 REGULATION CURRICULUM

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SCHOOL OF BIO AND CHEMICAL ENGINEERING

DEPARTMENT OF BIOMEDICAL ENGINEERING

Institution Mission

To be a Center of Excellence of International Repute in Education and Research

Institution Vision

To Produce Technically Competent, Socially Committed Technocrats and Administrators through Quality Education and Research

Department Mission

To be a globally recognized Centre of Excellence in the field of Biomedical Engineering for the advancement of human health

Department Vision

To produce skilled Biomedical Engineers, who are technically competent and socially committed, by imparting interdisciplinary education in the field of Biomedical Engineering

Program Educational Objectives (PEOs)

PEO1 Graduates would have attained a basic competency in the field of Biomedical Engineering for pursuing advanced courses in Biomedical Engineering and allied fields

PEO2 Graduates would be successful as entrepreneurs or attain responsible positions in government, biomedical and allied industries and, research centres.

PEO3 Graduates would exhibit effective communication and leadership skills and contribute to the advancement of human healthcare through life-long learning.

ABET Student Outcomes (ASOs)

ASO1: An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.

ASO2: An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.

ASO3: An ability to communicate effectively with a range of audiences.

ASO4: An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.

ASO5: An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.

ASO6: An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.

ASO7: An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

Mapping of ABET Student Outcomes and PEOs

ASOs / PEOs	PEO 1	PEO 2	PEO 3
ASO 1 - An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.	✓		
ASO 2 - An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.	✓		
ASO 3 - An ability to communicate effectively with a range of audiences.	✓		✓
ASO 4 - An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.		✓	✓
ASO 5 - An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.		✓	✓
ASO 6 - An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.		✓	
ASO 7 - An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.		✓	

NBA Program Outcomes (POs) and Program Specific Outcomes (PSOs)

PO1 – Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2 – Problem analysis: Identify, formulate, research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3 – Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4 – Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5 – Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

PO6 – The Engineer and Society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7 – Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of need for sustainable development.

PO8 – Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9 – Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10 – Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11 – Project Management and Finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12 – Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PSO1 - Utilization of Acquired knowledge: The ability of a graduate to utilize the knowledge acquired through the study of Mathematics, Basic Sciences, Biology, Environmental impact and needs, Core-engineering and, Human Anatomy and Physiology constituting the fundamentals of Biomedical Engineering.

PSO2 Recognize and Resolve Complications: The ability of a graduate to Analyze, Interpret, Model, Design, Recognize and Resolve Complications arising in the domain of Biomedical Engineering, and to satisfy the requirements of health-care industries/organizations.

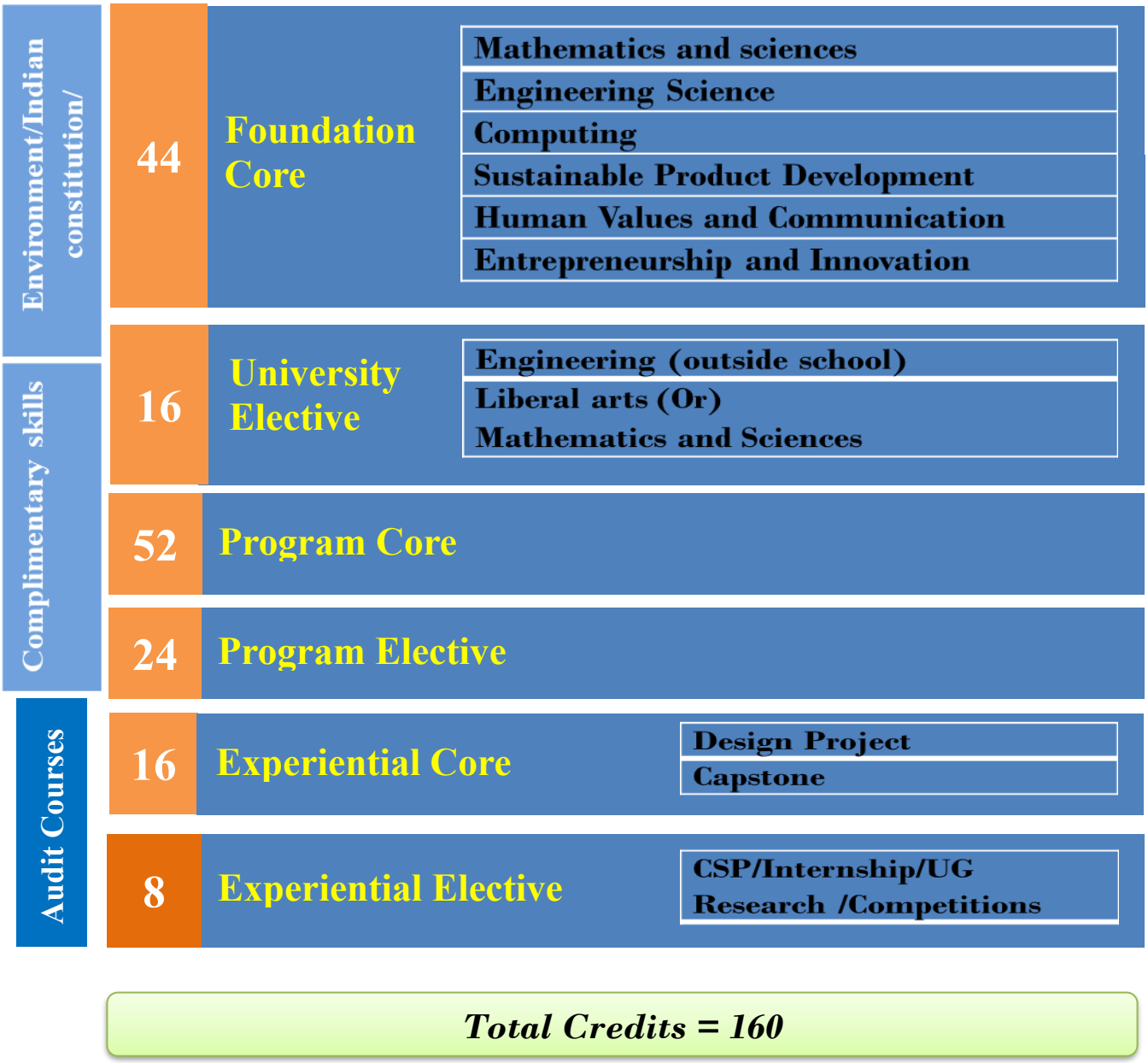
PSO3 - Self-sustainability: The ability of a graduate to be self-sustainable, and to be positioned as a Leader, Administrator, Entrepreneur, or to be a supporter for a multidisciplinary team designated to meet the specified target with standards through an elitist approach.

PSO4 - Well-being of Humanity: The ability of a graduate to be committed with the context of coalescing Pedagogical, Socio-ethical and Professional practices on proceeding with the knowledge gained through Biomedical Engineering for the well-being of Humanity.

POs' Consistency with Department PEOs'

PEO/PO, PSO	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
PEO1	✓	✓	✓		✓	-	-	-	-	-	-	✓	✓	✓	-	✓
PEO2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
PEO3	-	-	-	-	-	-	-	✓	✓	✓	✓	✓	-	-	✓	✓

2021 REGULATION CURRICULUMSTRUCTURE



Total Credits = 160

B.Tech. Biomedical Engineering Curriculum

Foundation Core

Sl. No.	Course Code	Course Name	L	T	P	X	Credits	Hours/ Week
1	211ENG1301	English For Engineers	2	0	0	3	3	5
2	211MEC1201	Introduction to Engineering Visualisation	0	0	2	3	2	5
3	211MEC1401	Sustainable Design and Manufacturing	1	0	2	3	3	6
4	211ECE1101	IoT Sensors and Devices	1	0	0	3	2	4
5	211CSE1401	Problem Solving using Computer Programming	1	0	2	3	3	6
6	211CSE1402	Python Programming	1	0	2	3	3	6
7	211MBA1101	Innovation and Entrepreneurship	1	0	0	3	2	4
8	211MAT1101	Statistics for Engineers	2	0	0	3	3	5
9	211MAT1301	Calculus and Linear Algebra	3	2	0	0	4	5
10	211MAT1303	Multiple Integration, Ordinarily Differential Equation, and Complex variable	3	0	2	0	4	5
11	211PHY1301	Physics	3	0	2	0	4	5
12	211CHY1301	Chemistry	3	0	2	0	4	5
13	211EEE1301	Basic Electrical and Electronics Engineering	3	0	2	0	4	5
14	211BIT1101	Biology for Engineers	3	0	0	0	3	3
						Total	**44**	**69**

Program Core

Sl. No.	Course Code	Course Name	Course Type	L	T	P	X	Credits	Hours/ Week	Pre-requisite
1	212BME1304	Fundamentals in Biomedical Engineering	IC-T	2	0	2	0	3	4	-
1	212BME1106	Medical Physics	T	3	0	0	0	3	3	-
2	212BME1105	Human Anatomy and Physiology	T	3	0	0	0	3	3	-
3	212BME1303	Electronics Devices and Circuits	IC-T	3	0	2	0	4	5	-

4	212BME1301	Clinical Biochemistry*	IC-T	2	0	0	3	3	5	-
5	212BME1102	Digital Logic Circuit	T	2	0	0	0	2	2	-
6	212BME2112	Biomaterials*	T	3	0	0	0	3	3	-
7	212BME2311	Biocontrol System*	IC-T	2	0	0	3	3	5	211MAT1303
8	215BME4215	Linear Integrated Circuits	T	3	0	0	0	3	3	212BME1303
9	212BME2119	Pathology and Microbiology	T	2	0	0	0	2	2	
10	212BME2320	Sensors and data acquisition*	IC-T	2	0	0	3	3	5	212BME1303
11	212BME2318	Microprocessors and Microcontrollers	IC-T	3	0	2	0	4	5	212BME1102
12	212BME2313	Biomechanics*	IC-T	2	0	0	3	3	5	212BME1105
13	212BME2117	Medical Imaging Techniques	T	3	0	0	0	3	3	-
14	212BME2314	Diagnostic and Therapeutic Instruments I	IC-T	3	0	2	0	4	5	215BME4215
15	212BME3337	Digital Signal Processing	IC-T	2	2	2	0	4	6	211MAT1303
16	212BME3336	Digital Image Processing	IC-T	3	0	2	0	4	5	-
							Total	**51**	**65**	**-**

Laboratory Core

Sl. No.	Course Code	Course Name	Course Type	L	T	P	X	Credits	Hours/ Week	Co-requisite
1	215BME4215	Integrated Circuits Laboratory	PC	0	0	2	0	1	2	215BME4215
							Total	**1**	**2**	-

Experiential Core

Sl.No.	Course Code	Course Name	Course Type	L	T	P	X	Credits	Hours/ Week
1	215BME4266	Design Project I	PC	0	0	9	0	3	9

32	215BME4267	Design Project II	PC	0	0	9	0	3	9
3	215BME4265	Capstone Project	PC	0	0	30	0	10	30
							Total	**16**	**48**

Experiential Elective									
Sl.No.	**Course Code**	**Course Name**	**Course Type**	**L**	**T**	**P**	**X**	**Credits**	**Hours/ Week**
1	216BME4268	Community Service Project	PC	0	0	9	0	3	9
2	216BME4271	Internship	PC	-	-	-	-	2	-
3	216BME4269	Hospital Training	PC	-	-	-	-	1	-
4	216BME4270	International/National Technical Competitions/Project Expo/Research Publication (Journal/ Conference/ Book chapter)	PC	-	-	-	-	2	-
							Total	**8**	**9**

Program Elective									
Sl. No.	**Course Code**	**Course Name**	**Course Type**	**L**	**T**	**P**	**X**	**C**	**Pre-requisite**
1	213BME2124	Design of Medical Instruments	T	3	0	0	0	3	
2	213BME2125	Graphical programming for Biomedical Applications	T	3	0	0	0	3	
3	213BME1107	Patent filing	T	3	0	0	0	3	
4	213BME3151	Introduction to Java for Biomedical Applications	T	3	0	0	0	3	
5	213BME2131	Special Electrical Machines	T	3	0	0	0	3	211EEE1301
6	213BME2121	Analog and Digital Communication	T	3	0	0	0	3	212BME1102
7	213BME2129	Medical Optics and lasers	T	3	0	0	0	3	
8	213BME3138	3D Printing in Medicine	T	3	0	0	0	3	
9	213BME3154	Mobile Application Development	T	3	0	0	0	3	
10	213BME2128	Medical Device regulatory India	T	3	0	0	0	3	
11	213BME2126	Hospital management	T	3	0	0	0	3	

12	213BME2122	Clinical Engineering	T	3	0	0	0	3	
13	213BME2127	Medical Device Marketing	T	3	0	0	0	3	
14	213BME3148	Ergonomics	T	3	0	0	0	3	
15	213BME3147	Embedded Systems Design*	T	3	0	0	0	3	212BME2318
16	213BME3143	Biometric Systems	T	3	0	0	0	3	
17	213BME3139	Advanced Microcontrollers	T	3	0	0	0	3	212BME2318
18	213BME3153	Microcontroller based system design	T	3	0	0	0	3	212BME2318
19	213BME3158	Robotics in Medicine	T	3	0	0	0	3	
20	213BME2123	Computers in Medicine	T	3	0	0	0	3	
21	213BME3159	Telehealth Technologies	T	3	0	0	0	3	
22	213BME3141	Biomedical Informatics	T	3	0	0	0	3	
23	213BME3146	Diagnostic and Therapeutic Instruments II	T	3	0	0	0	3	212BME2314
24	213BME3140	Biofluids and Dynamics	T	3	0	0	0	3	212BME2313
25	213BME3152	Mechanics of Biological systems	T	3	0	0	0	3	212BME2312
26	213BME3149	Finite Element analysis	T	3	0	0	0	3	
27	213BME3150	Human Assist Devices	T	3	0	0	0	3	
28	213BME2130	Rehabilitation Engineering	T	3	0	0	0	3	
29	213BME3155	Modeling of Physiological Systems	T	3	0	0	0	3	212BME2311
31	213BME3157	Neural Network and Pattern Recognition*	T	3	0	0	0	3	
32	213BME3144	Biosignal Processing	T	3	0	0	0	3	212BME3337
33	213BME3142	BioMEMS	T	3	0	0	0	3	
34	213BME3145	Design process in Biomaterials and artificial organs	T	3	0	0	0	3	
35	213BME3160	Tissue Engineering	T	3	0	0	0	3	
36	213BME3156	Biomedical Nanotechnology	T	3	0	0	0	3	

University Electives

Sl. No.	Course Code	Course Name	Course Type	L	T	P	C
1	214BME1109	Biomedical Instrumentation	**T**	3	0	0	3

2	214BME2133	Medical Optics	**T**	3	0	0	3
3	214BME2132	Computers in Medicine	**T**	3	0	0	3
4	214BME3163	Telemedicine	**T**	3	0	0	3
5	214BME1110	Biomedical Waste Management	**T**	3	0	0	3
6	214BME1108	Bioethics, IPR and Standards	**T**	3	0	0	3
7	214BME3161	Biometric Systems	**T**	3	0	0	3
8	214BME2135	Wearable systems	**T**	3	0	0	3
9	214BME2134	Rehabilitation Engineering	**T**	3	0	0	3
10	214BME3164	Tissue Engineering	**T**	3	0	0	3
11	214BME3162	Nanotechnology in Medicine	**T**	3	0	0	3

Honour Electives

Sl. No.	Course Code	Course Name	Course Type	L	T	P	X	C
1	216BME4173	Artificial organs	**T**	3	0	0	0	3
2	216BME4174	Biomechatronics	**T**	3	0	0	0	3
3	216BME4175	Biophotonics	**T**	3	0	0	0	3
4	216BME4172	Advanced optical imaging	**T**	3	0	0	0	3
5	216BME4180	Microfluidics	**T**	3	0	0	0	3
6	216BME4178	E-health systems	**T**	3	0	0	0	3
7	216BME4176	Brain computer interface	**T**	3	0	0	0	3
8	216BME4177	Cognitive neuroscience	**T**	3	0	0	0	3
9	216BME4179	Machine learning	**T**	3	0	0	0	3
10	216BME4182	Prosthetic science	**T**	3	0	0	0	3
11	216BME4181	Orthotic science	**T**	3	0	0	0	3

B.Tech. Biomedical Engineering Program Plan

July - November

Semester 1

#	Course Name	C	H
1	English for Engineers	3	5
2	Physics/Chemistry/	4	5
3	Calculus and Linear Algebra	4	5
4	Introduction to Engineering Visualisation	2	5
5	Problem Solving using computer Programming	3	6
6	Basic Electrical and Electronics Engineering (SEET)/Biology for Engineers (SBCE/PC or PE for all	3	3
	Total	**19**	29

December - April

Semester 2

#	Course Name	C	H
1	Basic Electrical and Electronics Engineering / PC or PE	4	5
2	Physics/Chemistry	4	5
3	Multiple Integration, ODE and complex variable	4	5
4	Sustainable Product Realisation	3	6
5	Python Programming	3	6
6	BME21R***/ Medical Physics	3	3
	Total	**21**	30

May - June

Summer term/break

July - November

Semester 3

#	Course Name	C	H
1	IoT sensors and devices	2	4
2	University Elective	4	4
3	BME21R***/ Human Anatomy and Physiology	3	3
4	BME21R***/ Electronics Devices and Circuits	4	5
5	BME21R***/ Clinical Biochemistry	3	5
6	BME21R***/ Digital Logic Circuit	2	2
7	BME21R***/ Biomaterials	3	3
8	BME21R***/Professional Elective I	3	3
	Total	**24**	29

December - April

Semester 4

#	Course Name	C	H
1	Design project 1(EC)	3	9
2 *	Statistics for Engineers	3	5
3	University Elective	3	3
4	BME21R***/ Biocontrol System	3	5
5	BME21R***/ Linear Integrated Circuits	3	3
7	BME21R***/ Pathology and Microbiology	2	2
8	BME21R***/ Integrated Circuits Laboratory	1	2
	Total	**18**	29

May - June

Summer term\break

Semester 5

#	Course Name	C	H
1	Experiential E (Community Services Project/UG Research Project)	3	9
2	University Elective	3	3
3	BME21R***/ Sensors and Data Acquisition	3	5
4	BME21R***/ Microprocessor and Microcontroller	4	5
5	BME21R***/ Biomechanics	3	5
6	BME21R***/ Professional Elective II	3	3
	Total	**19**	30

Semester 6

#	Course Name	C	H
1	Design Project 2(EC)	3	9
2	University Elective	3	3
3	BME21R***/ Medical Imaging Techniques	3	3
4	BME21R***/ Diagnostic and Therapeutic Equipment	4	5
5	BME21R***/ Digital Signal Processing	4	6
6	BME21R***/ Professional Elective III	3	3
	Total	**20**	29

Summer term\break

Semester 7

#	Course Name	C	H
1	**Experiential E	5	
2	University Elective	3	3
3	BME21R***/ Digital Image Processing	4	5
4	BME21R***/ Professional Elective IV	3	3
5	BME21R***/ Professional Elective V	3	3
6	BME21R***/ Professional Elective VI	3	3
7	BME21R***/ Professional Elective VII	3	3
8	BME21R***/ Professional Elective VIII	3	3
	Total	**27**	23

Semester 8

#	Course Name	C	H
1*	**Capstone**	**10**	**30**
	Total	**10**	30

Summer term

** Hospital Training, International/National Technical Competitions/Project Expo/Research Publication (Journal/ Conference/ Book chapter/Patent, Internship

SYLLABUS

PROGRAM CORE

Course Code	Course Name	L	T	P	X	C
212BME1304	FUNDAMENTALS OF BIOMEDICAL ENGINEERING	2	0	2	0	3

Prerequisite: Nil	**Syllabus revision:** Nil
Course Category: Program core	**Course Type:** Theory with X component

Course description

This course will enable students to develop an understanding in the fundamentals of biomedical engineering with respect to Basic human anatomy. This course will also provide the practical exposure to measure and simulate physiological parameters of human body.

Course outcomes:

On successful completion of the course the students will be able to

CO1	Explain the physical characteristics, function and components of blood tissue
CO2	Elaborate the blood groups and its relevant characteristics
CO3	Describe the anatomy, functions and events of human heart
CO4	Explain the Structure, functions and anatomy of human blood vessels
CO5	Describe the basics of physiological parameters measurement in human

CO	PO	PSO

	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
1	M															
2		L	H													
3				M												
4	M			L												
5	M				L											

H - High, M - Medium, L – Low

Unit 1	**BLOOD**	**Hours: 03**

Blood-Functions, Physical characteristics of blood, Components of Blood,Formation of Blood cells, Blood Cells – RBC-anatomy and physiology, WBC-Types and Functions, Platelets.

Unit 2	**BLOOD GROUPS AND BLOOD TYPES**	**Hours: 03**

Blood Groupsand Blood Types- ABO Blood Group, Transfusions, Rh Blood Group,Typing and Cross-Matching Bloodfor Transfusion

Unit 3	**HEART**	**Hours: 03**

Heart- Anatomy, Location, Layers of the Heart Wall, cardiac Chambers, Myocardial Thickness and Function, Fibrous Skeleton of the Heart,Heart Valves and its Operation, Cardiac cycle,

Unit 4	**BLOOD VESSELS**	**Hours: 03**

Basic Structure of a Blood Vessel,Arteries,Anastomoses,Capillaries,Venules and Veins,Blood Distribution, Circulationof Blood- Systemic and Pulmonary Circulations, Coronary Circulation.

Unit 5	**MEASUREMENTS**	**Hours: 03**

Cardiac output, Blood Pressure, Pulse rate, Heart rate, Blood Pressure and ECG Acquisitions

	Total Lecture hours	**45 Hours**
Text Books (Required Course Material)		
1	Tortora, G.J. and Derrickson, B.H., 2018. *Principles of anatomy and physiology*. John Wiley & Sons. (14th Edition or latest Edition)	
Reference Books		
1	Aaronson, Philip I., Jeremy PT Ward, and Michelle J. Connolly. The cardiovascular system at a glance. John Wiley & Sons, 2020.	
2	Martini, Frederic, Michael J. Timmons, Robert B. Tallitsch, William C. Ober, Claire W. Garrison, Kathleen B. Welch, and Ralph T. Hutchings. Human anatomy. San Francisco, CA: Pearson/Benjamin Cummings, 2006.	
Evaluation category		
Sl. No.	**Category**	**Weightage (%)**
1	Sessional Examinations (I & II)	**40**
2	End Semester Examination	**50**
3	Assignment	**10**
List of experiments suggested ("X" Component)		
Sl. No.	**Title**	**Hours**
1.	Blood group identification	**03**
2.	Estimation of Blood Clotting time/ Prothrombin time	**03**
3.	Estimation of Bleeding time	**03**
4.	Haemoglobin estimation	**03**
5.	Erythrocyte Sedimentation Rate Estimation	**03**

6.	Packed cell volume	**03**
7.	Total count of RBCs	**03**
8.	MCH, MCV, MCHCestimation	**03**
9.	Blood Pressure Measurement	**03**
10.	Spo2 Measurement	**03**
11.	Temperature Measurement system	
12.	Heart rate Computation	**03**
13.	Simulation/ Generation of Electrocardiogram (ECG).	**03**
	Total laboratory hours	**45**

Course Code	Course Name	L	T	P	X	C
212BME1106	MEDICAL PHYSICS	3	0	0	0	3

Prerequisite: Nil	**Syllabus revision:** r.3
Course Category: Program Core	**Course Type:** Theory

Course description

1	To understand the detection of electrical event within the body and the effects of externally applied electrical current.
2	To explain the basics of radioactivity and how isotopes are produced.
3	To explore the effects of radiation in matter and to understand various detectors for detecting the presence of ionizing radiation.
4	To learn the physics of light in medical imaging.
5	To understand the various effects of radiation at cellular level.

Course outcomes:
On successful completion of the course the students will be able to

CO1	To understand the biological effects of low and high frequencies of electromagnetic fields and safety issues associated with the handling of electromedical equipment.
CO2	To describe the fundamentals of radioactivity and radioactive isotopes.
CO3	To illustrates the methods of detecting and recording the ionizing radiation and its interaction with matter.
CO4	To explain the clinical applications of light in imaging techniques.
CO5	To elucidate the effects of radiation on humans and various protection measures.

CO	PO	PSO

	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
1	M	M	M			H							H			
2	M	H	M			H							M			M
3	M	H	M	L		M							M			M
4	M	M	M	L												
5	M	M	L	L		H							M			M

H–High, M–Medium, L–Low

Unit 1	**Non-Ionizing Electromagnetic Radiation:Tissue Absorption and Safety Issues**	**Hours: 9**

Radiation and its types – overview, Tissue as a leaky dielectric, Effects of non-ionizing radiation – low and high frequency effects, Electromedical equipment safety standards– Physiological effects of electricity, Leakage current, Classification of equipment, Acceptance and routine testing of equipment.

Unit 2	**Principles of Radioactive Nuclides**	**Hours: 8**

Nuclear Stability and Decay– Alpha Decay, Beta Decay, Decay Schemes, Mathematics of Radioactive Decay, Decay Equations and Half-Life, Transient Equilibrium, Production of Isotopes – Naturally Occurring Radioactivity, Neutron Reactions and Man-Made Radioisotopes, Isotope Generators, Cyclotron, Reactor Produced Radionuclides. Applications of radionuclides in medicine.

Unit 3	**Ionizing Radiation**	**Hours: 12**

Characteristics of interactions, directly ionizing radiation – Interactions of electrons, Interactions of Heavy Charged Particles, Indirectly Ionizing Radiation– Interactions of Neutrons, Attenuation of X and γRadiation, Dose and Exposure Measurement, Maximum Permissible Levels, measurement methods –Ionization chambers, G-M counters, Scintillation counters, Film dosimeters, Thermoluminescent dosimetry (TLD). Application of ionizing radiation – LINAC, Cyber knife and Gamma knife.

Unit 4	**Physics of Light in Imaging**	**Hours: 5**

Infrared Photography, Transillumination, Infrared imaging, Liquid crystal Thermography, Microwave Thermography. Imaging by Diaphanography – Clinical Applications, Physical basis of transillumination, Experimental arrangements.

Unit 5	**Radiation Biology**	**Hours: 11**

Interactions at the Cell and Tissue Levels, Cell Survival Studies, Modification of Cellular Responses, Stochastic Effects of Radiation, Nonstochastic Effects of Radiation. Protection from External Sources of Radiation – Regulatory Authority for RadiationProtection, Effective Dose Limits, Safety Recommendations for Sources of X andγRadiation, Protective Barriers

for Radiation Sources, Area and Personnel Monitoring. Protection from Internal Sources of Radiation – Committed Dose Equivalent, Estimating Internal Dose, Radiation Dose from Internal Radioactivity, Recommendations for Safe use of RadioactiveNuclides.	
Total Lecture hours	**45**
Textbooks	
1	Brown, Brian H., et al. *Medical physics and biomedical engineering*. CRC Press, 1998.
2	Hendee, William R., and E. Russell Ritenour. *Medical imaging physics*. John Wiley & Sons, 2003.
3	S.Webb, *The Physics of Medical Imaging.* Taylor & Francis Group, 1988.
Reference Books	
1	Maqbool, Muhammad, ed. *An introduction to medical physics*. Springer, 2017.
2	Dance, D. R., et al. *"Diagnostic radiology physics: A handbook for teachers and students.* Endorsed by: American Association of Physicists in Medicine, Asia-Oceania Federation of Organizations for Medical Physics, European Federation of Organisations for Medical Physics." (2014).
3	Saha, Gopal B. *Physics and radiobiology of nuclear medicine*. Springer Science & Business Media, 2012.

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Course Code	Course Name	L	T	P	X	C
212BME1105	HUMAN ANATOMY AND PHYSIOLOGY	3	0	0	0	3

Prerequisite: Nil	**Syllabus revision:** r.3
Course Category: Program core	**Course Type:** Theory

Course description

This course will enable students to develop an understanding of the relationships between the structures and functions of the human body. This course provides a comprehensive study of the anatomy and physiology of the human body. This course examines the biological structure of living organisms and their components, such as organs, muscles and bones.

Course outcomes:
On successful completion of the course the students will be able to

CO1	Explain the Interrelationships Among Molecular, Cellular, Tissue and Organ Functions
CO2	Explain different types and properties of muscular and skeletal systems. Illustrate the process of digestion
CO3	Describe and categorize the organs and its functions associated with circulation of blood and perfusion.
CO4	Describe the passage of neural signals within the human body.
CO5	Describe the basic components and functions of urinary, special sensing and reproductive systems.

CO	PO												PSO			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**	**4**
1	H												H			H
2	H	L	M										H			H
3	H		M										H			H

4	H		L										H			H
5	H			L									H			H

H – High, M – Medium, L – Low

Unit 1	**CELLS, TISSUES AND BASIC ANATOMICAL TERMINOLOGY**	**Hours: 09**

Introduction to the Human Body, Levels of Structural Organization, Basic Life Processes of the Human Body, Cell and Its Organelles, Cellular Diversity, Excitable Cells and non-Excitable Cells, Action Potential, Cell division, Cell signalling, Tissue Level of Organization, Types of Tissues. Basic Anatomical Terminology- Body Positions, Regional Names, Directional Terms, Planes and Sections, Body Cavities, Abdominopelvic Regions and Quadrants. Homeostasis

Unit 2	**MUSCULOSKELETAL SYSTEM AND DIGESTIVE SYSTEM**	**Hours: 09**

Muscular System: Type of muscles, properties of muscles, Functions of Muscle. Skeletal Muscle- Contraction and Relaxation of Skeletal Muscle.
Skeletal System: Divisions of the Skeletal System, Types of bones, classification, Structure and composition of bone, cartilage, tendon, ligament.
Joints: Classification of joints, structure and types of synovial joint, Types of Movements at Synovial Joints.
Digestive System: Organs of Digestive system – Digestion and Absorption

Unit 3	**CARDIOVASCULAR AND RESPIRATORY SYSTEM**	**Hours: 09**

Blood: Functions and Properties of Blood, Blood Cells – RBC, WBC, Platelets, Blood Groups and Blood Types.
Heart: Anatomy and physiology of Heart, Heart Valves and Circulation of Blood, Properties of Cardiac Muscles, Cardiac Conduction System, Cardiac cycle, Cardiac output.
Types of Blood Vessels, Regulation of Heart rate and blood pressure.
Respiratory system: Respiratory System Anatomy, Pulmonary Ventilation, Lung Volume and Capacities, Exchange and Transport of O2 and Co2, Control of Respiration.

Unit 4	**NERVOUS SYSTEM**	**Hours: 09**

Organization of the Nervous System: Central and Peripheral Nervous System, Functions of the Nervous System, Structure and Types of Neurons, Synapse and Neurotransmitters,
Electrical Signal in Neurons, Signal Transmission.
Brain: Organization, Divisions of brain lobes and its functions, Functional Organization of the Cerebral Cortex, Cerebrospinal Fluid, Autonomic Nervous System and its function
Spinal cord: Tracts of spinal cord – Reflex mechanism

Unit 5	**RENAL SYSTEM, SPECIAL SENSES AND REPRODUCTIVE SYSTEM**	**Hours: 09**

Renal System: Anatomy and Physiology of Kidney, Nephron, Mechanism of Urine formation,Regulation of Blood pressure by Urinary System– Urinary reflex.

Special Senses- Eye, Ear, Integumentary System **Reproductive System**	
Total Lecture hours	**45 Hours**
Textbooks	
1	Tortora, G.J. and Derrickson, B.H., 2018. *Principles of anatomy and physiology*. John Wiley & Sons. (14th Edition or latest Edition)
Reference Books	
1	Hall JE, Hall ME. Guyton and Hall Textbook of medical physiology e-Book. Elsevier Health Sciences; 2020 Jun 13.
2	Saladin Kenneth S., 2014. Anatomy & Physiology: The Unity of Form and Function. McGraw-Hill Education
3	Sembulingam, K. and Sembulingam, P., 2012. Essentials of medical physiology. JP Medical Ltd.
4	Gerald Karp, Cell and Molecular Biology – Concepts and Experiments, John Wiley & Sons, USA, 7th Edition, 2013.
5	Gardner, E.J., Simmons, M.J. Snustad, D.P. Principles of Genetics Wiley-India Ltd, New Delhi , 8th Edition, 2008.

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Course Code	Course Name	L	T	P	X	C
212BME1303	ELECTRONICS DEVICES AND CIRCUITS	3	0	2	0	4

Prerequisite: have to include any basic science course	**Syllabus revision:** r.2
Course Category: Program core	**Course Type:** Integrated Course

Course description

1	To introduce basic semiconductor devices, their characteristics and application
2	To understand analysis and design of simple transistor circuit
3	To use BJT as a small signal amplifier circuit
4	To introduce the negative feedback and positive feedback in transistor
5	To apply the inculcated knowledge for developing simple electronic circuits.

Course outcomes:
On successful completion of the course the students will be able to

CO1	Demonstrate an understanding of the operation of semiconductor devices
CO2	Design and analyse simple BJT and FET circuits.
CO3	Understand the operation and design of various types of small signal amplifier circuits
CO4	Discuss the effects of negative feedback on amplifier circuits and study the different types of oscillator circuits.
CO5	Understand the applications of diodes and transistors

CO	PO												PSO			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**	**4**
1	L															

2	L	L														
3	L	L														
4	L	L	L	L				M					L			
5	L	L	L	M				L				M	M	L		

H – High, M – Medium, L – Low

Unit 1	**INTRODUCTION TO DIODES**	**Hours: 9**
Review of Network and Semiconductor Basics, PN Junctions, Formation of Junction, Physical operation of diode, Contact potential and Space Charge phenomena, I – V Characteristics, Zener diode, LDR, Physical operation of special diodes (Tunnel diode, LED, OLED, Varactor diode, Schottky diode and Photo Diode).		
Unit 2	**INTRODUCTION TO TRANSISTOR**	**Hours: 9**
Operation and Characteristics of BJT, FET, MOSFET and UJT, biasing Circuits of BJT, FET, analysis and design of CC,CE and CB configuration, Analysis and Design of CS, CD and CG, Photo transistor		
Unit 3	**SMALL SIGNAL AMPLIFIERS**	**Hours: 9**
Transistor as Amplifier, Amplifier design, Multistage amplifier: RC coupled amplifier, tuned amplifier, Thermal run away in BJT circuits		
Unit 4	**FEEDBACK AMPLIFIERS AND OSCILLATOR**	**Hours: 9**
Properties of Negative feedback, Types of feedback configuration: Voltage shunt, voltage series, current series and current shunt, Sinusoidal Oscillator, RC Oscillator, Colpit Oscillator and Hartley Oscillator, Clapp, Crystal Oscillator, non-sinusoidal oscillator, Saw tooth, Triangular wave generators		
Unit 5	**APPLICATION OF ELECTRONIC DEVICES**	**Hours: 9**
Regulated Power Supplies, Design of Passive Filters, voltage regulators: shunt, series, Clipping and Clamping circuits, Multivibrators, Schmitt Trigger		
	Total Lecture hours	**45**
Textbooks		
1	Electronic Principles, Seventh Edition: Albert Malvino and David J.Bates	
Reference Books		
1	Adel S. Sedra, Kenneth C. Smith &Arun N. Chandorkar, Microelectronic Theory and Applications, 2013, Fifth edition, Reprint, Oxford University press, New York, USA.	
2	B G.Streetman and S.Banerjee, Solid State Electronic Education, 2015,	

	Seventh edition, New Delhi, India
3	Jacob Millman, Christos C Halkias and SatyabrataJit, Electronic devices and circuits, 2015, Fourth edition, Tata McGraw Hill, New Delhi, India
4	Thomas L.Floyd ,Electronic Devices Electron Flow Version, Ninth Edition,Prentice Hall

Practical component

Sl. No.	Experiments	Hours
1	Study of basic tools (oscilloscope, multimeter, circuit connection, soldering)	6
2	Transistor Biasing with and without stabilization	2
3	Transistor as an Amplifier	2
4	FET characteristics and Evaluation of its parameters, MOSFET characteristics	4
5	UJT characteristics	2
6	FET biasing methods	2
7	Two stage RC coupled amplifier, Frequency response Class B Complementary symmetry power amplifier	6
8	Differential amplifier using BJT	2
9	Phase shift oscillator using BJT/FET	4
10	BJT based Multivibrators	4
	Total Lecture hours	**34**

Course Code	Course Name	L	T	P	X	C
212BME1301	CLINICAL BIOCHEMISTRY	3	0	0	0	3

Prerequisite: Nil	**Syllabus revision:** r.3
Course Category: Program Core	**Course Type:** Theory

Course description

This course deals with the chemical level of organization of living beings and offers detailed knowledge on biological macromolecules such as classification, structure and properties of carbohydrates, Lipids, Protein and Enzymes also emphasis on relation to other life sciences.

Course outcomes:
On successful completion of the course the students will be able to

CO1	Describe the principles governing the complex interactions of chemicals in living system
CO2	Understand the importance of carbohydrates and vitamins in cellular machinery
CO3	Describe the structure of proteins and elucidate the clinical significance of biological catalysts
CO4	Understand the structure of various lipids and its derivatives with their implications in physiology
CO5	Elucidate the different bonds and structural components of nucleic acids

CO	PO												PSO			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**	**4**
1	H												H			
2	H					M							H			H
3	H					M							H			H
4	H					M							H			H

5	H					M							H			H

H – High, M – Medium, L – Low

Unit 1	**CHEMICAL LEVEL OF ORGANIZATION**	**Hours: 06**

Organization of Matter-ions, molecules and compounds.Chemical Bonds-Ionic Bonds, Covalent Bonds, Hydrogen Bonds, Hydrophobic and hydrophilic interactions. Chemical Reactions- Forms of Energy and Chemical Reactions, Energy Transfer in Chemical Reactions, Types of Chemical Reactions.Inorganic Compounds and Solutions-Water, Solutions, Colloids, and Suspensions, Inorganic Acids, Bases, and Salts. Acid–Base Balance: The Concept of pH, Maintaining pH: Buffer Systems,Organic Compounds-Introduction,Carbon and Its Functional Groups.

Unit 2	**CARBOHYDRATES AND VITAMINS**	**Hours: 06**

Classification and structure of monosaccharides, disaccharides, Polysaccharides: structural polysaccharides and storage polysaccharides. Reactions of monosaccharides.Disorders of carbohydrate metabolism. Diagnosis of diabetes mellitus. Carbohydrate chemistry in blood typing. Vitamins, Fat soluble and water-soluble vitamins; Classification, structures and physiological functions.

Unit 3	**AMINOACIDS, PROTEINS AND ENZYMES**	**Hours: 06**

Structure and characteristics of amino acids. Peptide bond. Structural organization of proteins – primary, secondary, tertiary, quaternary structure of protein – Conformation of proteins: Globular and fibrous proteins. Disorders of amino acid metabolism. Diagnostic enzymes: Clinical significance of Aspartate aminotransferase, Alanine aminotransferase, Lactate dehydrogenase.

Unit 4	**LIPIDS AND HORMONES**	**Hours: 06**

Structure, and properties classification of lipids, fatty acids, triglycerides, waxes, phospholipids, cerebrosides, lipoproteins and gangliosides- Prostaglandins and their physiological implications- Steroids and bile acids. Disorders of lipid metabolism. Hormones and their biological functions.

Unit 5	**NUCLEIC ACIDS**	**Hours: 06**

Structure of purines, pyrimidine, nucleosides and nucleotides – phosphodiester and hydrogen bonds. Histones – Watson and Crick model of DNA, Types of RNA. Disorders of purine and pyrimidine metabolism, diagnosis of genetic disorders

	Total Lecture hours	**30 + 45**

Textbooks

1	Nelson.D.L, Cox. M. M., Lehningers Principle of biochemistry, 6th ed.

	Freeman, 2013
Reference Books	
1	Tortora, G.J. and Derrickson, B.H., 2018. *Principles of anatomy and physiology*. John Wiley & Sons. (14th Edition or latest Edition)-For unit 1
2	Murray. R.K., Granner, D.K., Mayes. P. A. and Rodwell, V.W., Harpers Biochemistry, McGraw Hill, 27th Edition, 2006.
3	Berg. J.M., Tymoczko.J.L., Stryer, L., Biochemistry, Freeman, 7th edition, 2012
4	Voet, D., Voet, G., Biochemistry, John Wiley and Sons, Singapore, 4thEdition, 2011.
	Voet D, Voet JG., Biochemistry. 4th edition (2011)., Willey

List of experiments suggested ("X" Component)

Sl. No.	Title	Hours
1	Visualization of macromolecule	**3**
2	Calculation of pH	**3**
3	General tests for carbohydrates	**3**
4	Estimation of blood glucose.	**3**
5	General tests for carbohydrates	**3**
6	Estimation of blood glucose.	**3**
7	Differential count of different WBCs	**3**
8	General tests for proteins.	**3**
9	Separation of amino acids by thin layer chromatography (paper chromatography)	**3**
10	General tests for lipids.	**3**
11	Estimation of cholesterol	**3**
12	Protein structure modelling.	**3**
13	Separation of DNA by agarose gel electrophoresis	**3**

14	Estimation of creatinine and urea	**3**
15	DNA Modelling	**3**
	Total laboratory hours	**45**

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Course Code	Course Name	L	T	P	X	C
212BME1102	DIGITAL LOGIC CIRCUIT	2	0	0	0	2

Prerequisite: Electronic devices and Circuits	**Syllabus revision:** NA
Course Category: Program core	**Course Type:** Theory

Course description

1	To represent number system and different types of codes
2	To represent logical functions in canonical and standard forms
3	To design and analyse the combinational logic circuits
4	To design and analyse the sequential logic circuits
5	To implement combinational and sequential logic circuits using Verilog HDL

Course outcomes:
On successful completion of the course the students will be able to

CO1	Apply the number system and codes for interpreting workingof Digital System
CO2	Apply the Boolean Expressions to realize the logic circuits
CO3	Design a simple combinational circuit
CO4	Design simple sequential circuits.
CO5	Investigation of data converters and PLDs in digital electronics systems

CO	PO	PSO

	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
1	L															
2	L	L		L									L			
3	L	M	L	L	M				M				L	L		

4	L	L	L	L	L				L				L	L		
5	L															

H – High, M – Medium, L – Low

Unit 1	**NUMBER SYSTEM AND CODES**	**Hours: 9**

Base or radix of number systems, Binary, Octal, Decimal and Hexadecimal number system.Binary arithmetic: Addition, Subtraction, Multiplication, Division.Subtraction using 1's complement and 2's complementCodes: BCD, Gray Code, Excess-3, ASCII codeBCD Arithmetic: BCD Addition

Unit 2	**LOGIC GATES AND LOGIC FAMILIES**	**Hours: 9**

Logic Gates: Symbol, diode/transistor switch circuit and logical expression, truth table of basic gates (AND, OR, NOT), Universal gates (NAND, NOR) and special purpose gates (Ex-OR, Ex-NOR), Tristate Logic.Laws of Boolean algebra, Duality Theorem, De-Morgan's TheoremLogic Families: Characteristics of Logic families, Comparison TTL, CMOS, Types of TTL NAND gate.

Unit 3	**COMBINATIONAL LOGIC CIRCUITS**	**Hours: 9**

Sum of Product (SOP) & Product of Sum (POS), Maxterm and Minterm , Conversion between SOP and POS forms, realization using NAND/NOR gatesK-map reduction technique for the Boolean expression: Minimization of Boolean functions up to 4 variables (SOP & POS form)Design of Arithmetic circuits and code converter using K-map: Half and Full Adder, Half and Full Subtractor, Gray to Binary and Binary to Gray Code Converter (up to 4 bit).Encoder/Decoder,Multiplexer and Demultiplexer: Buffer

Unit 4	**SEQUENTIAL LOGIC CIRCUITS**	**Hours: 9**

Basic Memory Cell: RS Latch- using NAND & NOR., Triggering Methods, SR Flip Flops, JK Flip Flops, Shift Register SISO, SIPO, PIPO, PISO, 4 Bit Universal Shift Registers Counters, Asynchronous Counter, Synchronous Counter.

Unit 5	**DATA CONVERTERS AND PLDS**	**Hours: 9**

DAC: Types, weighted resistor circuit and R-2RLadder circuit, DAC IC 0808 specifications, ADC: Block diagram, types and working of Dual Slope ADC, SAR ADC, ADC IC 0808/0809 specification, RAM and ROM basic building blocks, read and write operation, types of semiconductor memoriesPLD: Basic building blocks and types of PLDs, PLA, PAL, GAL.CPLD, FPGA: Basic building blocks and functionality.

	Total Lecture hours	**45**

Textbooks

1	M. Morris R. Mano and Michael D. Ciletti, Digital Design With an Introduction to theVerilog HDL, 2014, 6th Edition, Prentice Hall of India, India.

2	John. F. Wakerly, “Digital Design Principles and Practices”, Fourth Edition, Pearson Education, 2007
Reference Books	
1	Charles H. Roth, Jr., Fundamentals of Logic Design, 2014, 7th Edition Reprint, Brooks/Cole, Pacific Grove, US
2	Michael D. Ciletti, Advanced Digital Design with the Verilog HDL, 2011, 2nd Edition,Pearson Pvt. Ltd, Noida, India.
3	Stephen Brown and ZvonkoVranesic, Fundamentals of Digital Logic with Verilog Design,2013, Third Edition, McGraw-Hill Higher Education, New Delhi, India.

Course Code	Course Name	L	T	P	X	C
212BME2112	BIOMATERIALS	2	0	0	3	3

Prerequisite: Nil	**Syllabus revision:** r.3
Course Category: Program core	**Course Type:** Theory

Course description

This course covers the principles of materials science and cell biology underlying the design of medical implants, artificial organs, and matrices for tissue engineering. Methods for biomaterials surface characterization and analysis of protein adsorption on biomaterials.

Course outcomes:
On successful completion of the course the students will be able to

CO1	Experiment with the classes of materials that can be used for medical applications
CO2	Illustrate the response of human body towards the application of biomaterial and the characterization methodologies for biomaterials
CO3	Apply the Biomaterials as drug delivery systems and in ophthalmology
CO4	To characterize the Biomaterials using microscopy and perform combination of materials that could be used as a tissue replacement implant.
CO5	To understand and design the artificial organs

CO	PO												PSO			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**	**4**
1	M	L	L	L		M	M	M	M	L	L	H	M	M	L	M
2	M	M	M	M	L	M	M	M	M	L	M	H	M	M	L	M
3	M	M	H	H	H	H	M	M	H	M	M	H	H	H	M	M
4	H	M	H	H	H	H	M	M	H	M	M	H	H	H	H	M

5	M	M	H	H	H	H	M	M	H	M	M	H	M	H	H	M

H-High, M-Medium, L-Low

Unit 1	**CLASSES OF MATERIALS USED IN MEDICINE**	**Hours: 09**

Classification of Biomaterials: Metals and alloys; stainless steel, cobalt based alloys, titanium-based materials – ceramics – bioinert ceramics – carbon, alumina, zircona and titania – bioactive ceramics – bioactive glass and glass ceramics, calcium phosphate ceramics – polymers – PMMA bone cement, articulating component – UHMWPE – composites, matrix and filter components, Surface properties and Bulk mechanical properties.Nanostructured Biomaterials.

Unit 2	**BIOLOGICAL PERFORMANCE OF MATERIALS**	**Hours: 09**

Biocompatibility-Tissue Compatibility – material response: – deformation and failure – friction and wear – Host response – Inflammatory process – capsule formation – coagulation and hemolysis – approach to thromboresistant material development –carcinogenesis. Biocompatibility testing: -in vitro and in vivo studies of biocompatibility.
Interactions of materials with the human body.

Unit 3	**OPHTHALMOLOGIC APPLICATIONS AND DRUG DELIVERY SYSTEMS**	**Hours: 09**

Materials for ophthalmology – contact lens and intraocular lens materials – Corneal Implants-Implants for Glaucoma-Implants for Retinal Detachment surgery- drug delivery systems: -Diffusion Controlled-Water penetration controlled –Chemically Controlled-Regulated Systems

Unit 4	**BIOMEDICAL CHARACTERIZATION TECHNIQUES AND IMPLANTS**	**Hours: 09**

Rheology, Atomic Force Microscopy, Electron Microscopy, Transmission Electron Microscopy Fourier Transform Infrared Spectroscopy. Biocompatibility, bioactivity, biodegradability,Percutaneous and skin implants, maxillofacial augmentation, Vascular grafts, hard tissue replacement Implants, joint replacements, Dental Implants, Pancreas replacement.

Unit 5	**ARTIFICIAL ORGANS**	**Hours: 09**

Artificial blood, artificial skin, Artificial Heart, Prosthetic Cardiac Valves, Artificial lung (oxygenator), Artificial Kidney (Dialyzer membrane)

Total Lecture hours	**45**

Textbooks

1	Buddy D.Ratner and Allan S.Hoffman Biomaterials Science "An Introduction to Material in Medicine" Third Edition, 2013.
2	Jonathan Black, Biological Performance of materials, Fundamentals of Biocompatibility, Marcel Dekker Inc., 4th edition New York, 2005

3	Joon Park, R S Lakes, Biomaterials: An Introduction, Springer science and Business Media, 2007
4	Sujatha.V..Bhat, Biomaterials,II Edition Alpha Science 2005
Reference Books	
1	Fredrick H. Silver: Biomaterials, Medical Devices & TissueEngineering: An integrated approach. Chapman & Hall, 1994
2	Ratner B, Hoffman A. et al. Biomaterials science: An introduction to materials in medicine, Academic Press, 2004
3	Amit Bandhyopadhya, Susmita Bose, Characterization of Biomaterials, Newnes, 2013

List of experiments suggested ("X" Component)

Sl. No.	Title	Hours
1	Teaching about the basics of Ansys software and Introduction to the different biomaterials.	05
2	Design and analyze of the strength for the given material and dimensions	05
3	Design a simple model of drug delivery system and analyze the flow of the fluid using the software.	05
4	Design a simple model of dental implant by using the given material and dimensions	05
5	Modeling of an artificial organs by using the given dimensions	05
	Total laboratory hours	**25**

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Course Code	Course Name	L	T	P	X	C
212BME2311	BIOCONTROL SYSTEM	2	0	0	3	3

Prerequisite: Math course which includes z transform, differential equation	**Syllabus revision:** r.3
Course Category: Program Core	**Course Type:** Theory with "X" component

Course objective

To impart profound knowledge in understanding, analyzing, and applying system concepts to physiological systems.

Course outcomes:
On successful completion of the course, the students will be able to

CO1	Understand and apply system elements and properties to the linear physiological system model.
CO2	Analyze steady-state characteristics of muscle stretch reflex, cardiac output, ventilation
CO3	Analyze the transient response of first & second-order response and to model eye movement control, neuromuscular reflex motion
CO4	Analyze circulatory and ventilation model using sinusoidal inputs
CO5	Apply various techniques to check the stability of pupillary light reflex and ventilation

CO	**PO**												**PSO**			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**	**4**
1	H	H		L	H				M				M			
2	H	H		L	H				M					H		
3	H	H		L	H				H				M	H		
4	H	H		M	H				H					H		

5	H	H		M	H				H					H		

H-High, M-Medium, L-Low

Unit 1	**Modelling& System representation**	**Hours: L: 06, X: 09**
Terminology and the basic structure of control system, examples of the closed-loop system, system properties, models with a combination of system elements, linear models of physiological systems, Laplace transform & transfer function, state-space analysis.		
Unit 2	**Static Analysis**	**Hours: L: 06, X: 09**
Open-loop versus closed-loops system, Block diagram representation of muscle stretch reflex model, Regulation of cardiac output, cardiac output curve, venous return curve, closed-loop analysis, regulation of glucose-insulin, chemical regulation of ventilation.		
Unit 3	**Time Domain Analysis**	**Hours: L: 06, X: 09**
The electrical analogy of lung mechanics model, Open & closed-loop, Transient response first-order model: impulse and step response, Transient response second-order model: impulse and step response, Second-order dynamics, other consideration: reduction of the effects of external disturbances.		
Unit 4	**Frequency Domain Analysis**	**Hours: L: 06, X: 09**
Steady-state response to sinusoidal inputs, Frequency response representation, Bode plot, Nyquist plot, Nichol's chart.		
Unit 5	**Stability Analysis**	**Hours: L: 06, X: 09**
Stability & transient response, Root locus method, Routh-Hurwitz stability criterion, Nyquist stability criterion, Relative stability.		
	Total Lecture hours	**30 + 45**
Textbooks		
1	Khoo, Michael C. K. Physiological Control Systems: Analysis, Simulation, and Estimation. Germany, Wiley, 2018.	
2	Blesser, William B. A Systems Approach to Biomedicine. United Kingdom, McGraw-Hill, 1969.	
Reference Books		
1	Kuo, B. C. (1995). Automatic control systems. India: Prentice Hall.	
2	Dukkipati, R. V. (2006). Analysis and design of control systems using MATLAB. India: New Age International.	
3	Bishop, R. H. (1993). Modern control systems analysis and design using	

	MATLAB. United Kingdom: Addison-Wesley.

X – Component

a) Introduction to MATLAB & SIMULINK, Implementation, and analysis of Lung mechanics model in SIMULINK
b) Mechanical response of a cancerous tissue illustrating the lumped parameter model
c) Conversion of muscle mechanics transfer function model into an equivalent state-space model
d) Steady-state solution for muscle stretch reflex model with nonlinear characteristics
e) Analyzing the steady-state characteristics regarding the cardiac output curve of a patient
f) Steady-state values of ventilation and how the change in gas mixture affect ventilation
g) Model of eye-movement control
h) Simulink application of dynamics of neuromuscular reflex motion
i) Simulink application of dynamics of glucose-insulin regulation
j) Frequency response of ventilatory control model
k) Frequency response of linearized lung mechanics
l) Frequency response model of a circulatory model
m) Effect of how to rate sensitivity is expected to affect relative stability in the model of the ventilatory control system
n) Stability analysis of pupillary light reflex
o) Model of Cheyne stokes breathing

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Course Code	Course Name	L	T	P	X	C
215BME4215	LINEAR INTEGRATED CIRCUITS	3	0	0	0	3

Prerequisite: Electronic devices and Circuits	**Syllabus revision:** r.2
Course Category: Program core	**Course Type:** Theory

Course description

1	To introduce basic semiconductor devices, their characteristics and application
2	To understand analysis and design of simple OP-AMP circuit
3	To use OP-AMP as a filter circuit
4	To discuss about various analog integrated circuit
5	To discuss about integrated circuit fabrication technology

Course outcomes:
On successful completion of the course the students will be able to

CO1	Demonstrate an understanding of the operation of operational amplifier and its characteristics
CO2	Discuss the effects of closed loop configuration and study the different types of oscillator circuits.
CO3	Design and analyze the performance of active filter and timer circuits
CO4	Discuss the effects of negative feedback on amplifier circuits and study the different types of oscillator circuits.
CO5	Understand the various IC fabrication techniques

CO	PO	PSO

	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
1	M													M		
2	L	M	L	M									L	L		
3	L	M	L	M	M								L	L		
4	L	M	L	M								M	L	L		
5	M	L	M										L	M		

H – High, M – Medium, L – Low

Unit 1	**CHARACTERISTICS AND APPLICATION OF OP-AMP**	**Hours: 9**

D.C Characteristics of ideal op-amp, pin configuration of 741 op-amp, bias, offsets, drift, bandwidth, A.C characteristics – slew rate, frequency compensation, Applications – inverting and non-inverting amplifiers, Carrier Amplifier, Isolation Amplifier, Chopper Amplifier, Instrumentation Amplifier, Differentiator, integrator, log and antilog amplifiers.

Unit 2	**COMPARATOR AND SIGNAL GENERATORS**	**Hours: 9**

Comparator-regenerative comparators, input output characteristics, Signal generators-monostable,astable multivibrator, Triangular wave generator, R-C Phase shift oscillator, Wein bridge oscillator

Unit 3	**ACTIVE FILTER AND TIMERS**	**Hours: 9**

Filter-low pass, high pass filters, Band Pass, Band Reject filters, Butterworth filters first and second order filters, Switched capacitor filters, 555 timers' functional diagram, Monostable operation, Astable Operation

Unit 4	**ANALOG ICS**	**Hours: 9**

PLL-basic block diagram, operation, capture range and lock range, simple applications, AM detection, FM detection, FSK demodulation, ADC and DAC-weighted resistor, R-2R& inverted R-2R DAC, Monolithic DAC, Flash ADC, counter type ADC, Dual slope ADC, successive approximation ADC, Conversion times of typical ADC, voltage regulator –series op amp regulator IC voltage regulator, IC 723 general purpose regulator, switching regulator, optocoupler IC.

Unit 5	**INTEGRATED CIRCUIT FABRICATION TECHNOLOGY**	**Hours: 9**

Introduction, Monolithic IC Technology-planar process, BJT& FET fabrication, CMOS,MEMS and Nano Technology, Monolithic diodes, metal semiconductor contact, IC resistor, IC capacitors, Integrated circuit packaging.

	Total Lecture hours	**45**

Text Books	
1	Op–amps and Linear Integrated Circuits, Ramakant A. Gayakward, 4th Edition, Pearson Education
2	Linear Integrated Circuits, Roy Choudhary and D., SheilB.Jani 3rd Edition, New Age International
Reference Books	
1	Adel S. Sedra, Kenneth C. Smith & Arun N. Chandorkar, Microelectronic Theory and Applications, 2013, Fifth edition, Reprint, Oxford University press, New York, USA.
2	B G.Streetman and S.Banerjee, Solid State Electronic Education, 2015, Seventh edition, New Delhi, India
3	Robert F.Coughlin., Fredrick F.Driscoll, Op–amp and Linear Ics,6th Edition, Pearson Education
4	Franco, Design with Operational Amplifier and Analog Integrated Circuits, 3rd Edition, McGraw Hill Education (India) Private Limited

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Course Code	Course Name	L	T	P	X	C
212BME2119	PATHOLOGY AND MICROBIOLOGY	2	0	0	0	2

Prerequisite: Nil	**Syllabus revision:** r.3
Course Category: Program Core	**Course Type:** Theory

Course description

Pathology and Microbiology course offers fundamental knowledge on general pathologic mechanisms, and various pathologic conditions related to the body fluids. It also involves the study of microorganisms with particular emphasis on the biology of bacteria and viruses, and their impact on humans.

Course outcomes:
On successful completion of the course the students will be able to

CO1	Illustrate the different types of Cell degeneration, how and when it gets repaired.
CO2	Understand different pathologic conditions related to the body fluids
CO3	Illustrate the structure and function of different types of microorganisms.
CO4	Demonstrate various culture techniques for growing microbes and to visualize them through staining
CO5	Interpret the response of the human body when a microbe enters the human system and the techniques to confirm the presence of microbe.

CO	**PO**												**PSO**			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**	**4**
1	H		M	L									H			H
2	H		M										H			H
3	H												H			H
4	H				M	H							H			H

5	H				M	H							H			H

H – High, M – Medium, L – Low

Unit 1	**GENERAL PATHOLOGY**	**Hours: 06**
Cell injury and Necrosis, Apoptosis, Intracellular accumulations, Pathological calcification, Inflammation and Repair, Neoplasia, Classification, Benign and Malignant tumors, carcinogenesis, spread of tumors. Autopsy and biopsy.		
Unit 2	**FLUID AND HEMODYNAMIC DERANGEMENTS**	**Hours: 06**
Edema, normal hemostasis, thrombosis, disseminated intravascular coagulation, embolism, infarction, shock. Hematological disorders – Leukaemia, Lymphomas.		
Unit 3	**STRUCTURE AND FUNCTION OF MICROORGANISMS**	**Hours: 06**
Structure of the bacterial cell wall, appendages of bacteria – Pili and flagella, capsule, slime and bacterial endospores, Overview of Viruses, Structure and classification, multiplication of fungi, Disease caused by virus and fungi		
Unit 4	**MICROBIAL GROWTH**	**Hours: 06**
Growth curve of bacteria, identification of bacteria, culture media and its types, culture techniques and observation of culture. Principle of Light and Electron Microscope. Staining techniques: Simple, Gram and AFB staining.		
Unit 5	**IMMUNOPATHOLOGY**	**Hours: 06**
Natural and artificial immunity; Innate and acquired immunity, opsonization, phagocytosis, inflammation, Immune deficiency syndrome, antibodies and its types; antigen and antibody reactions, immunological techniques: immune diffusion, immunoelectrophoresis, RIA and ELISA, monoclonal antibodies.		
	Total Lecture hours	**30**

Text Books

1	Ramzi S Cotran, Vinay Kumar & Stanley L Robbins, “Pathologic Basis of Diseases”, 7th edition, WB Saunders Co. 2005 (Units I & II)

Reference Books

1	Ananthanarayanan&Panicker, “Microbiology” Orientblackswan, 2017 10th edition. (Units III,IV and V).
2	Prescott, Harley and Klein, “Microbiology”, 10th edition, McGraw Hill, 2017
3	Prescott, LM, Microbiology, 6th ed. 2005, McGraw-Hill.

4	Atlas, RM., Principles of Microbiology. 2nd ed.,1997, McGraw-Hill
5	Underwood JCE: General and Systematic Pathology Churchill Livingstone, 3rd edition, 2000.

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Course Code	Course Name	L	T	P	X	C
212BME2320	SENSORS AND DATA ACQUISITION	2	0	0	3	3

Prerequisite:	**Syllabus revision:** r.3
Course Category: Program core	**Course Type:** Theory with "X" component

Course description

This course educates students to about the principle of operation of different sensors and their applications in the use, selection, and design of instrumentation and data acquisition systems for agricultural, food, environmental and biological systems. Measurement of position (GPS), force, pressure, power, torque, flow, temperature and environmental sensors will be emphasized. Labs will focus on building and using measurement systems, and programming PC computers for data acquisition and analysis.

Course outcomes:
On successful completion of the course the students will be able to

CO1	Understand the principle of operation of different sensors and their applications
CO2	Be updated on the recent trends in sensor technologies.
CO3	Design a wireless sensor network
CO4	To learn the fundamentals of signal conditioning, data acquisition and communication systems used in mechatronics system development.
CO5	Solve design and modelling issue using complex engineering mathematics

CO	**PO**												**PSO**			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**	**4**
1	M	M		M	M	L		L	L	L		L	M			
2	M	M		M	M	L		L	L	L		L		M		
3	M			M	M	L		L	L	L		L			L	

4	H	M										L				M
5	H	H	L	M	M	L	L					L				H

H – High, M – Medium, L – Low

Unit 1	**INTRODUCTION**	**Hours: 6**

Introduction to smart sensors, Principles of operation, design approach, interface design, configuration supports.

X – Component: a) Introduction to MATLAB & SIMULINK and LabVIEW,Implementation of data acquisition with using of DAQ.

Unit 2	**DATA TRANSMISSION**	**Hours: 6**

Components of Measuring- Inputs and Outputs- Origin of Signals–Transducer-Sensors-General Signal Conditioning Functions-Analog-to-Digital Control-Digital-to-Analog Control-Pulse Codes-Analog and Digital Modulation Techniques-Wireless Communication-RF Network Analyser-Distributed Automation and Control Systems-SCADA-Architecture-Security Concerns-

X – Component: Usage of Input and Output Ports for data Transmission, Controlling of Analog and digital I/O, Using of domestic monitoring system based IoT.

Unit 3	**MEMS SENSOR**	**Hours: 6**

MEMS sensor, Comparison between MEMS and Macro sensor, Fabrication and packaging issue in sensor design Thick film and thin film technique Physical sensors. Bio sensor, Silicon sensor, RF Sensor, sensors for robotics.

X – Component: IoT based domestic monitoring and alerting system for paralyzed patient.

Unit 4	**SIGNAL CONDITIONING and DAQ SYSTEMS**	**Hours: 6**

Amplification – Filtering – Sample and Hold circuits – Data Acquisition: Single channel and multi-channel data acquisition – Data logging – applications – Automobile, Aerospace, Home appliances, Manufacturing, Environmental monitoring-Fiber–Optic Instrumentation – Fiber-Optic Sensors – Fiber–Optic Pressure Sensors – Fiber–Optic Voltage Sensor – Fiber–Optic Liquid LevelMonitoring–OpticalFiberTemperatureSensors–Fiber–OpticStressSensorFiber–OpticGyroscope Polarization Maintaining-GratingsinFiber–Advantages of Fiber Optics Instrumentation.

X – Component: Ultrasonic stick for blind people.

Unit 5	**APPLICATIONS**	**Hours: 6**

Design and 47imulink47 issue in advanced sensing technique. Introduction of different mathematical tools used in sensor design. LASER Heating, Welding, Melting and Trimming-Laser Trimming and Melting-Smart Instruments-Calibration and Standards-Topics in Intelligent Instrumentation – The role of PCA, LDA,

X – Component: Neural network in designing sensor array-Lie detector.

Total Lecture hours	**30+45**

Text Books		
1	Kirianaki, Nikolay V., Sergey Y. Yurish, Nestor O. Shpak, and Vadim P. Deynega. Data acquisition and signal processing for smart sensors. Chichester, England: Wiley, 2002.	
Reference Books		
1	H Rosemary Taylor, "Data Acquisition for Sensor systems", 2013, 1stedition, Springer Publishing, U.S	
2	Maurizio Di Paolo Emilio., "Data Acquisition Systems" From Fundamentals to Applied Design, 2013, Springer, New York.	
List of experiments suggested ("X" Component)		
Sl. No.	**Title**	**Hours**
1	To introduce to the LabView software.	3
2	Introduction to LabView software package and an introduction to data acquisition.	3
3	Introduce the concepts of precision, bias, calibration, linearity and other ideas best discussed when monitoring a static system.	3
4	Calibration of Sensors	3
5	Introduce to basic concepts of electrical circuits (DC and AC) and their components for data acquisition	3
6	Introduce the concepts of sensor responsiveness; zeroth, first, and second order sensors	3
7	Determine the time constant of various temperature sensors when exposed to changing conditions.	3
8	Basics of signal transmission, signal noise, and grounding for safety and signal transmission	3
9	Basics of signal conditioning including passive and active, low- and high-pass filter circuits	3
10	Transducers for measuring displacement	3
	Total Lecture hours	**30**

Course Code	Course Name	L	T	P	X	C
212BME2318	MICROPROCESSORS AND MICROCONTROLLERS	3	0	2	0	5

Prerequisite: Electronic devices and Circuits	**Syllabus revision:** r.3
Course Category: Program core	**Course Type:** Integrated Course

Course description

1	To introduce basic Microprocessor and Microcontrollers.
2	To understand analysis the instruction sets, programming of 8-bit Microprocessor 8085.
3	To discuss about interfacing IC for basic microprocessor and microcontroller.
4	To discuss about 8051 microcontroller.
5	To apply the inculcated knowledge for developing simple applications.

Course outcomes:
On successful completion of the course the students will be able to

CO1	Describe fundamental of Microprocessor and Microcontrollers.
CO2	Illustrate the architecture and analyze the instruction sets, programming of 8-bit Microprocessor 8085.
CO3	Study the different peripheral devices and their interfacing to 8085.
CO4	Illustrate the architecture of 8051 microcontroller.
CO5	Study the interrupt and timers of 8051 microcontroller and design the microcontroller based control circuit for electrical and electronics applications.

CO	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
1	S						S					S	S			
2		L	M	M	M		L	L				M				
3			L	L	M		L					L				
4	S	L	L		L								S			
5	L	L	S	L	S		L	L				L	L			

H – High, M – Medium, L – Low

Unit 1	FUNDAMENTALS OF MICROPROCESSORS AND MICROCONTROLLER	Hours: 9

Introduction- Importance of Microprocessor and Microcontrollers , origin and evolution of microprocessors, Classification of Microprocessor , Microcontrollers and memories, Common input and output devices for computers, Bus structures used in computers and technology improvements

Unit 2	8085 MICROPROCESSOR	Hours: 9

8085 architecture – Instruction set – Addressing modes- Timing diagram – Assembly Language Programming – Counters time delays – Interrupts , 8086 Architecture -Instruction set – Addressing modes

Unit 3	MICROPROCESSOR INTERFACING TECHNIQUES	Hours: 9

Interfacing serial I/O (8251) – Parallel I/O (8255) – RS232, SPI, I2C, Introduction and interfacing to protocols like Blue-tooth and Zigbee. Keyboard and display controller (8279) – ADC/DAC interfacing.

Unit 4	8051 MICROCONTROLLER	Hours: 9

8051 microcontroller hardware – I/O Pins, Ports and circuits – external memory, 8051 Instruction set – Addressing Modes – counters and timers – serial data input and output – interrupts – Interfacing to external memory and 8255.

Unit 5	8051 PROGRAMMING AND APPLICATIONS	Hours: 9

Assembly Language Programming – I/O Port Programming – Timer and counter Programming – Serial Communication – Interrupt Programming – 8051 Interfacing with LED, ADL, Sensors, Stepper Motor, keyboard, C language programs. Assemblers and compilers. Programming and debugging tools.

	Total Lecture hours	45

Text Books		
1	Gaonkar, R.S., Microprocessor Architecture Programming and Application, Wiley Eastern Ltd., New Delhi, 2005.	
2	M. A.Mazidi, J. G. Mazidi and R. D. McKinlay, "The8051Microcontroller and Embedded Systems: Using Assembly and C",Pearson Education, 2007.	
Reference Books		
1	Hall, D.V., Microprocessor and Interfacing Programming and Hardware, Tata McGraw Hill Publishing Company, 2nd edition, 2012	
2	YuCheng Liu & Glenn A Gibson, Microcomputer System, 8086/8088 Family, 2nd edition, Prentice Hall of India, 2005	
3	Rafiquzzaman M., Microprocessor Theory and Application – Intel and Motorola, Prentice Hall of India, 2007.	
4	Raj Kamal, Microcontrollers: Architecture, Programming, Interfacing and System Design, 5th edition, Pearson Education India	
5	Tze Ying Sim, Effectiveness of the Methods for Engineering Courses in a Large Non Homogeneous class setting, Kassel University Press.	
Practical Component		
Sl. No.	**Experiments**	**Hours**
	Introduction to Digital Trainer Kit	**4**
1	Simple arithmetic operations in 8085 Microprocessor	6
2	ADC and DAC interfacing using 8085 Microprocessor	6
3	Arithmetic operation with 8051 execution.	2
4	Sine wave and Square wave generation in 8051 micro controller	2
5	ADC and DAC interfacing using 8051 micro controller	2
6	Stepper motor control using 8051 micro controller	2
7	Servomotor control using 8051 micro controller	2
8	Seven segment display using 8051 micro controller	2
9	Basic programming using KEIL IDE	2
10	Traffic light control using 8051 Microcontroller	2
	Total Lecture hours	**32**

Course Code	Course Name	L	T	P	X	C
212BME2313	BIOMECHANICS	2	0	0	3	3

Prerequisite: Nil	**Syllabus revision:** r.3
Course Category: Program core	**Course Type:** Theory

Course description

To provide students with an understanding of the internal and external forces acting on the body during human movement through mechanics. To generate force and controlling movement by muscles is emphasized.

Course outcomes:
On successful completion of the course the students will be able to

CO1	To describe the fundamental of biomechanics
CO2	Understand and describe the properties of blood, bone and soft tissues like articular cartilage tendons and ligaments.
CO3	Able to understand the unique features of biological flows, especially constitutive laws and boundaries and approximation methods in fluid mechanics and their constraints.
CO4	Gain broad knowledge about the mechanics of moving systems and familiarity with human anatomy to competently analyze gross movement of the human body.
CO5	Be able to computationally analyze the dynamics of human movement from the most commonly used measurement devices in the field, such as motion capture and force platform systems.

CO	PO												PSO			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**	**4**
1	H	M	L	L		L	L		L			H	H	L	M	M
2	H	L	L	M	L	H	M	M	M	M	M	H	H	M	L	M
3	H	L	M	H	L	H	M	M	M	M	M	H	H	M	L	M

4	H	H	M	M	M	H	M	M	M	M	M	H	H	H	M	M
5	H	H	M	M	M	H	M	M	M	M	M	H	H	H	M	M

H-High, M-Medium, L-Low

Unit 1	**INTRODUCTION TO BIOMECHANICS**	**Hours: 09**

Principles of Mechanics, Vector mechanics, Mechanics of motion – Newton's laws of motion, Kinetics, Kinematics of motion, Resultant forces of Coplaner&Noncoplaner and Concurrent & non-concurrent forces, parallel force in space, Equilibrium of coplanar forces, Work and energy, Moment of inertia.

Unit 2	**TISSUE BIOMECHANICS**	**Hours: 09**

UNIT II: Tissue Biomechanics

Hard Tissues: Bone structure & composition mechanical properties of bone, cortical and cancellous bones,. Electrical properties of bone, type of fractures, biomechanics of fracture healing.

Soft Tissues: Structure and functions of Soft Tissues: Cartilage, Tendon, Ligament, and Muscle; Material Properties: Cartilage, Tendon, Ligament, and Muscle; Modeling: Cartilage, Tendon, Ligament, and Muscle.Viscoelastic properties, Maxwell & Voight models – anisotropy

Unit 3	**BIOFLUID MECHANICS**	**Hours: 09**

Stress, strain, elasticity, Hooke's law, viscosity, Newtonian fluid, Non- Newtonian fluid, viscoelastic fluids. Euler equations and Navier Stoke's equations, Viscoelasticity, Constitutive equations. Rheological properties of blood, laminar flow, Velocity and pressure of blood flow, Resistance against flow, Vascular tree. Relationship between diameters, material properties of Blood vessels. Flow properties of blood in the intact human cardiovascular system.

Unit 4	**JOINTS BIOMECHANICS AND IMPLANTS**	**Hours: 09**

Skeletal joints, forces and stresses in human joints, Analysis of rigid bodies in equilibrium, free body diagrams, types of joint, biomechanical analysis of elbow, shoulder, hip, knee and ankle. Design of orthopedic implant, specifications for a prosthetic joint, biocompatibility, Introduction to the requirement and characteristics of different types of biomaterials, manufacturing process of implants, fixation of implants.

Unit 5	**Movement Biomechanics**	**Hours: 09**

Gait analysis, body & limbs: mass & motion characteristics actions, forces transmitted by joints. Joints forces results in the normal & disable human body, normal & fast gait on the level. Patterns: Push/Throw Continuum Biomechanics of push – like motions, Biomechanics of throw – like motions.

Total Lecture hours	**45**

Text Books

1	Duane Knudson, "Fundamentals of Biomechanics", Second Edition Springer Science+Business Media, 2007
2	Marcelo Epstein, "The Elements of Continuum Biomechanics", ISBN: 978-1-119-99923-2, 2012.
3	Fung, Y.C. "Biomechanics Mechanical Properties of Living Tissues", New age international, ISBN: 978-81-8128-811-0, 2007
4	Carol A. Oatis, The Mechanics and Pathomechanics of Human Movement, Lippincott Williams & Wilkins, 2010

Reference Books

1	Jay D. Humphrey, Sherry De Lange, "An Introduction to Biomechanics: Solids and Fluids, Analysis and Design" , Springer Science+Business Media, 2004.
2	Shrawan Kumar, "Biomechanics in Ergonomics", Second Edition, CRC Press 2007.
3	White &Puyator, Biomechanics, Private publication UAE, 2010

List of experiments suggested ("X" Component)

Sl. No.	Title	Hours
1	Teaching about the basics of solid works software and Introduction to the mechanics of motion and forces.	05
2	Design a human femur bone by using the given dimensions	05
3	Design and modelling of blood vessels by using the given dimensions.	05
4	Design and modelling of human knee joint using the given dimensions.	05
5	Design an artificial leg by using the given dimensions.	05
	Total laboratory hours	**25**

Course Code	Course Name	L	T	P	X	C
212BME2117	Medical Imaging Techniques	3	0	0	0	3

Prerequisite: Nil	**Syllabus revision:** r.1
Course Category: Program Core	**Course Type:** Theory

Course description:
This course aims to develop an understanding of the different modalities in Radiology and recognize the images of each modality. This also helps in understanding of the applications of physical processes to the diagnosis and treatment of disease, including an understanding of contemporary developments in professional practice.

Course outcomes:
On successful completion of the course the students will be able

CO1	To describe the working principle of X ray machine and its application.
CO2	To illustrate the principle computed tomography.
CO3	To interpret the technique used for visualizing various sections of the body using magnetic resonance imaging.
CO4	To demonstrate the applications of radio nuclide imaging.
CO5	To relate the utilization of ultrasound in medicine.

CO	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
1	M	M	M	M									M			M
2	M	M	M	M									M			M
3	M	M	M	M		M							M			M

4	M	M	M	M									M			M
5	M	M	M	M		M							M			M

H – High, M – Medium, L – Low

Unit 1	**X-ray Radiography**	**Hours: 12**

Fundamentals of X-ray production, Conventional X-Ray Tubes, Energizing and Controlling the X ray Tube – Tube Voltage and Voltage Waveforms, Relationship between Filament Current And Tube Current, Emission Spectra, Collimation and Filtration, Factors Influencing X ray spectra and output, Tube Vacuum, Envelope and Housing, Special-Purpose X-Ray Tubes, Instrumentation for planar radiography – collimator, anti-scatter grids, Digital radiography, Quantitative characteristics of planar X-ray images, X-ray contrast agents, Specialized X-ray imaging techniques.

Unit 2	**Computed Tomography**	**Hours: 5**

Principles of CT – X ray projection, attenuation and acquisition of transmission profiles, Hounsfield units, CT Imaging System – Historical and current acquisition configurations, Gantry and table, The X ray tube and generator, Collimation and filtration, Detectors, Image reconstruction and processing – General concepts, Object space, image space and Radon space, Filtered back projection and other reconstructions, Acquisition - CT Image Quality

Unit 3	**Magnetic Resonance Imaging**	**Hours: 10**

Principles of nuclear magnetism, RF magnetic field and resonance, magnetic resonance (MR) signal, nuclear spin relaxations, gradient pulse, slice selection, phase encoding, frequency encoding, spin echoes, gradient echoes, K-space data acquisition and image reconstruction. MRI scanner hardware: magnet, gradient coil, RF pulse transmission and RF signal reception. Diagnostic utility and clinical MRI, functional MRI, magnetic resonance angiography (MRA), magnetic resonance spectroscopy (MRS), diffusion MRI, bio-effects and safety levels.

Unit 4	**Nuclear Imaging**	**Hours: 8**

Nuclear medicine –Radioactivity and radiotracer half-life, Properties of radiotracers for nuclear medicine, The distribution of technetium-based radiotracers within the body, The gamma camera, Single photon emission computed tomography (SPECT), Data processing in SPECT, SPECT/CT, Clinical applications of SPECT and SPECT/CT, Positron emission tomography (PET), Radiotracers used for PET/CT, Instrumentation for PET/CT, Two-dimensional and three-dimensional PET imaging, Data processing in PET/CT, Clinical applications of PET/CT

Unit 5	**Ultrasound Imaging**	**Hours: 10**

Wave propagation and characteristic acoustic impedance, Wave reflection, refraction and scattering in tissue, Absorption and total attenuation of ultrasound, Instrumentation¸ Single element ultrasound transducers, Transducer arrays, Clinical diagnostic scanning modes, Image characteristics¸ Doppler ultrasound for blood flow measurements¸ Ultrasound contrast agents,

Safety guidelines in ultrasound imaging, Clinical applications of ultrasound, Artifacts in ultrasound imaging.	
Total Lecture hours	**45**
Text Books	
1	Smith, Nadine Barrie, and Andrew Webb. *Introduction to medical imaging: physics, engineering and clinical applications*. Cambridge university press, 2010.
2	Hendee, William R., and E. Russell Ritenour. *Medical imaging physics*. John Wiley & Sons, 2003.
3	S.Webb, *The Physics of Medical Imaging.* Taylor & Francis Group, 1988.
Reference Books	
1	Saha, Gopal B. *Physics and radiobiology of nuclear medicine*. Springer Science & Business Media, 2012.
2	Dance, D. R., et al. *"Diagnostic radiology physics: A handbook for teachers and students.* Endorsed by: American Association of Physicists in Medicine, Asia-Oceania Federation of Organizations for Medical Physics, European Federation of Organisations for Medical Physics." (2014).

Course Code	Course Name	L	T	P	X	C
212BME2314	Diagnostic & Therapeutic Instruments-I	3	0	2	0	4

Prerequisite: Medical Electronics, Medical Physics	**Syllabus revision:** r.3
Course Category: Program Core	**Course Type:** Integrated Course

Course description

To obtain thorough knowledge on the basic understanding of the diagnostic and therapeutic medical instruments.

Course outcomes:
On successful completion of the course, the students will be able to

CO1	Understand and record the electrical activity of the heart, muscle, and eye
CO2	Understand and measure basic physiological signal measurements
CO3	Understand and apply the diagnostic procedures in ophthalmology &fetal monitoring instruments.
CO4	Understand the therapeutic procedures in the cardiovascular system
CO5	Understand the therapeutic procedures in assisting ventilation, hearing.

CO	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
1	H		H	H									H			
2	H		H	H									H			
3	H			H									H			
4	M			H									H			
5	M			H									H			

H – High, M – Medium, L – Low

Unit 1	**Diagnostic Instruments part 1**	**Hours: 09**
Monitoring and recording of ECG, EEG, EMG, PCG, EOG, electrodes for physiological measurement, Recording system.		
Unit 2	**Diagnostic Instruments part 2**	**Hours: 09**
Heart rate, blood pressure, temperature, respiration rate & cardiac output measurement, Blood flow measurement.		
Unit 3	**Diagnostic Instruments part 3**	**Hours: 09**
Cardiac monitor, Patient Monitoring System, Pulmonary function analyzer, Endoscopes, Laryngoscope, Ophthalmoscope, fetal monitoring instruments, oximeters.		
Unit 4	**Therapeutic Instruments part 1**	**Hours: 09**
Cardiac Defibrillators, Pacemakers, blood warmers, Heart-Lung machine, Intravenous blood administration pumps, Haemodialysis, electro surgery machine.		
Unit 5	**Therapeutic Instruments part 2**	**Hours: 09**
Ventilators, humidifiers, oxygen concentrators, CPAP, BiPAP, Anaesthesia equipment, Lithotriptors, hearing aids, audiometer.		
	Total Lecture hours	**45**
Text Books		
1	Street, L. J. (2016). Introduction to Biomedical Engineering Technology. United States: CRC Press.	
Reference Books		
1	Handbook of Biomedical Instrumentation. (2003). India: McGraw-Hill Education (India) Pvt Limited.	
2	Pfeiffer, E. A., Weibell, F. J., Cromwell, L. (2011). Biomedical Instrumentation and Measurements. United States: Prentice-Hall.	
3	Khandpur, R. S. (2020). Compendium of Biomedical Instrumentation, 3 Volume Set. United Kingdom: Wiley.	
4	Medical Instrumentation: Application and Design. (2020). United Kingdom: Wiley.	

Laboratory Components

Sl. No.	Experiments	Hours per week
1	Recording of ECG, EMG, EEG signal	02

2	Design and implementation of instrumentation amplifier	02
3	Design and implementation of optical isolation amplifier	02
4	Design and implementation of the acquisition of ECG signal	02
5	Temperature & heart rate measurement	02
6	Audiometer	02
7	Surgical diathermy	02
8	Study of biotelemetry	02
9	Shortwave and ultrasonic diathermy	02
10	Electrical safety measurements	02
11	Study of ESU – cutting and coagulation modes.	02
12	Measurement of visually evoked potential	02
13	Patient Monitoring System	02
14	Doppler blood flow monitoring	02
15	Blood pressure measurement	02
	Total practical hours	**30**

Course Code	Course Name	L	T	P	X	C
212BME3337	Digital Signal Processing	2	2	2	0	4

Prerequisite: Nil	**Syllabus revision:** r.3
Course Category: Program Core	**Course Type:** Integrated Course

Course description: This course aims to equip students with the fundamental tools that are used to describe and analyse the various types of signals and systems along with their characteristics. This course builds a strong base for developing algorithms for signal processing systems and enables the students to understand the effects of word length in digital signal processing.

Course outcomes:
On successful completion of the course the students will be able

CO1	To understand the basic types and properties of signals and systems.
CO2	To analyse Continuous and Discrete time domain signals by applying Z-transform and Discrete Fourier transform.
CO3	To design and develop algorithms for IIR filters.
CO4	To design and develop algorithms for FIR filter design using different techniques.
CO5	To understand the effects of finite word length in digital Filters.

CO	PO												PSO			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**	**4**
1	H	H	M			M							H	H		
2	H	H	H			H							H	H		

3	H	H	H			H							H	H		
4	H	H	H			H		M					H	H		
5	H	H	M			H							H	H		

H – High, M – Medium, L – Low

Unit 1	**Signals and Systems**	**Hours: 12**

Introduction and Classification of signals: Definition of signal and systems, communication and control systems as examples. Sampling of analog signals, Continuous time and discrete time signal, Classification of signals as even, odd, periodic and non-periodic, deterministic and non-deterministic, energy and power. Elementary signals/Functions: exponential, sine, impulse, step and its properties, ramp, rectangular, triangular, signum, sync functions. Operations on signals: Amplitude scaling, addition, multiplication, time scaling, time shifting and time folding.
Systems: Definition, Classification: linear and nonlinear, time variant and invariant, causal and non-causal, static and dynamic, stable and unstable, invertible.

Unit 2	**Z Transform and Discrete Fourier Transforms**	**Hours: 12**

Z-Transform: Direct Z-Transform, Properties of the Z-Transform, Examples, Inverse Z-Transform by Partial- Fraction Expansion method – Causality and Stability.
Introduction to DFT – Properties of DFT – Circular Convolution – Filtering methods based on DFT – FFT Algorithms –Decimation in time Algorithms, Decimation in frequency Algorithms – Use of FFT in Linear Filtering.

Unit 3	**Infinite Impulse Response Filter**	**Hours: 12**

Structures of IIR systems: Direct form, Cascade form, Parallel form structures – Analog filter design – Discrete time IIR filter from analog filter – IIR filter design by Impulse Invariance, Bilinear transformation, Approximation of derivatives – (LPF, HPF, BPF, BRF) filter design using frequency translation.

Unit 4	**Finite Impulse Response Filter**	**Hours: 12**

Structures of FIR – Linear phase FIR filter – Fourier Series – Filter design using windowing techniques (Rectangular Window, Hamming Window, Hanning Window), Frequency sampling techniques – Implementation of FIR filters by direct form realization.

Unit 5	**Finite Word Length Effects in Digital Filters**	**Hours: 12**

Fixed point and floating point number representation – ADC – quantization – truncation and rounding – quantization noise – input / output quantization – coefficient quantization error –

product quantization error – overflow error – limit cycle oscillations due to product quantization and summation – scaling to prevent overflow.Multirate Digital Signal Processing: Decimation and Interpolation process.

Total Lecture hours	**60**

Text Books

1	John G. Proakis& Dimitris G.Manolakis, "Digital Signal Processing – Principles, Algorithms & Applications", Fourth Edition, Pearson Education / Prentice Hall, 2007.
2	A.V.Oppenheim, R.W. Schafer and J.R. Buck, "Discrete-Time Signal Processing", 8th Indian Reprint, Pearson, 2004.

Reference Books

1	Andreas Antoniou, "Digital Signal Processing", Tata Mc Graw Hill, 2006.
2	Sanjit K. Mitra, "Digital Signal Processing – A Computer Based Approach", Tata Mc Graw Hill, 2007.
3	Emmanuel C.Ifeachor, & Barrie.W.Jervis, "Digital Signal Processing", Second Edition, Pearson Education / Prentice Hall, 2002.

Laboratory Components

S. No	List of Experiments	Hours
	Introduction to MATLAB and Basic commands	4
1	Representation of Continuous and Discrete time signals.	4
2	Computation of Linear and Circular Convolution.	2
3	DFT and IDFT of a Sequence.	2
4	Design of IIR Butterworth and Chebyshev filter.	2
5	Design of FIR filter using windowing techniques.	2
6	Design a Notch Filter of 50 Hz to Remove the Power Line Interference in Acquired ECG Signal.	2
7	Design a Low Pass Filter of Defined Cut-Off Frequency to Remove the High Frequency Noises in Acquired ECG Signal.	2
8	Design a High Pass Filter of Defined Cut-Off Frequency to Remove the Low Frequency Noises in Acquired ECG Signal.	2
9	Signal Averaging of ECG	2
10	Perform a Spectral Analysis of ECG Signal	2

11	EMG processing using MATLAB –Rectification and Signal Averaging.	2
12	Detection of R Peak and R-R Interval from Acquired ECG Signal	2
	Total Hours	**30**

Course Code	Course Name	L	T	P	X	C
212BME3336	Digital Image Processing	3	0	3	0	4

Prerequisite: Nil	**Syllabus revision:** r.3
Course Category: Program Core	**Course Type:** Integrated Course

Course description

To study the image fundamentals and mathematical transforms necessary for image processing.
To study the image enhancement techniques
To study image restoration procedures.
To study the image compression procedures.

Course outcomes:
On successful completion of the course the students will be able to

CO1	Understand x-ray, ultrasound, and magnetic resonance interactions with tissue and the various components of imaging systems.
CO2	Use fundamentals of mathematics and physics to analyze image data.
CO3	Understand modern imaging devices and their application in medicine and industry.
CO4	Demonstrate understanding of image data collection, resolution, reconstruction, storage, processing, visualization, fusion, and communication.
CO5	Develop a competence in the Fundamental analytical and computational tools used in medical imaging.

CO	PO	PSO

	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
1	H	H			L								H			
2	H	H											H			
3					H	L	L							M		L

4			L	M	H	M						L		M		L
5	H	L	M	M	H	M							H			

H – High, M – Medium, L – Low

Unit 1	**DIGITAL IMAGE FUNDAMENTAL**	**Hours: 9**

Elements of digital image processing systems, Elements of Visual perception, Image sampling and quantization, – Gray scale and Color images, Some Basic relationships between pixels, Matrix and Singular Value representation of discrete images.

Unit 2	**IMAGE TRANSFORMS**	**Hours: 9**

1D DFT, 2D DFT, Cosine, Sine Hadamard, Haar, Slant, KL transform and their properties.

Unit 3	**IMAGE ENHANCEMENT**	**Hours: 9**

Basic gray level Transformations, Histogram – Modification and specification techniques, Enhancement by point processing Image smoothening, Image sharpening, Image Segmentation, generation of spatial masks from frequency domain specification, Homomorphic filtering, and color image processing.

Unit 4	**IMAGE RESTORATION AND RECONSTRUCTION OF MEDICAL IMAGES**	**Hours: 9**

Noise Models, Noise Reduction, Image degradation models, Unconstrained and Constrained restoration, inverse filtering, Least mean square filter, Image reconstruction from projections – Radon transforms, Filter back projection algorithm, 3D tomography, Fourier reconstruction of MRI Images.

Unit 5	**MEDICAL IMAGE COMPRESSION TECHNIQUES**	**Hours: 9**

Run length, Huffman coding, arithmetic coding, Pixel coding, transform coding, JPEG Standard, predictive techniques, Application of image processing techniques in thermography, SPECT, PET images. Case studies –Medical image analysis Application of Image processing in healthcare

	Total Lecture hours	**45 + 30**

Text Books

1	Rafael C., Gonzalez and Richard E. Woods, Digital Image Processing, Pearson Education Asia, 2001
2	Anil K. Jain, Fundamentals of Digital Image Processing, Prentice Hall of India, 1997.

Reference Books

1	William K. Pratt, Digital Image Processing, John Wiley, NJ, 1987.
2	Albert Macouski, Medical Imaging systems, Prentice Hall, New Jersey.1983.

3	Sid Ahmed M.A., Image Processing Theory, Algorithm and Architectures, McGraw Hill, 1995.

List of experiments

Sl. No.	Title	Hours
1	Digital image Fundamentals – Sampling and quantization.	3
2	Image Enhancement – Spatial filtering, Filtering in frequency domain	3
3	Removal of noise in medical images.	3
4	Image Transformation in spatial domain and frequency domain.	3
5	Edge detection and boundary tracing techniques.	3
6	Region based processing	3
7	Color image processing	3
8	Basic Morphological operations.	3
9	Image compressions.	3
10	Image segmentation by Thresholding	3
	Total laboratory hours	**30**

PROGRAM ELECTIVES

Course Code	Course Name	L	T	P	X	C
213BME2124	Design of Medical Instruments	3	0	0	0	3

Prerequisite: BME21R251, BME21R404	**Syllabus revision:** r.3
Course Category: Program Elective	**Course Type:** Theory

Course description

To understand and analyze the design procedures in medical instruments from idea to product realization

Course outcomes:
On successful completion of the course, the students will be able to

CO1	To understand the medical device classification and design criteria in medical instruments
CO2	To understand the feasibility, reliability and human factors in design of medical instruments.
CO3	To analyze the risk and safety analysis in the design of medical instruments
CO4	To analyze the validation and verification in medical instruments design
CO5	To understand the manufacturing of medical devices

CO	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
1			H								H	H		H		
2			H		H						H	H		H		
3			H		H						H	H		H		
4			H		H						H	H		H		

5			H								H	H		H		

H – High, M – Medium, L – Low

Unit 1	**Introduction**	**Hours: 09**
General Medical Instrumentation System, Medical Measurement Constraints, Alternative Operation modes, Classification of Biomedical Instruments, Interfering and Modifying inputs, Compensation techniques, Design Criteria.		
Unit 2	**Feasibility**	**Hours: 09**
Reliability, failure concept, design & development process, design definition, human factors, requirements engineering, liability, IP, project team, reliability goal & plan.		
Unit 3	**Design**	**Hours: 09**
Safety & risk management, Hardware design & risk analysis, design for six sigma, software design & risk analysis, software coding.		
Unit 4	**Verification & Validation**	**Hours: 09**
Types of testing, Medical device directive – FDA, CE, IEC 60601, ISO 13485 and other standards, hardware & software verification & validation, hardware & software data analysis.		
Unit 5	**Design Transfer & Manufacturing**	**Hours: 09**
Transfer to manufacturing, hardware & software manufacturing, configuration management, field data analysis		
	Total Lecture hours	**45**

Text Books

1	Fries, R. C. (2016). Reliable Design of Medical Devices. United States: CRC Press.
2	King, P. H., Fries, R. C., Johnson, A. T. (2014). Design of Biomedical Devices and Systems, Third Edition. United Kingdom: Taylor & Francis.
3	Perez, R. (2002). Design of Medical Electronic Devices. United States: Elsevier Science.

Reference Books

1	Prutchi, D., Norris, M. (2005). Design and Development of Medical Electronic Instrumentation: A Practical Perspective of the Design, Construction, and Test of Medical Devices. Germany: Wiley.
2	Ogrodnik, P. J. (2012). Medical Device Design: Innovation from Concept to Market. Netherlands: Elsevier Science.

3	Becchetti, C., Neri, A. (2013). Medical Instrument Design and Development: From Requirements to Market Placements. Germany: Wiley.
4	Webster, J. G. (1997). Design of Pulse Oximeters. United Kingdom: CRC Press.

Course Code	Course Name	L	T	P	X	C
213BME2125	GRAPHICAL PROGRAMMING FOR BIOMEDICAL APPLICATIONS	3	0	0		3

Prerequisite: Nil	**Syllabus revision:** NA
Course Category: Program Elective	**Course Type:** Theory

Course description

1	To introduce virtual instrumentation concepts
2	To design VI using LabVIEW
3	To use data acquisition and control in VI
4	To Interface various communication protocol in LabVIEW
5	To apply the inculcated knowledge in LabVIEW for developing simple medical applications

Course outcomes:
On successful completion of the course the students will be able to

CO1	To comprehend and appreciate the significance and role of this course in the present contemporary world
CO2	Identify salient traits of a virtual instrument.
CO3	Understand the use of VI for data acquisition.
CO4	Experiment, analyze and document different types of interfaces
CO5	Apply the virtual instrumentation technologies for medical applications

CO	PO												PSO			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**	**4**
1	L												M	M		
2		M	M										M	M		

3		S	M										M	M		
4		S	S			M		M					M	M		
5		S	M			S		S					M	M		

H – High, M – Medium, L – Low

Unit 1	**Introduction**	**Hours: 9**
History of Virtual Instrumentation(VI), advantages, block diagram and architecture of a virtual instrument, Programming paradigms – Virtual Instrumentation – LabVIEW software – LabVIEW basics – LabVIEW environment.		
Unit 2	**VI Using LabVIEW**	**Hours: 9**
Creating, Editing and debugging a VI in LabVIEW – Creating a sub VI – Loops and charts – Case and sequence structures – File I/O – VI customization.		
Unit 3	**Data Acquisition And Control In VI**	**Hours: 9**
Plug-in DAQ boards – Organization of the DAQ VI System – Performing analog input and analog output – Scanning multiple analog channels – Driving the digital I/Os – Buffered data acquisition – Simple problems		
Unit 4	**Instrument Interfaces**	**Hours: 9**
Current loop, RS 232C/RS 485, Arduino Boards, GPIB, System basics, Interface basics: USB, PCMCIA, networking basics for office & industrial application VISA & IVI, image acquisition & processing, Motion Control. ADC, DAC, DIO, DMM, waveform generator		
Unit 5	**Application of VI In Biomedical Engineering**	**Hours: 9**
Design of virtual applications for Electrocardiography (ECG), Electromyography (EMG), Air Flow and Lung Volume, Heart Rate variability analysis, Noninvasive Blood Pressure Measurement, Biofeedback, Virtual Reality & 3D graphical 72imulink72, Virtual Prototyping.		
	Total Lecture hours	**45**

Text Books	
1	Gary Johnson, “LABVIEW Graphical Programming”, McGraw Hill, 2 nd Edition,1997
2	Sanjay Gupta and Joseph John, “ Virtual Instrumentation using LabVIEW”, Tata Mc Graw – Hill Publishing Company Limited, New Delhi, 1st Edition, 2005.
Reference Books	
1	Kevin James, “PC Interfacing and Data Acquisition: Techniques for Measurement, Instrumentation and Control”, Newnes, 2000.

2	S. Gupta, J.P. Gupta," PC Interfacing for Data Acquisition and Process Control", ISA, 2nd Edition, 1994.
3	Technical Manuals for DAS Modules of Advantech and National Instruments.
4	Jon B. Olansen, Eric Rosow, "Virtual Bio-Instrumentation: Biomedical, Clinical, and Healthcare Applications in LabVIEW" Pearson Education, 2001.

Course Code	Course Name	L	T	P	X	C
213BME1107	PATENT FILING	3	0	0	0	3

Prerequisite: Nil	**Syllabus revision:** NA
Course Category: Program Elective	**Course Type:** Theory

Course description

To understand and implement the procedures and steps involved in patenting procedures and to get granted

Course outcomes:
On successful completion of the course, the students will be able to

CO1	To understand the basic patenting system and the subject contents that can be patented
CO2	To understand the patenting ability towards a subject matter
CO3	To know the patenting application procedure
CO4	To understand and know the procedures in patenting registration
CO5	To understand the licencing and commercialising procedures

CO	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
1						H			H		H				H	H
2						H			H		H				H	H
3						H			H		H				H	H
4						H			H		H				H	H
5						H			H		H				H	H

H – High, M – Medium, L – Low

Unit 1	Introduction	Hours: 09

Patent system, invention, grant of patent, discovery vs invention, patent act in India patentable subject matter		
Unit 2	**Patent ability**	**Hours: 09**
Utility, novelty, publication, non-obvious and obvious, tests of hindsight, combination patents, foreign patents, claims		
Unit 3	**Patent application**	**Hours: 09**
Specification, pitch, marrow, claims to be supported for description, construction and amendment to specification		
Unit 4	**Patent registration**	**Hours: 09**
Controller of patents, examination, register of patents, opposition to grant of patents, surrender and revocation of patents		
Unit 5	**Patent rights**	**Hours: 09**
Patent rights and infringement, licencing of patents, patent rights and marketing rights		
	Total Lecture hours	**45**
Text Books		
1	Guru, M., Rao, M. B., Rao, M. B. (2010). Patent Law in India. Netherlands: Kluwer Law International.	
2	Rao, M. B., Guru, M. (2010). Patent Law in India. Netherlands: Wolters Kluwer.	
Reference Books		
1	PATENTING IN INDIA. (n.d.). (n.p.): Lulu.com.	
2	Kankanala, K., Radhakrishnan, V., Narasani, A. (2012). Indian Patent Law and Practice. India: OUP India.	
3	Karhad, P. (2018). How to Patent an Idea in India: From Idea to Granted Patent in Quickest Time, Saving Costs and Making Money with Your Patented Invention; a Step by Step Guideline on Intellectual Property Rights. (n.p.): Independently Published.	

Course Code	Course Name	L	T	P	X	C
213BME3151	Introduction to Java for Biomedical Applications	3	0	0		3

Prerequisite: Nil	**Syllabus revision:** NA
Course Category: Program Elective	**Course Type:** Theory

Course description

1	To comprehend the Fundamentals of OOP and Java Language Constructs
2	To familiarize the student with Object Oriented Programming in Java.
3	To solve problems using the OOP language constructs
4	To familiarize the functions and protocols of each layer of TCP/IP protocol suite.
5	To Develop Web applications with Java.

Course outcomes:
On successful completion of the course the students will be able to

CO1	Design problem solutions using Object Oriented Techniques.
CO2	Apply the concepts of polymorphism, overloading, and inheritance for problem solutions.
CO3	Use the concepts of Java for problem solving
CO4	Examine important technologies that are being used today by web developers to build a wide variety of web applications.
CO5	To design web applications using Java, Servlets, XML.

CO	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
1	L												M	M		
2		M	M										M	M		

3		S	M										M	M		
4		S	S			M		M					M	M		
5		S	M			S		S					M	M		

H – High, M – Medium, L – Low

Unit 1	**Fundamentals Of Object Oriented Programming And Java**	**Hours: 9**

Introduction to OOP. Introduction to Java – Java Specifications, Java Language basics – Variables, Operators, Expressions, Statements, Blocks, Control flow Statements, Arrays, Classes and Objects, Strings, Constructors and Destructors, Type Casting, Package Access – Java API Packages.

Unit 2	**Inheritance, Polymorphism And Exception Handling In Java**	**Hours: 9**

Inheritance – Sub Classes and Subclass Types, Exception Handling- Java Exception Hierarchy – User Defined Exception Types – Assertions – Garbage Collection and Method finalize, Polymorphism – Abstract Classes and Methods- Overloading and Overriding, Operator instance of and Down Casting – final Methods and Classes –Clone class – Interface – Implementation – Multithreading.

Unit 3	**Files And Streams In Java**	**Hours: 9**

Files and Streams – Formatted Output – Object Concurrency- Serialization – Generic Collections – Generic Classes and Methods – Java utility Packages and Bit Manipulation – Java Collections.

Unit 4	**Introduction To The Internet**	**Hours: 9**

Review of Network technologies, Internet addressing, Internet Protocols – TCP/IP, UDP, DNS and Domain Names, Higher-level Protocols, Address resolution protocols (ARP/RARP). E-Mail, Telnet, FTP, NFS.WWW- Versions – HTTP – Request and Response Messages – URI, URN, URL, MIME Type.

Unit 5	**Java Programming In The Internet**	**Hours: 9**

Web Clients: - Introduction to HTML- CSS, XHTML, XML Parser – Client Side Scripting – Java Script, PHP. Connecting to web- Introduction to Java Applets- swings- Remote Method Invocation – Java Database Connectivity – connectivity – Querying statements – Results – JSP- Java servlets- Architecture- JSP Technology Introduction- Running basic JSP applications,Design GUI based biomedical applications

Total Lecture hours	**45**

Text Books

1	Paul Dietel and Harvey Deitel, “Java How to Program” Pearson Education, 10th Edition, 2016.

2	Larry L. Peterson, Bruce S. Davie, "Computer Networks: A Systems Approach", Morgan Kaufmann Publishers Inc., 5 th Edition, 2011
Reference Books	
1	Y. Daniel Liang, "Introduction to Java Programming Comprehensive Version", Pearson Education, 10th Edition, 2014.
2	Sachin Malhotra, Sourabh Choudhary, "Programming in Java", Oxford University Press, 2 nd Edition, 2018.
3	William Stallings, "Data and Computer Communications", Pearson Education, 10th Edition, 2013.
4	Deitel and Deitel, "Internet and World Wide Web: How to Program", Pearson Education, 5 th Edition, 2012.

Course Code	Course Name	L	T	P	X	C
213BME2131	SPECIAL ELECTRICAL MACHINES	3	0	0		3

Prerequisite: Knowledge in DC Machines and Transformers and AC machines.	**Syllabus revision:** NA
Course Category: Program Elective	**Course Type:** Theory

Course description

The main objective of the course is to understand various SRM, PMBLDC and PMSM construction, operating principles and control techniques of special electrical machines.

Course outcomes:
On successful completion of the course the students will be able to

CO1	Analyze the performance of synchronous reluctance motor & vernier motor.
CO2	Apply the knowledge of modes of operation of various stepper motor in practical applications and analyze its linear & non-linear performance.
CO3	Describe the performance of power semiconductor switching circuits for the different operating modes of switched reluctance motor.
CO4	Determine the EMF and torque productions of a PMBLDC motor based on its characteristics & driver circuits.
CO5	Analyze the performance of a permanent magnet synchronous motor based on its constructional features & open and closed loop control of it.

CO	PO												PSO			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**	**4**
1	L	M		L	L	L		L	L	L		L	M			
2	L	M		L	L	L		L	L	L		L		M		
3	L			L	L	L		L	L	L		L			L	
4	L	M										L				M
5	L	H	L	M	M	L	L					L				H

H – High, M – Medium, L – Low		
Unit 1	**SYNCHRONOUS RELUCTANCE MOTORS**	**Hours: 9**
Constructional features – Types – Axial and Radial flux motors – Operating principles – Variable Reluctance Motors – Voltage and Torque Equations – Phasor diagram – performance characteristics – Applications.		
Unit 2	**STEPPER MOTORS**	**Hours: 9**
Constructional features – Principle of operation – Variable reluctance motor – Hybrid motor – Single and multi-stack configurations – Torque equations – Modes of excitation – Characteristics – Drive circuits – Microprocessor control of stepper motors – Closed loop control-Concept of lead angle– Applications.		
Unit 3	**SWITCHED RELUCTANCE MOTORS**	**Hours: 9**
Constructional features -Principle of operation- Torque prediction-Characteristics Steady state performance prediction – Analytical Method – Power controllers – Control of SRM drive-Sensor less operation of SRM -Applications.		
Unit 4	**PERMANENT MAGNET BRUSHLESS DC MOTORS AND INDUCTION MACHINES**	**Hours: 9**
Constructional features – Principle of operation – Types and magnetic circuit analysis – EMF and torque equations – Power driving circuits – Motor characteristics and control – Synchronous Induction motor – Induction voltage regulator – Rotor position sensors – Linear motors – Tutorial-4.		
Unit 5	**PERMANENT MAGNET SYNCHRONOUS MOTORS**	**Hours: 9**
Constructional features – Principle of operation – EMF and torque equations – Phasor diagram – Power controllers – Converter – volt–ampere requirements – Torque speed characteristics – Microprocessor based control – Tutorial-5.		
	Total Lecture hours	**45**
Text Books		
1	K.Venkataratnam, ‘Special Electrical Machines’, Universities Press (India) Private Limited, 2008.	
2	T.J.E. Miller, ‘Brushless Permanent Magnet and Reluctance Motor Drives’, Clarendon Press, Oxford, 1989.	
Reference Books		
1	R.Krishnan, ‘Switched Reluctance Motor Drives – Modeling, Simulation, Analysis, Design and Application’, CRC Press, New York, 2001.	

2	P.P. Aearnley, ‘Stepping Motors – A Guide to Motor Theory and Practice’, Peter Perengrinus London, 1982.
3	T. Kenjo and S. Nagamori, ‘Permanent Magnet and Brushless DC Motors’, Clarendon Press, London, 1988.

Course Code	Course Name	L	T	P	X	C
213BME2121	ANALOG AND DIGITAL COMMUNICATION	3	0	0	0	3

Prerequisite: Nil	**Syllabus revision:**r.2
Course Category: Program Elective	**Course Type:** Theory

Course description

To understand analog and digital communication techniques and to gain knowledge on multi-user radio communication.

Course outcomes:
On successful completion of the course the students will be able to

CO1	Describe types of the Analog modulation techniques
CO2	Describe types of the Pulse modulation techniques
CO3	Analyse the types of Digital modulation and transmission techniques
CO4	Describe the information theory and coding
CO5	Spread Spectrum and types of Multiple Access

CO	PO	PSO

	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
1	M	M	H					L	L	L		L	M			
2	H	M	M					L	L	L		L		M		
3	M	M	M					L	L	L		L			L	
4	M	M	M									L				M
5	M	H	M	M	M	L	L					L				H

H – High, M – Medium, L – Low

Unit 1	ANALOG MODULATION	Hours: 9

Introduction to Communication Systems – Modulation – Types – Need for Modulation. Theory of Amplitude Modulation-Amplitude Modulation – AM, DSBSC, SSBSC, VSB – PSD, modulators and demodulators – Angle modulation – PM and FM – PSD, modulators and demodulators – Superheterodyne receivers.		
Unit 2	**PULSE MODULATION**	**Hours: 9**
Low pass sampling theorem – Quantisation – PAM – Line coding – PCM, DPCM, DM, ADPCM and ADM, Channel Vocoder – Time Division Multiplexing, Frequency Division Multiplexing 57- Data Communication Circuits – Data Communication Codes – Data communication Hardware – serial and parallel interfaces.		
Unit 3	**DIGITAL MODULATION AND TRANSMISSION TECHNIQUES**	**Hours: 9**
Phase shift keying – BPSK, DPSK, QPSK – Principles of M-arysignaling M-ary PSK & QAM – Comparison, ISI – Pulse shaping – Duo binary encoding – Cosine filters – Eye pattern, equalizers.		
Unit 4	**INFORMATION THEORY AND CODING**	**Hours: 9**
Measure of information – Entropy – Source coding theorem – Shannon–Fano coding, Huffman Coding, LZ Coding – Channel capacity – Shannon-Hartley law – Shannon‟s limit – Error control codes – Cyclic codes, Syndrome calculation – Convolutional Coding, Sequential and Viterbi decoding.		
Unit 5	**SPREAD SPECTRUM AND MULTIPLE ACCESS**	**Hours: 9**
PN sequences – properties – m-sequence – DSSS – Processing gain, Jamming – FHSS – Synchronisation and tracking – Multiple Access – Global System for Mobile Communications (GSM) – FDMA, TDMA, CDMA,		
	Total Lecture hours	**45**
Text Books		
1	H Taub, D L Schilling, G Saha, “Principles of Communication Systems” 3/e, TMH 2007.	
2	S. Haykin “Digital Communications” John Wiley 2005.	
Reference Books		
1	1. B.P.Lathi, “Modern Digital and Analog Communication Systems”, 3/e, Oxford University Press, 2007	
2	H P Hsu, Schaum Outline Series – “Analog and Digital Communications” TMH 2006	
3	B.Sklar, Digital Communications Fundamentals and Applications” 2/e Pearson Education 2007.	

Course Code	Course Name	L	T	P	X	C
213BME2129	Medical Optics & Lasers	3	0	0	0	3

Prerequisite: have to include any basic science course	**Syllabus revision:** r.2
Course Category: Program Elective	**Course Type:** Theory

Course description

1	To understand the basics of tissue optics
2	To analyze the principles of photonic detection methods
3	To understand the biomedical diagnostic applications
4	To analyze the optical biopsy techniques
5	To apply and evaluate the intervention and diagnostic techniques

Course outcomes:
On successful completion of the course the students will be able to

CO1	Demonstrate an understanding of the tissue optical properties and its instrumentation
CO2	Enlighten the principles of photonic detection techniques and the usage of the same in biomedical imaging
CO3	Understand the various biomedical diagnostic applications in the field of biomedical engineering
CO4	Analyze the concepts involved in various fluoroscopy based biomedical diagnostics
CO5	Evaluate and expound the diagnostic methodologies followed in biomedical photonics

CO	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
1		H		H									H	H		
2		H		H									H	H		
3		H		H	H								H	H		
4		H		H	H								H	H		
5		H		H	H								H	H		

H – High, M – Medium, L – Low

Unit 1	**Tissue Optics & Photonic Devices**	**Hours: 9**
Optical properties of tissue, light-tissue interactions, Optical Diffusion Tomography, Laser light in Medicine, Basic Instrumentation in Photonics		
Unit 2	**Photonic Detection and Imaging Techniques**	**Hours: 9**
Lifetime based imaging, near-field imaging in biological and biomedical applications, Optical Coherence Tomography imaging, Laser doppler perfusion monitoring and imaging, thermal imaging for biological and medical diagnostics		
Unit 3	**Biomedical Diagnostics**	**Hours: 9**
Glucose diagnostics, In vitro clinical diagnostic instrumentation, biosensors for medical applications, functional imaging with diffusing light		
Unit 4	**Optical Biopsy**	**Hours: 9**
Optoacoustic Tomography, Ultrasonically modulated optical imaging, quantitative characterization of biological tissue using optical spectroscopy, Fluorescence spectroscopy for biomedical diagnostics		
Unit 5	**Intervention and Diagnostic Techniques**	**Hours: 9**
Principles of PDT and its clinical applications, laser tissue welding, laser in dermatology, ophthalmology, Laser treatment for breast tumors, image guided surgery		
	Total Lecture hours	**45**
Text Books		
1	Biomedical Photonics Handbook. (2003). United Kingdom: Taylor & Francis.	
Reference Books		

1	Biomedical Photonics Handbook, Second Edition: Fundamentals, Devices, and Techniques. (2014). United States: Taylor & Francis.
2	Biomedical Photonics Handbook, Second Edition: Biomedical Diagnostics. (2014). United States: Taylor & Francis.
3	Biomedical Photonics Handbook, Second Edition: Therapeutics and Advanced Biophotonics. (2014). United Kingdom: Taylor & Francis.
4	Biomedical Photonics Handbook, 3 Volume Set. (2014). United States: CRC Press.

Course Code	Course Name	L	T	P	X	C
213BME3138	3D PRINTING IN MEDICINE	3	0	0	0	3

Prerequisite: Nil	**Syllabus revision:** r.1
Course Category: Program Elective	**Course Type:** Theory

Course description

This course deals with the basics of additive manufacturing and 3D printing technologies and its application in medicine.

Course outcomes:
On successful completion of the course the students will be able to

CO1	Understand the basics of additive manufacturing in product development.
CO2	Identify the 3D printing technology for specific application.
CO3	Process the radiological images using tools.
CO4	Describe the various applications of 3D printing in medicine.
CO5	Identify the technical considerations and regulatory bodies for making 3D models using 3D printing technologies.

CO	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
1	M	M											M			
2		M	M										M			
3		M	M		H								M			
4	L	L											L			
5								M								L

H – High, M – Medium, L – Low		
Unit 1	**Introduction to Additive Manufacturing and Basic Principles**	**Hours:**
Systematics of Manufacturing Technologies, Systematics of Layer Technology, Hierarchical Structure of Additive Manufacturing Processes, Integration of Additive Manufacturing in the Product Development Process, Basic Principles of the Additive Manufacturing Process, Generation of Layer Information, Physical Principles for Layer Generation, Elements for Generating the Physical Layer, Classification of Additive Manufacturing Processes, Summary Evaluation of the Theoretical Potentials of Rapid Prototyping Processes.		
Unit 2	**3D Printing Technologies**	**Hours:**
Communicating with a 3D Printer: The Standard Tessellation File Format and Beyond, 3D Printing Technologies – Vat Photopolymerization, Material Jetting, Binder Jetting, Material Extrusion, Powder Bed Fusion, Other Technologies. 3D Printer Resolution, Accuracy, and Reproducibility, 3D Printing Materials.		
Unit 3	**Post-processing of DICOM Images**	**Hours:**
Image Segmentation, STL Generation, Computer-Aided Design Software, Model Refinement and CAD Design, Virtual Procedural Planning, Model Quality, Preparation for 3D Printing, Special Applications. Beginning and Developing a Radiology-Based In-Hospital 3D Printing Lab.		
Unit 4	**Application of 3D Printing in Medicine**	**Hours:**
3D Printing in Neurosurgery, Cardiovascular 3D Printing, Musculoskeletal 3D Printing, Craniofacial Applications, Medical Imaging and Digital Design of Patient-Matched Implants		
Unit 5	**FDA Regulatory and Technical Considerations**	**Hours:**
The FDA's Role, Brief Overview of FDA Regulatory Pathways for Medical Devices – Resources, Classification, Regulatory Landscape for 3D-Printed Medical Devices, Printing Materials, The Design Process, The Manufacturing Process, Verification and Process Validation. Quality and Safety of 3D-Printed Medical Models		
	Total Lecture hours	
Text Books		
1	Rybicki, Frank J., and Gerald T. Grant. "3D printing in medicine." *Cham: Springer International Publishing* (2017).	
Reference Books		
1	Gebhardt, Andreas, and Jan-Steffen Hötter. " *Additive manufacturing: 3D printing for prototyping and manufacturing"*. Carl Hanser Verlag GmbH Co	

	KG, 2016.
2	Kalaskar, Deepak M., ed. "*3D printing in medicine"*. Woodhead Publishing, 2017.
3	Ian Gibson, Ian Gibson. "Additive manufacturing technologies 3D printing, rapid prototyping, and direct digital manufacturing." (2015).

Course Code	Course Name	L	T	P	X	C
213BME3154	MOBILE APPLICATION DEVELOPMENT	3	0	0		3

Prerequisite: Nil	**Syllabus revision:** NA
Course Category: Program Elective	**Course Type:** Theory

Course description

1	To Understand system requirements for mobile applications
2	To Generate suitable design using specific mobile development frameworks
3	To Generate mobile application design
4	To Implement the design using specific mobile development frameworks
5	To Deploy the mobile applications in marketplace for distribution

Course outcomes:
On successful completion of the course the students will be able to

CO1	Describe the requirements for mobile applications
CO2	Discuss the challenges in mobile application design and development
CO3	Develop design for mobile applications for specific requirements
CO4	Implement the design using Android SDK
CO5	Implement the design using Objective C and iOS

CO	PO												PSO			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**	**4**
1	L												M	M		
2		M	M										M	M		
3		S	M										M	M		

4		S	S			M		M					M	M		
5		S	M			S		S					M	M		

H – High, M – Medium, L – Low

Unit 1	**Introduction**	**Hours: 9**
Introduction to mobile applications – Embedded systems – Market and business drivers for mobile applications – Publishing and delivery of mobile applications – Requirements gathering and validation for mobile applications		
Unit 2	**Basic Design**	**Hours: 9**
Introduction – Basics of embedded systems design – Embedded OS – Design constraints for mobile applications, both hardware and software related – Architecting mobile applications – user interfaces for mobile applications – touch events and gestures – Achieving quality constraints – performance, usability, security, availability and modifiability.		
Unit 3	**Advanced Design**	**Hours: 9**
Designing applications with multimedia and web access capabilities – Integration with GPS and social media networking applications – Accessing applications hosted in a cloud computing environment – Design patterns for mobile applications, Swift Programming		
Unit 4	**Mobile OS Technology I – Android**	**Hours: 9**
Introduction – Establishing the development environment – Android architecture – Activities and views – Interacting with UI – Persisting data using SQLite – Packaging and deployment – Interaction with server side applications – Using Google Maps, GPS and WiFi – Integration with social media applications.		
Unit 5	**Mobile OS Technology II – IOS**	**Hours: 9**
Introduction to Objective C – iOS features – UI implementation – Touch frameworks – Data persistence using Core Data and SQLite – Location aware applications using Core Location and Map Kit – Integrating calendar and address book with social media application – Using Wifi–iPhone marketplace.		
	Total Lecture hours	**45**

Text Books

1	Jeff McWherter and Scott Gowell, “Professional Mobile Application Development”, Wrox, 2012
2	Charlie Collins, Michael Galpin and Matthias Kappler, “Android in Practice”, DreamTech, 2012
3	David Mark, Jack Nutting, Jeff LaMarche and Frederic Olsson, “Beginning iOS 6 Development: Exploring the iOS SDK”, Apress, 2013.

Reference Books	
1	Matthew R Mageeon" Swift Programming ",The Big Nerd Ranch Guide, 2 nd Edition,2017
2	Matthew Mehrtenson , "iOS Programming", The Big Nerd Ranch Guide, 6th Edition, 2017.
3	Bill Phillips,ChrisStewart,and92imulinMarsictano "Android Programming", The Big Nerd Ranch Guide,3rd Edition 2017.
4	James Dovey and Ash Furrow, "Beginning Objective C", Apress, 2012

Course Code	Course Name	L	T	P	X	C
213BME2128	MEDICAL DEVICE REGULATORY INDIA	3	0	0	0	3

Prerequisite: Nil	**Syllabus revision:** NA
Course Category: Program Elective	**Course Type:** Theory

Course description

This course is designed to impart the fundamental knowledge on the medical devices and in vitro diagnostics, basis of classification and product life cycle of medical devices, regulatory requirements for approval of medical devices in regulation in India along with WHO regulations. It prepares the students to learn in detail on the harmonization initiatives, quality and ethical considerations, regulatory and documentation requirements for marketing medical devices and IVDs in regulated countries.

Course outcomes:
On successful completion of the course the students will be able to

CO1	Have basic knowledge about the medical devices.
CO2	Describe the medical devices divisions in India.
CO3	Understand the ethics and standards of medical devices.
CO4	Discuss the laws and regulations of medical devices in India.
CO5	Understand the rules framed for medical devices by FDA and WHO.

CO	PO												PSO			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**	**4**
1	L	M	H	M	M	H	M	M	M	M	M	H	L	M	H	M
2	L	M	H	M	L	H	L	L			M	H	L	L	H	M
3	L	M	H	M	L	H	L	L	H		M	H	L	L	M	M
4	L	M	H	M	L	H	L	L	H		M	H	M	M	H	M

5	L	M	H	M	L	H	L	L	H		M	H	M	M	H	M

H-High, M-Medium, L-Low

Unit 1	**INTRODUCTION TO MEDICAL DEVICES**	**Hours: 09**
Introduction, Definition, Risk based classification and Essential Principles of Medical Devices and IVDs. Differentiating medical devices IVDs and Combination Products from that of pharmaceuticals. History of Medical Device Regulation- Product Lifecycle of Medical Devices and Classification of Medical Devices IMDRF/GHTF.		
Unit 2	**MEDICAL DEVICE DIVISION IN INDIA**	**Hours: 09**
Functions of medical device division- Registration and Licensing- Import Procedure- Approval of new medical devices- Constitution of medical advisory committees. Clinical trial regulation- Concerns in clinical trials. Diversity of medical devices.		
Unit 3	**ETHICS AND STANDARDS IN CLINICAL INVESTIGATION OF MEDICAL DEVICES**	**Hours: 09**
Clinical Investigation of Medical Devices- Clinical Investigation Plan for Medical Devices- Good Clinical Practice for Clinical Investigation of medical devices (ISO 14155:2011). Quality: Quality System Regulations of Medical Devices: ISO 13485, Quality Risk Management of Medical Devices: ISO 14971, Validation and Verification of Medical device. Adverse Event Reporting of Medical device. Current trends in the use of standards in medical device regulations.		
Unit 4	**LAWS AND GUIDELINES FOR HANDLING MEDICAL DEVICES AND DRUGS IN INDIA**	**Hours: 09**
Objectives of Drugs & Cosmetic Act 1940 & Rules 1945, Functions of CDSCO, Functions of state licensing authorities, Drug Testing Laboratories, Differences between drugs and devices.		
Unit 5	**REGULATIONS AND GUIDELINES OF MEDICAL DEVICES IN WHO AND FDA**	**Hours: 09**
Introduction, Organizational Structure, Purpose and Functions of Regulatory Guidelines- Working Groups, Summary Technical Document (STED), Global Medical Device Nomenclature (GMDN). WHO regulations of Medical Devices, FDA regulations of Medical Devices.		
	Total Lecture hours	**45**

Text Books

1	FDA regulatory affairs: a guide for prescription drugs, medical devices, and biologics by Douglas J. Pisano, David Mantus.
2	Medical Device Development: A Regulatory Overview by Jonathan S. Kahan.

3	Medical Product Regulatory Affairs: Pharmaceuticals, Diagnostics, Medical Devices by John J. Tobin and Gary Walsh.
4	Regulatory Affairs for Biomaterials and Medical Devices, Edited by: S. Amato and B. Ezzell, Woodhead Publishing.

Course Code	Course Name	L	T	P	X	C
213BME2126	HOSPITAL MANAGEMENT	3	0	0	0	3

Prerequisite: Nil	**Syllabus revision:** r.3
Course Category: Program Elective	**Course Type:** Theory

Course description

This course equips the students with managerial skills like planning, organizing and decision making in healthcare industry and also helps in understanding the functional and structural organization of various departments in hospitals.

Course outcomes:
On successful completion of the course the students will be able to

CO1	Know how to plan for building a new hospital.
CO2	Understand the organizational structure and process involved in recruitment.
CO3	Plan and design medical and ancillary services
CO4	Plan and design various support service departments
CO5	Understand the significance of engineering departments in hospital.

CO	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
1	L	L				M	M	M	M	M	M				M	L
2										M	M				M	L
3	L	L	L				M	M			M				M	L
4	L	L	L				M	M			M				M	L
5							L	L			L				L	L

H – High, M – Medium, L – Low

Unit 1	**Hospital Facility Planning**	**Hours: 9**
Planning for a new hospital, Guiding principles in planning hospital facilities and services, Preliminary survey, Financial planning, Equipment planning, Permanent Health Organization, Operational and Functional plan, Facility master plan, Design team and development stage, Building contract and contract documents, Furnishing and Equipping the hospital, Purchase of capital equipment.		
Unit 2	**Hospital Organization and Management**	**Hours: 9**
Organization structure, Management structure, organizational chart, Two lines of authority in the hospital, Professional management of the hospital, Recruitment and Selection, Orientation, Training and Development.		
Unit 3	**Planning and Designing Medical and Ancillary Services**	**Hours: 9**
Outpatient services, Emergency services, Clinical Laboratories, Radiological department, Surgical department, Labor and Delivery suite, Physical therapy, occupational therapy, Recreational therapy, Speech and hearing therapy, Pulmonary medicine, CATH lab.		
Unit 4	**Planning and Designing Support Services**	**Hours: 9**
Admitting department, Medical Record department, CSSD, Pharmacy, Material management, Dietary service, Laundry and linen service, Housekeeping, Volunteer department. Planning and Designing of Public area and Staff facilities.		
Unit 5	**Hospital Engineering**	**Hours: 9**
Engineering Departments – Air conditioning, Medical Gas supply systems, Plumbing, Electrical systems, Communication systems, Transportation, Solid waste management, Clinical Engineering department. Safety and Security in hospitals.		
	Total Lecture hours	**45**
Text Books		
1	Kunders, G. D. *Hospitals: facilities planning and management*. Tata McGraw-Hill Education, 2004.	
Reference Books		
1	Dyro, Joseph, ed. *Clinical engineering handbook*. Elsevier, 2004.	

Course Code	Course Name	L	T	P	X	C
213BME2122	CLINICAL ENGINEERING	3	0	0	0	3

Prerequisite: Nil	**Syllabus revision:** r.3
Course Category: Program Elective	**Course Type:** Theory

Course description

This course gives an introduction to the role of clinical engineer in various departments in hospital specifically in device designing, equipment planning and maintenance, quality control and evaluation.

Course outcomes:
On successful completion of the course the students will be able to

CO1	Understand the daily activities of clinical engineer in hospital.
CO2	Identify the technology management practices for the assessment and deployment of medical technology.
CO3	Understand the nuts and bolts to build an environment which supports high-quality patient care.
CO4	Understand the specific issues to be considered in medical device design, manufacturing, and control.
CO5	Understand the impact and importance of the various regulatory bodies' involvement with medical devices.

CO	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
1						M					L				L	
2							M	M			M				M	M
3							M	M			M				M	M

4							M	M			M				M	M
5							M	M	M		M				M	M

H – High, M – Medium, L – Low

Unit 1	**Introduction to Clinical Engineering**	**Hours: 9**

Clinical Engineering, The Role of Clinical Engineering Within the Hospital Organization, Major Functions of a Clinical Engineering Department, A Model Clinical Engineering Department, Clinical Engineering in an Academic Medical Center, Regional Clinical Engineering Shared Services and Cooperatives, Nationwide Clinical Engineering System, Clinical Engineering at the Bedside.

Unit 2	**Health Technology Management**	**Hours: 9**

Introduction to Medical Technology Management Practices, Good Management Practice for Medical Equipment, Health Care Strategic Planning Utilizing Technology Assessment, Technology Evaluation, Technology Procurement, Equipment Control and Asset Management, Computerized Maintenance Management Systems, Maintenance and Repair of Medical Devices, A Strategy to Maintain Essential Medical Equipment in Developing Countries, New Strategic Directions in Acquiring and Outsourcing High-Tech Services by Hospitals, Vendor and Service Management, National Health Technology Policy.

Unit 3	**Engineering the Clinical Environment**	**Hours: 9**

Physical Plant, Heating, Ventilation, and Air Conditioning, Electrical Power, Medical Gas Systems, Support Services, Construction and Renovation, Radiation Safety, Sanitation, Water Systems in Health Care Facilities, Disaster Planning

Unit 4	**Medical Devices: Design, Manufacturing, Evaluation, and Control**	**Hours: 9**

Medical Device Design and Control in the Hospital, Medical Device Research and Design, Human Factors: Environment, Medical Devices: Failure Modes, Accidents, and Liability, Medical Device Software Development, Comparative Evaluations of Medical Devices, Evaluating Investigational Devices for Institutional Review Boards. Overview of Medical Devices: Utilization and Service.

Unit 5	**Medical Device Standards, Regulations, and the Law**	**Hours: 9**

Primer on Standards and Regulations, Medical Device Regulatory and Technology Assessment Agencies, Health Care Quality and ISO 9001:2000, Hospital Facilities Safety Standards, Clinical Engineering Standards of Practice for Canada, Regulations and the Law, European Union Medical Device Directives and Vigilance System, United States Food & Drug Administration, Tort Liability for Clinical Engineers and Device Manufacturers

Total Lecture hours	**45**

Text Books	
1	Dyro, Joseph, ed. *Clinical engineering handbook*. Elsevier, 2004.
Reference Books	
1	Taktak, Azzam, et al., eds. *Clinical engineering: a handbook for clinical and biomedical engineers*. Academic Press, 2019.

Course Code	Course Name	L	T	P	X	C
213BME2127	Medical Device Marketing	3	0	0	0	3

Prerequisite: Nil	**Syllabus revision:** NA
Course Category: Program Elective	**Course Type:** Theory

Course description

This course focuses on Medical Device Marketing Strategies, Game-plans & Resources for Successful Product Management.

Course outcomes:
On successful completion of the course the students will be able to

CO1	Understand the fundamentals of customers and buyers characteristics
CO2	Perceive the steps and procedures for product development and launch
CO3	Analyze the product phase-out process and also understand the roles of product manager.
CO4	Analyze and compare the strategies of marketing
CO5	Strategize the planning for relationship marketing program

CO	**PO**	**PSO**

	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
1						M	M								M	
2						M	M								M	
3						M	M								M	

4						M	M								M	
5						M	M								M	

H–High, M–Medium, L – Low

Unit 1	**Introduction**	**Hours: 09**

Introduction, customers, Decision making, Buyer and Follow-up, Fundamentals of reimbursement and healthcare economics, the letter of law, ethics and responsibilities.
Business plan – Market research, accessing opportunity, financial analysis, project scope, stage gate process

Unit 2	**Product Development and launch**	**Hours: 09**

Project definition, financial targets, physician input, FDA approval and reimbursement, managing issues, meeting deadlines.
Product launch – Forecasting, Pricing, Product and sales support. Managing an existing product line.

Unit 3	**Product Phase out and product manager role**	**Hours: 09**

Phase-out checklist, Assessing lifecycle, customers and competition, Financials, pricing analysis, distribution decisions and timings, promotion possibilities, External communication.
Product manager role – sales and marketing, critical skill sets.

Unit 4	**Strategy and market planning**	**Hours: 09**

Strategic Planning, Marketing Strategies, Reassessment of Mission Statement, Strategic Alliances, Marketing Planning. Buyers Key Psychological Processes, The Buying Decision Process: The Five-Stage Model, Organizational Buying and Decision Making

Unit 5	**Relationship marketing program**	**Hours: 09**

Business and brand objectives, special consideration, segmentation strategy development, professional segmentation for relationship marketing, personas and experiences by segment, marketing campaigns, media planning and selection.

	Total Lecture hours	**45**

Text Books

1	Terri Wells, Medical Device Marketing: Strategies, Gameplans & Resources for Successful Product Management, Outskirts Press, 2010, 1st Ed. ISBN-9781432750725, 1432750720. (Unit I, II, III)

Reference Books

1	Kotler, Philip, Joel I. Shalowitz, and Robert J. Stevens. Strategic marketing for health care organizations: building a customer-driven health system. John Wiley & Sons, 2008. (Unit IV)
2	Haimowitz, Ira J. Healthcare relationship marketing: strategy, design and measurement. CRC Press, 2016. (Unit V)

Course Code	Course Name	L	T	P	X	C
213BME3148	ERGONOMICS	3	0	0	0	3

Prerequisite: Nil	**Syllabus revision:** NA
Course Category: Program Elective	**Course Type:** Theory

Course description

This course describes the concept of ergonomics design in equipment and the performance of work space design considering physical space and inters personal space.

Course outcomes:
On successful completion of the course the students will be able to

CO1	To provide basic introduction about the ergonomics
CO2	To understand the workspace design process of various workers.
CO3	To understand the factors to be considered for designing the product.
CO4	To understand the medical issues caused by the ergonomics.
CO5	To design the wheel chair and its performance by applying the techniques.

CO	PO												PSO			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**	**4**
1	L	L	M	M		M	L	M	L	L	M	H	M	M	L	M
2	M	H	H	H	M	H	L	M	M	M	M	H	M	H	H	M
3	M	H	H	H	M	H	L	M	M	M	M	H	H	H	H	M
4	L	M	M	M	L	H	M	M	M	L	M	H	L	M	M	L

5	M	H	H	H	M	H	L	M	M	M	M	H	H	H	H	M

H-High, M-Medium, L-Low

Unit 1	**INTRODUCTION**	**Hours: 09**
Introduction to Ergonomics and its application; Man-Machine-Environment System and joint motions. Musculoskeletal, cardiovascular and nervous system. Anatomical position, reference planes and movements		
Unit 2	**WORK SPACE DESIGN**	**Hours: 09**
Anthropometry – workspace design for standing and seated workers – Arrangements of components within a physical space – Interpersonal aspect of workplace design.		
Unit 3	**DESIGN OF EQUIPMENT**	**Hours: 09**
Programme factors to be considered, design of displays and controls – design for maintainability – heat stresses – manual lifting		
Unit 4	**FACTORS CAUSING ERGONOMICS RELATED ISSUES**	**Hours: 09**
Work Posture, Environmental factors and human performance; Designing of Controls and Displays, Control panel Organization; Principals of product design; Problem solving; **Seminar on ergonomics related issues in Medicine**. Ergonomics- Gait analysis, Design of work station, Sports biomechanics, Injury mechanics.		
Unit 5	**DESIGN OF WHEELCHAIR AND ITS PERFORMANCE**	**Hours: 09**
Wheel chairs: Categories of Wheelchairs, Wheelchair structure and Component design, Ergonomics of Wheelchair Propulsion, Power Wheelchair Electrical Systems. Personal Transportation for the Handicap: Vehicle Selection, Lift Mechanisms, Hand Controls, Wheelchair restraint Mechanisms.		
	Total Lecture hours	**45**

Text Books

1	Martin Helander, A Guide to Ergonomics of Manufacturing, TMH, 1996.

Reference Books

1	E.J. McCormick: *Human Factors in Engineering and Design*, Tata Mcgraw-Hill, 1976.

2	O.P. Astrand& R. Kaare: *Textbook of Work Physiology*, McGraw Hill, 1970.
3	W.T. Singleton: *The Body at Work: Biological Ergonomics*, Cambridge University Press, 1982.
4	E.R. Tichauer: *The Biomechanical Basis of Ergonomics*, Wiley, 1978.
5	R.D. Huchingson: *New Horizons for Human Factor Design*, McGraw-Hill, 1981.

Course Code	Course Name	L	T	P	X	C
213BME3147	EMBEDDED SYSTEM DESIGN	3	0	0		3

Prerequisite: Nil	**Syllabus revision:** r.3
Course Category: Program Electives	**Course Type:** Theory

Course description

1	Describe the differences between the general computing system and the embedded system, also recognize the classification of embedded systems.
2	To acquire knowledge in various processors employed in embedded systems
3	Implementation of concurrent process and data flow models
4	Design real time embedded systems using the concepts of RTOS
5	Apply the concept of embedded system in various medical applications.

Course outcomes:
On successful completion of the course the students will be able to

CO1	Describe the differences between the general computing system and the embedded system, also recognize the classification of embedded systems.
CO2	To acquire knowledge in various processors employed in embedded systems
CO3	Implementation of concurrent process and data flow models
CO4	Design real time embedded systems using the concepts of RTOS
CO5	Apply the concept of embedded system in various medical applications.

CO	PO												PSO			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**	**4**
1	S	S											M			

2	S				S		S	S	S	S				S	S	S
3	S	S	L	L	M		M	M	M	M			M	L		
4	S	S	S	S	M		L	M	M	M			S	S		
5			S	L	M		L	M	M	M						

H-High, M-Medium, L-Low

Unit 1	**Introduction To Embedded System**	**Hours: 9**
Introduction, design challenge, processor technology, IC technology, Design technology, Trade-offs, Single purpose processors, RT-level combinational logic, sequential logic (RT-level), custom single purpose processor design (RT-level) and optimization techniques.		
Unit 2	**General Purpose Processors, State Machine**	**Hours: 9**
Basic architecture, operation, Pipelining, Programmer‟s view, development environment, Application Specific Instruction-Set Processors (ASIPs) – Micro Controllers and Digital Signal Processors, models Vs. languages, finite state machines with data path model (FSMD), using state machines, program state machine model (PSM),		
Unit 3	**Concurrent Process Models**	**Hours: 9**
Concurrent process model, concurrent processes, communication among processes, synchronization among processes, implementation, data flow model, real-time systems.		
Unit 4	**Communication Interfaces**	**Hours: 9**
Need for communication interfaces, ISO/OSI layer architecture RS232 / UART, RS422 / RS485, USB, Infrared, IEEE 1394 Firmwire, Ethernet, IEEE 802.11, Blue tooth.		
Unit 5	**Applications**	**Hours: 9**
Embedded Web Server applications, Embedded Database Applications, Embedded medical applications: Ophthalmology – Glaucoma screening device, Medical Imaging Acquisition User Interface, Drug delivery systems, Patient monitoring Systems.		
	Total Lecture hours	**45**
Text Books		
1	Frank Vahid, Tony D. Givargis, “Embedded System Design – A Unified Hardware/Software Introduction”, John Wiley, 2002	
2	K.V.K.K. Prasad, “Embedded / Real Time Systems”, Dreamtech Press, 2005.	
Reference Books		

1	Sri Ram V Iyer– Pankaj Gupta, "Embedded Real Time Systems Programming", Tata McGraw Hill, 2005.
2	Steve Heath, "Embedded System Design", Elsevier, Second Ed., 2004.

Course Code	Course Name	L	T	P	X	C
213BME3143	BIOMETRIC SYSTEMS	3	0	0	0	3

Prerequisite: Nil	**Syllabus revision:** r.3
Course Category: Program Elective	**Course Type:** Theory

Course description

1	To understand the technologies of fingerprint, iris, face.
2	To understand the general principles of design of biometric systems and the underlying trade-offs.
3	To recognize personal privacy and security implications of biometrics based identification technology.
4	To identify issues in the realistic evaluation of biometrics based systems.
5	To understand the technologies of speech recognition.

Course outcomes:
On successful completion of the course the students will be able to

CO1	Understand the concept of Biometrics and its applications
CO2	Illustrate the various methodologies involved in fingerprint technology
CO3	Develop techniques for face recognition and hand geometry biometrics
CO4	Demonstrate the multimodal biometrics and the methods for evaluating the performance
CO5	Distinguish the authentication mechanism of the biometric systems

CO	PO												PSO			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**	**4**
1	L	L			L								H			
2	M												H			
3		H														
4						M						L		M		
5					L								H	M		

H – High, M – Medium, L – Low

Unit 1	**INTRODUCTION TO BIOMETRICS**	**Hours: 9**

Biometric technologies – passive biometrics – active biometrics –Biometric systems – Enrollment – templates – algorithm – verification – Biometric applications –biometric characteristics- Authentication technologies –Need for strong authentication – Protecting privacy and biometrics and policy-Biometric systems.

Unit 2	**FINGERPRINT TECHNOLOGY**	**Hours: 9**

Finger print feature processing techniques – fingerprint sensors using RF imaging techniques – fingerprint quality assessment – computer enhancement and 111imulink111 of fingerprint images – fingerprint enhancement – Feature extraction – fingerprint classification – fingerprint matching.

Unit 3	**FACE RECOGNITION AND HAND GEOMETRY**	**Hours: 9**

Face recognition from correspondence maps – Hand geometry – scanning – Feature Extraction – Adaptive Classifiers -Visual- Based Feature Extraction and Pattern Classification – feature extraction – types of algorithm.

Unit 4	**MULTIMODAL BIOMETRICS AND PERFORMANCE EVALUATION**	**Hours: 9**

Behavioral Biometrics – Introduction to multimodal biometric system – Integration strategies – Architecture – level of fusion – combination strategy –training and adaptability – examples of multimodal biometric systems – Performance evaluation- Statistical Measures of Biometrics.

Unit 5	**BIOMETRIC AUTHENTICATION**	**Hours: 9**

Biometric Authentication Systems – Biometric authentication by fingerprint -Biometric Authentication by Face Recognition. -. Expectation- Maximization theory – Support Vector Machines. Biometric authentication by fingerprint –biometric authentication by hand geometry- Securing and trusting a biometric transaction – matching location.

Total Lecture hours	**45**

Text Books	
1	James Wayman, Anil Jain, Davide Maltoni, Dario Maio, “Biometric Systems, Technology Design and Performance Evaluation”, Springer, 2005
2	S.Y. Kung, S.H. Lin, M.W.Mak, “Biometric Authentication: A Machine Learning Approach”Prentice Hall, 2005
Reference Books	
1	Paul Reid, “Biometrics for Network Security”, Pearson Education, 2004.
2	Nalini K Ratha, Ruud Bolle, “Automatic fingerprint Recognition System”, Springer, 2003
3	L C Jain, I Hayashi, S B Lee, U Halici, “Intelligent Biometric Techniques in Fingerprint and Face Recognition” CRC Press, 1999.

Course Code	Course Name	L	T	P	X	C
213BME3139	ADVANCED MICROCONTROLLERS	3	0	0		3

Prerequisite: Microprocessor and Microcontroller	**Syllabus revision:** NA
Course Category: Program Elective	**Course Type:** Theory

Course description

This subject focuses on the study of advanced microcontroller along with the use of microcontroller. It also briefs the students about interfacing of memory and various I/O devices like A to D converter, D to A converter to advanced microcontrollers. The students learn the Programming language (Embedded C) used for microcontrollers. They will be able to use the advanced fast microcontroller in electrical engineering related fields like Power system protection, instrumentation, power electronics.

Course outcomes:
On successful completion of the course the students will be able to

CO1	Describe working of PIC 18F Microcontroller Architecture and Programming model.
CO2	Design interfacing circuits for PIC 18F Microcontroller.
CO3	Review of the advanced features in 8051 Microcontroller.
CO4	Design of basic circuits for ARM microcontroller.
CO5	Implement assembly and c-program of ARM microcontrollers

CO	PO												PSO			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**	**4**
1	M	M		M	L	L		L	L	L		L	M			
2	M	M		M	L	L		L	L	L		L		M		
3	M			M	L	L		L	L	L		L			L	

4	L	M										L				M
5	L	H	L	M	M	L	L					L				H

H – High, M – Medium, L – Low

Unit 1	**PIC Microcontroller**	**Hours: 9**
PIC 18F Software PIC18F addressing modes, Instruction set, Instruction format, Integrated Development Environment (IDE), Assembling, Debugging, and Executing a program using MPLAB IDE in assembly and embedded C. Data copy operation, Arithmetic operation, Branch and Skip operation, Logic operations, bit Operation, Stack and Subroutine, Code conversion programs and Software Design.		
Unit 2	**Integrated peripherals of PIC Microcontroller**	**Hours: 9**
Integrated peripherals of PIC 18F Microcontroller I/O ports, Timer, capture/compare/PWM (CCP) module, ECCP module. Master Synchronous Serial Port (MSSP) Module, Enhanced Universal Synchronous, Asynchronous Receiver Transmitter (EUSART), Analog-To-Digital Converter (A/D) Module, Comparator module.		
Unit 3	**Advanced concepts in 8051 architecture**	**Hours: 9**
Review of 8051 architecture, concept of synchronous serial communication, SPI and I2C communication protocols, study of SPI port on 89LP 51RD2, study of SAR ADC/DAC MCP3304 / MCP 33, interfacing concepts for SPI based ADC/DAC, study of watchdog timer, study of PCA timer in different modes like capture mode, PWM generation mode, High speed output toggle mode Embedded ‘C’ programming for the above peripherals.		
Unit 4	**Introduction to ARM CORTEX M profile**	**Hours: 9**
CORTEX M0 and M4 cores, Harvard and Von Neumann architectures, CPU Registers, CPU Operating Modes, Thumb-2 Instruction Set, Memory Map, Bus Interface, bit bending , interrupt handling ,NVIC (Nested Vectored Interrupt Controller), system tick timer, Debug system		
Unit 5	**Advanced concepts in Embedded ‘C’ programming**	**Hours: 9**
Pointers, structures, unions, pointers to structures, pointers to functions, addressing mechanism for memory mapped registers, enumerators, Interrupt HandlersEmbedded software architecture: Round robin architecture, Round robin with interrupt architecture		
	Total Lecture hours	**45**

Text Books

1	John .B.Peatman, “Design with PIC Microcontroller”, Prentice Hall, 1997.
2	Andrew N.Sloss, Dominic Symes and Chris Wright “ARM System Developer‟s Guide : Designing and Optimizing System Software” , First edition, Morgan Kaufmann Publishers, 2004.

Reference Books	
1	Steve Furber, “ARM System –On –Chip architecture”, Addision Wesley, 2000.
2	Valvano, “Embedded Microcomputer Systems”, Thomson Asia PVT LTD first reprint 2001. Readings: Web links www.ocw.nit.edu www.arm.com
3	Mazidi M.A., PIC 18F Microcontroller & Embedded systems, Pearson Education Second edition.
4	Ramesh Gaonkar, Fundamentals of Microcontrollers and application in Embedded system (With PIC 18 Microcontroller family) Penram International Publishing.

Course Code	Course Name	L	T	P	X	C
213BME3153	MICROCONTROLLER BASED SYSTEM DESIGN	3	0	0	0	3

Prerequisite: Microprocessor and Microcontroller	**Syllabus revision:** NA
Course Category: Program Elective	**Course Type:** Theory

Course description

This subject focuses on the study of

- To introduce the architecture of PIC microcontroller
- To educate on use of interrupts and timers
- To educate on the peripheral devices for data communication and transfer
- To introduce the functional blocks of ARM processor
- To educate on the basics of Embedded system

Course outcomes:
On successful completion of the course the students will be able to

CO1	Understand concepts of PIC controller and Programming them.
CO2	Understand concepts of Interrupt handling and timer circuits in PIC controller applications.
CO3	Analyse and implement various interfacing circuits necessary for various applications
CO4	Understand concepts of ARM Processor.
CO5	Understand the basics of embedded system

CO	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
1	L	M		L	L	L		L	L	L		L	M			
2	L	M		L	L	L		L	L	L		L		M		
3	L			L	L	L		L	L	L		L			L	

4	L	M										L				M
5	L	H	L	M	M	L	L					L				H

H – High, M – Medium, L – Low

Unit 1	**INTRODUCTION TO PIC MICROCONTROLLER**	**Hours: 09**
Introduction to PIC Microcontroller–PIC 16C6x and PIC16C7x Architecture–PIC16cxx-Pipelining – Program Memory considerations – Register File Structure – Instruction Set – Addressing modes – Simple Operations.		
Unit 2	**INTERRUPTS AND TIMER**	**Hours: 09**
PIC micro controller Interrupts- External Interrupts-Interrupt Programming–Loop time subroutine – Timers-Timer Programming– Front panel I/O-Soft Keys– State machines and key switches– Display of Constant and Variable strings.		
Unit 3	**PERIPHERALS AND INTERFACING**	**Hours: 09**
I2C Bus for Peripherals Chip Access– Bus operation-Bus subroutines– Serial EEPROM—Analog to Digital Converter–UART-Baud rate selection–Data handling circuit–Initialization – LCD and keyboard Interfacing -ADC, DAC, and Sensor Interfacing.		
Unit 4	**INTRODUCTION TO ARM PROCESSOR**	**Hours: 09**
ARM Architecture –ARM programmer's model –ARM Development tools- Memory Hierarchy –ARM Assembly Language Programming–Simple Examples–Architectural Support for Operating systems.		
Unit 5	**EMBEDDED SYSTEMS**	**Hours: 09**
Introduction to embedded systems – hardware and software components –types- examples characteristics –system on chip-challenges in embedded computing system design – embedded system design process.		
	Total Lecture hours	**45**

Text Books

1	Peatman,J.B., "Design with PIC Micro Controllers"PearsonEducation,3rdEdition, 2004.
2	Furber,S., "ARM System on Chip Architecture" Addison Wesley trade Computer Publication, 2000.

Reference Books

1	Mazidi, M.A., "PIC Microcontroller" Rollin Mckinlay, Danny causey Printice Hall of India, 2007.

2	Elahi, A., Arjeski, T., ARM Assembly Language with Hardware Experiments, Springer, (2014)
3	Hintenaus P, Engineering Embedded Systems, Springer, (2015)

Course Code	Course Name	L	T	P	X	C
213BME3158	ROBOTICS IN MEDICINE	3	0	0	0	3

Prerequisite: Nil	**Syllabus revision:** NA
Course Category: Program Elective	**Course Type:** Theory

Course description

This course provides an introduction to the field of robotics, fundamentals ideas and basic mathematics to describe the position and orientations in space.

Course outcomes:
On successful completion of the course the students will be able to

CO1	Understand the basics of robotic systems
CO2	Design basic Robotics system and formulate Kinematics.
CO3	Understand and able to design a flexible robots to perform a specific task.
CO4	Construct Inverse Kinematic motion planning solutions for various Robotic configurations.
CO5	Design Robotic systems for Medical application.

CO	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
1	H	H											H	H		
2	H	H	H										H	H		
3	H	H											H	H		
4	H	H	H										H	H		
5	H	H	H										H	H		

H – High, M – Medium, L – Low		
Unit 1	**Introduction to Robotics and Automation**	**Hours: 9**
Introduction Automation and Robots, Classification, Application, Specification, Notations, Direct Kinematics Dot and cross products, Coordinate frames, Rotations, Homogeneous coordinates Link coordination arm equation – Five-axis robot, Four-axis robot, Six-axis robot		
Unit 2	**Kinematics**	**Hours: 9**
Inverse Kinematics – General properties of solutions tool configuration, Five axis robots, Three Four axis, Six axis Robot, Workspace analysis and trajectory planning work envelope and examples, workspace fixtures, Pick and place operations, Continuous path motion, Interpolated motion, Straight-line motion.		
Unit 3	**Robot Vision**	**Hours: 9**
Robot Vision Image representation, Template matching, Polyhedral objects, Shane analysis, Segmentation – Thresholding, region 120imulink120, Shrink operators, Swell operators, Euler numbers, Perspective transformation, Structured illumination, Camera calibration.		
Unit 4	**Planning**	**Hours: 9**
Task Planning Task level programming, Uncertainty, Configuration, Space, Gross motion, Planning, Grasp Planning, Fine-motion planning, Simulation of planar motion, Source and Goal scenes, Task Planner simulation.		
Unit 5	**Robotic Applications in Medicine**	**Hours: 9**
Applications in Biomedical Engineering – Bio Engineering Biologically Inspired Robots, Neural Engineering, Application in Rehabilitation – Interactive Therapy, Bionic Arm, Clinical and Surgical – Gynaecology, Orthopaedics, Neurosurgery		
	Total Lecture hours	**45**
Text Books		
1	Schilling, Robert J. *Fundamentals of robotics: analysis and control*. Simon & Schuster Trade, 1996.	
2	Craig, John J. *Introduction to robotics: mechanics and control, 3/E*. Pearson Education India, 2009.	
Reference Books		
1	Groover, Mikell P., Mitchel Weiss, Roger N. Nagel, Nicholas G. Odrey, and Ashish Dutta. *Industrial robotics: technology, programming, and applications*.	

	McGraw-Hill, 2012.
2	Stadler, Wolfram. *Analytical robotics and mechatronics*. McGraw-Hill, Inc., 1995.
3	Niku, Saeed B. *Introduction to robotics: analysis, systems, applications*. Vol. 7. New Jersey: Prentice hall, 2001.
4	Staugaard Jr, Andrew C. *Robotics and AI: an introduction to applied machine intelligence*. Prentice-Hall, Inc., 1987.

Course Code	Course Name	L	T	P	X	C
213BME2123	COMPUTERS IN MEDICINE	3	0	0	0	3

Prerequisite: Nil	**Syllabus revision:** r.1
Course Category: Program Elective	**Course Type:** Theory

Course description

1	Describe general functions, purposes and benefits of health information systems.
2	Describe the evolution and adoption of health information systems
3	Compare health information systems in terms of their ability to support the requirements of a health care enterprise.
4	Propose the hardware, software, operating system and networking considerations necessary for effective data storage and use in health care organizations
5	Utilize the tools and techniques for collecting, storing, securing, retrieving, and reporting health care data.

Course outcomes:
On successful completion of the course the students will be able to

CO1	To understand the system of information managed in the hospital.
CO2	To demonstrate the application of software employed in medical data management.
CO3	To examine medical imaging data with an assist of computers.
CO4	To understand the concept of maintaining digital patient records.
CO5	To acquire knowledge in delivering instructions in medicine using computers.

CO	PO	PSO

	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
1	M				M								L			
2	L				M								L			
3	L	L			M	L	L						L			
4	M	L			M	M						L	L			
5	L	M			M	M							L			

H – High, M – Medium, L – Low

Unit 1	**HOSPITAL INFORMATION SYSTEM**	**Hours: 9**

Introduction –Foundations of Health-care Informatics- Ethics- Electronic Health Records- Information Infrastructure- computer based medical information retrieval.

Unit 2	**COMPUTERISED PATIENT DATABASE MANAGEMENT**	**Hours: 9**

Data base approach –EHR Functionality including Online Use of an EHRGovernment EHR Certification – Technical Infrastructure -Security - Interoperability & Health Information Exchanges - EHR Deployment & Project Management –Patient Centered EHR

Unit 3	**COMPUTER ASSISTED MEDICAL IMAGING AND DECISION MAKING**	**Hours: 9**

Computer Assisted Medical Decision Making-Model of CMD-Approaches-Decision Support Systems Algorithms –Analysis –CBR-Production Rule Systems-Cognitive Models-Semantic Networks – Decision Analysis in Clinical Medicine –Clinical Decision Support.

Unit 4	**COMPUTERISED PATIENT RECORD**	**Hours: 9**

Computerised Patient Record –Introduction-History Taking By Computer-Dialogue With The Computer – Computerised Prescriptions For Patients-Introduction-Adverse Drug Reactions-Computer Assisted Patient Education And Health Care Information –Introduction –Health Online –Electronic Communication With Patients-Importance Of Behaviour Modification.

Unit 5	**COMPUTER ASSISTED INSTRUCTION IN MEDICINE**	**Hours: 9**

Computer Assisted Drug Discovery And Development, Molecular Modelling By Computer-Computational Representation Of Molecules-Modelling GPCRS-Pharmacophores-New Drugs For Cancer-0 from Gene To Screen.

Total Lecture hours	**45**

Text Books	
1	R. D. Lee, Computers in Medicine, Tata McGraw Hill Publishing Company Limited, New Delhi, 1993.
Reference Books	
1	Harold Sackamn, Biomedical Information Technology, Academic Press, New York.
2	S.K.Chachan, PC Organisation, S.K. Kataria and Sons, Delhi 2000.

Course Code	Course Name	L	T	P	X	C
213BME3159	TELEHEALTH TECHNOLOGIES	3	0	0	0	3

Prerequisite: Nil	**Syllabus revision:** r.3
Course Category: Program Elective	**Course Type:** Theory

Course description

This course covers the role of information and communications technologies in enabling remote patient care, health professional collaboration at a distance, and in supporting patient-self management. Also enables the students to evaluate business and technology infrastructure models required for supporting telehealth services.

Course outcomes:
On successful completion of the course the students will be able to

CO1	Know the essential parameters, scope, benefits and limits of telemedicine.
CO2	Explain the application of multimedia and needs of communication networks in telemedicine.
CO3	Describe the needs of acquisition devices in telehealth monitoring and diagnosis.
CO4	Understand the use and necessity of various security and standards in telehealth modules.
CO5	Apply telehealth in healthcare.

CO	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
1			M											L		
2	L	L	M										L	L		
3	L	L	M										L	L		

4			M			M										M
5	L	L	M										L	L		

H – High, M – Medium, L – Low

Unit 1	**Introduction to Telemedicine**	**Hours: 9**

History and Evolution of telemedicine, Functional diagram of telemedicine system, Essential Parameters for Telemedicine, Delivery Modes in Telemedicine, Benefits and Limitations of Telemedicine.

Unit 2	**Multimedia and Communication Networks**	**Hours: 9**

Principles of Multimedia – Text, Audio, Video, data. Types of Communication and networking – PSTN, POTS, ANT, ISDN, Internet, Wireless Communications Basics, Types of Wireless Networks, Wireless Communication – GSM satellite, and Micro wave, Satellite communication, Cellular Digital Packet Data (CDPD).

Unit 3	**Data Acquisition And Storage System**	**Hours: 9**

Acquisition System – Camera, Scanners, Display Systems – Analogue Devices, LCD, Laser Displays, Holographic Representation, Virtual Screen devices, Storage System – Magnetic System, Optical System, Solid State Disk.

Unit 4	**Data Security and Standards**	**Hours: 9**

Security in Telemedicine systems – Access control, Fire wall, Encryption, Authentication, Digital certificate, Digital Timestamp. Protocols: TCP/IP, ISO-OSI, Standards to followed DICOM, HL7, H. 320 series (Video phone based ISBN) T. 120, H.324 (Video phone based PSTN). Ethical and legal aspects of telemedicine – Confidentiality, social and legal issues, safety and regulatory issues.

Unit 5	**Applications**	**Hours: 9**

Teleradiology, Telepathology, Telecardiology, Teleoncology, Teledermatology, Telesurgery, e Health and Cyber Medicine.

	Total Lecture hours	**45**

Text Books

1	Olga Ferrer Roca, M. SosaIudicissa, “Hand book of Telemedicine”, IOS press, 2002.
2	Fong, Bernard, A. C. M. Fong, and C. K. Li. “Telemedicine technologies.” *Information Technologies in Medicine and Telehealth* (2011).

3	Norris A C, “Essentials of Telemedicine and Telecare”, John Wiley, New York, 2002.
Reference Books	
1	Khandpur R S, “TELEMEDICINE – Technology and Applications”, PHI Learning Pvt Ltd., New Delhi, 2017.

Course Code	Course Name	L	T	P	X	C
213BME3141	BIOMEDICAL INFORMATICS	3	0	0	0	3

Prerequisite: Nil	**Syllabus revision:** NA
Course Category: Program Elective	**Course Type:** Theory

Course description

This course will enable you to: Become familiar with the basic definitions, key concepts, terminology, and historical context of Health Informatics Understand fundamental characteristics of data, information, and knowledge in the Health Informatics domain Become familiar with common algorithms for health applications and IT components in representative clinical processes. Develop understanding of population health and precision medicine Understand basic principles of knowledge management systems in biomedicine. Develop understanding of various aspects of Health Information Technology Standards. Become familiar with IT aspects of clinical process 128imulink128 and health information systems

Course outcomes:
On successful completion of the course the students will be able to

CO1	Able to understand the fundamentals of health informatics
CO2	Able to understand the history and national landscape of health information system.
CO3	To understand the medical algorithms for different applications and decision making in medical.
CO4	To understand the applications of 128imulink128 and simulation in biomedicine
CO5	To clearly understand the standards in health informatics.

CO	**PO**												**PSO**			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**	**4**
1	L			M		M	L			L	M	H	M	L	L	L
2	L	L	M	M		M	L			L	M	H	L	L	M	L

3	M	M	M	M	L	M	L		M	M	M	H	M	H	M	M
4	H	H	H	H	M	H	L	L	M	M	M	H	M	H	H	M
5	M	M	L	M		M	L	L	M	M	M	H	M	M	M	M

H-High, M-Medium, L-Low

Unit 1	**Introduction to Health Informatics & Data, Information, and Knowledge**	**Hours: 09**

Introduction to health informatics and its significance Definitions and key concepts in health informatics Background disciplines, historical overview, and future challenges.
Introduction to knowledge hierarchy: Data, information, and knowledge. The definitions of healthcare data and information Types of healthcare information.

Unit 2	**The National Landscape of Healthcare IT & History of Healthcare Information System**	**Hours: 09**

The major influences shaping the health IT landscape in the US- The roles played by the major government initiatives and private sectors in advancing health IT in the US- The major events that have influences the adoption of health IT and systems.
History and evolution of healthcare information systems (HCIS)- The major advances in information technology and significant federal initiatives that influenced the adoption of healthcare information systems- The major types of administrative and clinical information systems used in healthcare Current issues pertaining to the use HCIS.

Unit 3	**Medical Algorithms & Medical Decision Making**	**Hours: 09**

Various ways to describe algorithms, such as flowchart, pseudocode, and conceptual graph-Introduction to medical algorithms- Algorithms in computer science, such as decision tree and regression Calculation of measurements of classification performance—sensitivity and specificity.
Medical decision-making process (diagnosis, treatment, monitoring, prognosis) Informatics in clinical decision-making Introduction to evidence-based medicine.

Unit 4	**Modeling and Simulations & Population Health and Precision Medicine**	**Hours: 09**

Develop understanding of 129imulink129 and simulation Become familiar with applications of 129imulink129 and simulation in biomedicine.
Data and information need of health systems in managing population health Key health IT tools and strategies for population health management Concepts of precision medicine.

Unit 5	**Standards in Health Informatics**	**Hours: 09**

Introduction to standards-The Need for Health Informatics Standards-The role of federal initiative and legislation that have significant impact on the adoption of healthcare information standards in the United States- Major types of healthcare information standards and the

organization that develop or approve them- the importance of healthcare IT standards to the future of the US health care delivery system.	
Total Lecture hours	**45**
Reference Books	
1	Wager, K. A., Lee, F. W., & Glaser, J. P. (2017). Health care information systems: A practical approach for health care management -4th Edition. Jossey-Bass.
2	Trotter, F. and Uhlman, D. (2011). Hacking healthcare: A guide to standards, workflows, and meaningful use.
3	Braunstein, M. L. (2014). Contemporary Health Informatics. American Health Information Management Association

Course Code	Course Name	L	T	P	X	C
213BME3146	Diagnostic & Therapeutic Instruments-II	2	0	0	0	2

Prerequisite: Medical Electronics, Medical Physics

Syllabus revision: NA

Course Category: Program Elective

Course Type: Theory

Course description

The course provides a basic knowledge and understanding on the instruments used in dental and eye applications in surgery and diagnosis

Course outcomes:
On successful completion of the course the students will be able to

CO1	To understand the principle, working, usage and applications of ophthalmic surgical instruments
CO2	To understand the principle, working, usage and applications of dental instruments

CO	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
1		H											H			
2		H											H			

H – High, M – Medium, L – Low

Unit 1	Ophthalmic surgical instruments Part -1	Hours: 09

Instruments for cataract surgery, refractive surgery, strabismus surgery

Unit 2	Ophthalmic surgical instruments Part – 2	Hours: 09

Instruments for corneal surgeries and eye banking, oculoplastic surgeries, glaucoma surgeries, sterilization of surgical instruments

Unit 3	**Dental Instruments part 1**	**Hours: 09**
Exam and basic hand instruments, diagnostic and treatment planning instruments, hand cutting instruments, restorative instruments		
Unit 4	**Dental Instruments part 2**	**Hours: 09**
Dental handpieces, dental burs and rotatory instruments, impression and laboratory-based instruments		
Unit 5	**Dental Instruments part 3**	**Hours: 09**
Oral and maxillofacial surgery instruments, orthodontic and endodontic instruments, radiological instruments and infection control		
	Total Lecture hours	**45**
Textbooks		
1	Titiyal, J. S., Sinha, R., Sharma, V. K. (2017). Ophthalmic Surgical Instruments. India: Jaypee Brothers, Medical Publishers Pvt. Limited.	
2	Boyd, L. B. (2020). Dental Instruments – E-Book: A Pocket Guide. United States: Elsevier Health Sciences.	
Reference Books		
1	Scheller– Sheridan, C. (2013). Basic Guide to Dental Instruments. Germany: Wiley.	
2	Boyd, L. B. (2020). Dental Instruments: A Pocket Guide. United States: Elsevier – Health Sciences Division.	
3	Ophthalmic Instruments and Surgical Tools. (2019). Germany: Springer Singapore.	

Course Code	Course Name	L	T	P	X	C
213BME3140	BIOFLUIDS AND DYNAMICS	3	0	0	0	3

Prerequisite: BME18R351-Biomechanics	**Syllabus revision:** r.2
Course Category: Program Elective	**Course Type:** Theory

Course description

This course elaborates on the application of fluid mechanics principles to major human organ systems. The course is an introduction to physiologically relevant fluid flow phenomena, underlying physical mechanisms from an engineering perspective and integration of various fluid mechanics concepts to address relevant problems of the human body's systems.

Course outcomes:
On successful completion of the course the students will be able to

CO1	To understand the basic fluid mechanisms, models and testing methods
CO2	To understand fluid flow and the properties of blood and vessel walls.
CO3	To classify the fluids according to its characteristics.
CO4	To study the biofluid dynamic concepts and its models
CO5	To use this knowledge in studying the biofluid mechanics of organ system's fluid flow properties.

CO	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
1	M	M	M	M		M	L				L	H	M	L	L	M
2	H	M	H	M	L	H	L	M	L	M	L	H	H	M	M	M

3	M	M	M	M		H	L				L	H	M	M	M	M
4	H	M	H	M	M	H	L	M	L	M	L	H	H	M	M	M
5	M	M	H	M	M	H	L	M	L	M	L	H	M	M	M	M

H-High, M-Medium, L-Low

Unit 1	**INTRODUCTION**	**Hours: 09**

Stress, strain, Strain rate, Nonviscous Fluid, Newtonian Viscous Fluid, Hookean Elastic Solid, Viscoelasticity – maxwell, Voigt and kelvin model, Response of a Viscoelastic Body to Harmonic Excitation, Methods of testing - Ostwald viscometer, Couette viscometer, cone-plate rheometer, A noncontact method for three-dimensional analysis of vascular elasticityin vivo and in vitro

Unit 2	**PROPERTIES OF BLOOD AND VESSEL WALL**	**Hours: 09**

Physical, Chemical and Rheological properties of blood, Constitutive Equation of Blood Based on Viscometric Data andCasson's Equation, Laminar Flow of Blood in a Tube, Apparent Viscosity and Relative Viscosity, Fahraeus-Lindqvist Effect and its inverse effect, Motion of Red Cells in Tightly Fitting Tubes, Hematocrit in Very Narrow Tubes, Effect of Turbulent Flow on Cell Stress

Unit 3	**BIOVISCOELSTIC FLUIDS AND SOLIDS**	**Hours: 09**

Fluids - Protoplasm, Mucus from the Respiratory Tract, Saliva, Cervical Mucus and Semen,Synovial fluids
Solids –Collagen, Thermodynamics of Elastic Deformation, Behaviour of Soft Tissues Under Uniaxial Loading, Quasi-Linear Viscoelasticity of Soft Tissues, The Concept of Pseudo-Elasticity, Biaxial Loading Experiments on Soft Tissues, Strain-Energy Function

Unit 4	**BIOFLUID DYNAMIC CONCEPTS**	**Hours: 09**

Biofluid-compartment Models, Tissue Heat and Mass Transfer, Joint Lubrication, Cell Transport and Microvascular Beds, Cardiovascular system

Unit 5	**BIOFLUID MECHANICS OF ORGAN SYSTEMS**	**Hours: 09**

THE LUNGS - Respiratory Tract Geometry. THE KIDNEYS - Fluid Flow and Mass Transfer in an ArtificialKidney Model. THE LIVER - Fluid Flow and Mass Transfer in a Liver Model

	Total Lecture hours	**45**

Text Books

1	Y.C Fung, “Biomechanics- Mechanical properties of living tissues”, 2nd Edition, Springer-Verlag, 1993 (Unit 1, 2, 3)

Reference Books

1	Clement Kleinstreuer–"Biofluid DynamicsPrinciples and Selected Applications" (2006, CRC Press) (unit 4 and 5)
2	K.L.Kumar, "Engineering fluid mechanics", Eurasia Publishing House (P) Ltd., New Delhi, 1998.
3	D.H.Bergel, "Cardiovascular fluid dynamics"- Vol. I, Academic press, London & New York, 1972.
4	David A. Rubenstein, Weiyin, Mary D. Frame, "Biofluid Mechanics- An Introduction to fluid
5	Mechanics, Macrocirculation and Microcirculation", Springer, 2013.

Course Code	Course Name	L	T	P	X	C
213BME3140	MECHANICS OF BIOLOGICAL SYSTEMS	3	0	0	0	3

Prerequisite: Nil	**Syllabus revision:** r.3
Course Category: Program Elective	**Course Type:** Theory

Course description

This course describes the basic concepts of human skeletal muscle mechanics. It also helps to examine the mechanics behind human motion and performance, including projectile motion, in sport and exercise.

Course outcomes:
On successful completion of the course the students will be able to

CO1	Illustrate the basics of soft tissue mechanics
CO2	Analyze the mechanics of head and neck after having an injury
CO3	Distinguish the mechanics of different joints of the body
CO4	Interpret the gait analysis
CO5	Discuss the functions of organs during sports and exercise

CO	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
1	M	L				M	L	L			M	H	M	M	L	M
2	M	H	M	M	M	H	L	L	M	M	L	H	M	M	L	M
3	M	M	L	L		H			L		L	H	M	M	L	M

4	H	H	H	H	H	H	L	L	M	M	M	H	H	H	M	M
5	H	H	H	H	H	H	L	L	M	M	M	H	H	H	M	M

H-High, M-Medium, L-Low

Unit 1	**MODELLING BIOLOGIAL SYSTEM &SOFT TISSUE BIOMECHANICS**	**Hours: 09**

Introductions to Molecular Dynamics, Monte Carlo and Langevin dynamics simulations. Fundamentals of Soft Tissue Mechanics: Muscle Architecture, Max Muscle Stress, Max Muscle Contraction Velocity, Muscle Force-Length Relationship, Muscle Force-Velocity Relationship, Tendon Biomechanics.

Unit 2	**MECHANICS OF HEAD AND NECK**	**Hours: 09**

Injury Mechanisms, Mechanical Response, Regional Tolerance, Biomechanics of Chest and Abdominal Impact, Biomechanical Responses During Impact, Injury Risk Assessment.
Case studies on the injury mechanism of chest and abdominal impact.

Unit 3	**BIOMECHANICS OF DIFFERENT JOINTS OF HUMAN BODY**	**Hours: 09**

Geometry of Articulating Surfaces, Joint Contact, Axes of Rotation of (Ankle, Knee, Hip, Shoulder, Elbow, Wrist, Hand), Tribology (Friction, Wear and Surface Damage), Hydrodynamic Lubrication Theories, Boundary Lubrication, Synovial Joints.

Unit 4	**GAIT ANALYSIS**	**Hours: 09**

Clinical Gait Analysis Information, Data Collection Protocol, Measurement Approaches and Systems (Stride and Temporal Parameters, Motion Measurement, Ground Reaction Measurement, Dynamic Electromyography) Case studies on Clinical Gait Analysis Information.

Unit 5	**PHYSIOLOGY IN SPORTS AND EXERCISE**	**Hours: 09**

Muscle Energetic, Cardiovascular Adjustments, Maximum Oxygen Uptake, Respiratory Responses, Optimization Techniques, Thermal Response, Applications. Case studies on the physiological response of the sports person

	Total Lecture hours	**45**

Text Books

1	J. D. Bronzino, "Biomedical Engineering Handbook", 3rd ed,CRC Press, 2006.

2	Nordine-Frankel, “Basic Biomechanics of the Musculoskeletal System”, Lea &Febiger, 2012.
3	Arthur T. Johnson, “Biomechanics and Exercise Physiology”, 2nd edition, John Wiley and Sons, 2007.
Reference Books	
1	Duane Knudson, “Fundamentals of Biomechanics”, Springer, 2nd Edition, 2007.
2	Donald R.Peterson, Joseph D.Brozino, “Biomechanics –Principles and Applications”, 2nd Edition, CRC press, 2007.
3	Ross Ethier, Craig A.Simmons, “Introductory Biomechanics-from cells to organisms”, 1st edition, Cambridge University Press, 2007.
4	Cees Oomens, Marcel Brekelmens, Frank Baaijens, “Biomechanics: Concepts and Computation”, 1st edition, Cambridge University Press, 2010

Course Code	Course Name	L	T	P	X	C
213BME3149	FINITE ELEMENT ANALYSIS	3	0	0	0	3

Prerequisite: Mathematics, Engineering Mechanics	**Syllabus revision:** NA
Course Category: Program Elective	**Course Type:** Theory

Course description

This course focuses on the fundamentals concepts and formulation of the finite element methods for solving differential equations arising in solid and fluid mechanics.

Course outcomes:
On successful completion of the course the students will be able to

CO1	Perceive and implement various steps involved in the Finite element Analysis (FEA)
CO2	Analyze 1D, 2D and 3D members using corresponding Finite elements (bar, plane and brick).
CO3	Apply FEM tools to the areas of structural, thermal and fluid dynamics applications
CO4	Analyze Structural dynamics and corresponding mathematical functions
CO5	Scrutinize the Finite element analysis for biomedical engineering applications

CO	**PO**												**PSO**			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**	**4**
1	H	H											H			
2	H	H											H			
3	H	H			M								H			

4	H	H											H			
5			M		M									M		

H – High, M – Medium, L – Low

Unit 1	**Basic Concepts of the Finite Element Method**	**Hours: 07**

Introduction, FEM Working, General Procedure, Strain – Displacement Relations, Stress – strain Relations, Spring, Bar and truss as FE, Strain energy, 140imulink140140o's First theorem, Potential energy and equilibrium; the 140imulink-ritz method. Method of weighted residuals – Galerkin's method.

Unit 2	**One Dimensional Problems**	**Hours: 10**

Finite Element Modelling, One dimensional Elements, Triangular elements, Rectangular Elements, Coordinates and shape function, The Potential energy approach, Treatment of boundary conditions, Quadratic shape Function, Gaussian Quadrature, Problems.

Unit 3	**Applications in Heat Transfer, Fluid and solid Mechanics**	**Hours: 10**

Steady State Heat Transfer (1D and 2D Heat Conduction, 1D and 2D heat transfer in Fins), Governing equations for incompressible flow, Velocity potential function in 2D flow, Incompressible viscous flow, Plane stress and strain analysis, Isoparametric formulation of the plane quadrilateral element, Axisymmetric stress analysis, Stress and strain computation, problems.

Unit 4	**Structural Dynamics and Dynamic Considerations**	**Hours: 10**

The simple harmonic oscillator, Multiple degree of freedom system, Bar and beam elements, Mass matrix for a general element, Evaluation of Eigenvalues and Eigenvectors, Interfacing with previous finite element programs and a program for determining critical speeds of shafts.

Unit 5	**Biomedical Engineering Application**	**Hours: 08**

Building Bone model from CT Data, FEM Model of Femur with anisotropic Materials, and FEA of the abdominal aortic aneurysm wall.

	Total Lecture hours	**45**

Text Books

1	Hutton, David V. Fundamentals of finite element analysis. McGraw-hill, 2004.
2	Chandrupatla, Tirupathi R., et al. Introduction to finite elements in engineering. Vol. 2. Upper Saddle River, NJ: Prentice Hall, 2002.

Reference Books	
1	Yang, Z. C. Finite element analysis for biomedical engineering applications. CRC Press, 2019.
2	Cook, Robert D. Concepts and applications of finite element analysis. John wiley& sons, 2007.
3	Liu, Gui-Rong, and Siu Sin Quek. The finite element method: a practical course. Butterworth-Heinemann, 2013.
4	Rao, Singiresu S. The finite element method in engineering. Butterworth-heinemann, 2017.

Course Code	Course Name	L	T	P	X	C
213BME3150	HUMAN ASSIST DEVICES	3	0	0	0	3

Prerequisite: Nil	**Syllabus revision:** r.3
Course Category: Program Elective	**Course Type:** Theory

Course description

This course offers basic understanding on principle, design and application of various human assist devices which include extracorporeal devices, cardiac assist devices, respiratory devices and hearing aids. This course also comprises the design aspects of prosthetic and orthotic devices for the disability.

Course outcomes:
On successful completion of the course the students will be able to

CO1	Illustrate the various building blocks of Heart lung Machine, artificial heart and its working principle.
CO2	Understand and describe the principle and working of various cardiac assist devices.
CO3	Understand the role and working of artificial kidney and visual augmentation
CO4	Ability to specify the type of assistive devices for rehabilitation.
CO5	Categorize the different types of respiratory assist devices and hearing aids.

CO	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
1	M														M	
2	M			M											M	

3	M			L											M	
4	M			H											M	
5	M			H											M	

H – High, M – Medium, L – Low

Unit 1	**HEART LUNG MACHINE AND ARTIFICIAL HEART**	**Hours: 09**

Condition to be satisfied by the H/L System. Different types of Oxygenators, Pumps, Pulsatile and Continuous Types, Monitoring Process, Shunting, The Indication for Cardiac Transplant, Driving Mechanism, Blood Handling System, Functioning and different types of Artificial Heart, Mock test setup for assessing its Functions

Unit 2	**CARDIAC ASSIST DEVICES**	**Hours: 09**

Synchronous Counter pulsation, Assisted through Respiration Right Ventricular Bypass Pump, Left Ventricular Bypass Pump, Open Chest and closed Chest type, Intra-Aortic Balloon Pumping, Veno Arterial Pumping, Prosthetic Cardio Valves, Principle and problem, Biomaterials for implantable purposes, its characteristics and testing.Case study.

Unit 3	**ARTIFICIAL KIDNEY, SENSORY AUGMENTATION AND ITS SUBSTITUTIONS**	**Hours: 09**

Indication and Principle of Haemodialysis, Membrane, Dialysate, Different types of heamodialysers, Monitoring Systems, Wearable Artificial Kidney, Implanting Type-Modeling and analysis. Case study

Classification of Visual Impairments, Prevention and cure of visual impairments, Visual Augmentation, Tactile vision substitution, auditory substitution and augmentation, tactile auditory substitution, Assistive devices for the visual impaired

Unit 4	**PROSTHETIC AND ORTHOTIC DEVICES**	**Hours: 09**

Hand and Arm Replacement – Different Types of Models Externally Powered Limb Prosthesis, Lower Limb and Upper limb orthotic devices, Functional Electrical Stimulation, Sensory Assist Devices, Materials for Prosthetic and orthotic devices, Haptic Devices

Unit 5	**RESPIRATORY AND HEARING AIDS**	**Hours:09**

Ventilator and its types-Intermittent positive pressure, Breathing Apparatus Operating Sequence, Electronic IPPB unit with monitoring for all respiratory parameters. Types of Deafness, Hearing Aids, Construction and Functional Characteristics

Total Lecture hours	**48 Hours**

Text Books

1	Kolff W.J, “Artificial Organs”, John Wiley and Sons, New York, 1979.
Reference Books	
1	Andreas.F.Vonracum,“Hand book of biomaterial evalution”,Mc-Millan Publishers, 1980.
2	Albert M.Cook, Webster J.G., “Therapeutic Medical Devices”, Prentice Hall Inc., New Jersey, 1982.
3	John. G. Webster – Bioinstrumentation – John Wiley & Sons (Asia) Pvt Ltd, 2004.
4	Muzumdar A., “Powered Upper Limb Prostheses: Control, Implementation and Clinical Application, “Springer, 2004.
5	Rory A Cooper, “An Introduction to Rehabilitation Engineering, Taylor & Francis, CRC Press, UK. 2006.

Course Code	Course Name	L	T	P	X	C
213BME2130	REHABILITATION ENGINEERING	2	0	0	3	3

Prerequisite: Nil	**Syllabus revision:** r.2
Course Category: Program Elective	**Course Type:** Theory

Course description

This course discuss the broad area of rehabilitation engineering solutions and their limitations for persons who suffer from physical or sensory impairments and its application to assist people with impairments in sensing, communication, seating, manipulation, and mobility.

Course outcomes:
On successful completion of the course the students will be able to

CO1	Have basic knowledge about the principles of rehabilitation.
CO2	Describe the features of human movement in health and disability and discuss the application of these properties in rehabilitation engineering design.
CO3	Learn therapeutic Exercise Techniques.
CO4	Discuss the various rehabilitation communication techniques.
CO5	Understand orthopedic prosthetics and orthotics in rehabilitation

CO	PO												PSO			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**	**4**
1	M	L	L	L		M						H	M	M	H	M
2	M	M	M	M	L	H	L	M	M	L		H	M	M	H	M
3	M	H	H	M	M	H	L	M	M	M		H	M	H	H	M
4	M	H	H	M	M	H	L	M	M	H		H	M	H	H	M

5	M	H	H	M	M	H	L	M	H	M		H	M	H	H	M

H-High, M-Medium, L-Low

Unit 1	**INTRODUCTION TO REHABILITATION & REHABILITATION TEAM**	**Hours: 09**
What is Rehabilitation, Epidemiology of Rehabilitation, Health, Levels of Prevention, Preventive Rehabilitation, Diagnosis of Disability, Functional Diagnosis, Importance of Psychiatry in Functional diagnosis, Impairment disability handicap, Primary & secondary Disabilities, Rehabilitation team-Classification of members. HAAT – Human Activity Assistive Technology.		
Unit 2	**PRINCIPLES OF REHABILITATION AND ITS TECHNOLOGY**	**Hours: 09**
Introduction, The Human Component, Principles of Assistive Technology Assessment, Principles of Rehabilitation Engineering- Key Engineering Principles, Key Ergonomic Principles – Practice of Rehabilitation and Assistive Technology. Wheel chairs: Categories of Wheelchairs, Wheelchair structure and Component design, Ergonomics of Wheelchair Propulsion, Power Wheelchair Electrical Systems		
Unit 3	**THERAPEUTIC EXERCISE TECHNIQUE**	**Hours: 09**
Co-ordination exercises, Frenkels exercises, Gait analyses-Pathological Gaits, Gait Training, Relaxation exercises-Methods for training Relaxation, Strengthening exercises-Strength training, Types of Contraction, Mobilization exercises, Endurance exercises.		
Unit 4	**Sensory Rehabilitation Systems**	**Hours: 09**
Engineering concepts in sensory rehabilitation, Sensory Augmentation & substitution: Visual System- types of visual aids Auditory system- Hearing aids, Types of conventional hearing aid, Writing aids.		
Unit 5	**ORTHOTIC & PROSTHETIC DEVICES**	**Hours: 09**
General orthotics, Classification of orthotics-functional & regional, General principles of Orthosis, Calipers- FO, AFO, KAFO, HKAFO. Application of motor control principles to rehabilitation engineering; emphasis on iterative interdisciplinary collaborations. Prosthetic devices: Hand and arm replacement, Body powered prosthetics, Myoelectric controlled prosthetics and Externally powered limb prosthetics.		
	Total Lecture hours	**45**
Text Books		
1	Dr. S. Sunder, Rehabilitation Medicine-, 3rd Edition, Jaypee Medical Publications, New Delhi. 2010 (Units I, III, IV & V)	

2	Joseph D.Bronzino, The Biomedical Engineering Handbook, Third Edition: Three Volume Set, CRC Press, 2006 (Units II & V).
Reference Books	
1	Rory A Cooper, An Introduction to Rehabilitation Engineering, Taylor & Francis, CRC press, 2006.
2	Susan B O'Sullivan, Thomas J Schmitz, Physical Rehabilitation. 5th Edition, Davis publications, 2007.

List of experiments suggested ("X" Component)

Sl. No.	Title	Hours
1	Design of wheel chair for the patients	10
2	Design of the prosthetic hand	10
	Total laboratory hours	**20**

Course Code	Course Name	L	T	P	X	C
213BME3155	MODELING OF PHYSIOLOGICAL SYSTEM	2	0	0	3	3

Prerequisite: BME21R251	**Syllabus revision:** r.3
Course Category: Program Elective	**Course Type:** Theory with "X" component

Course description

To understand the physiological system 148imulink148 concepts and its SIMULINK application

Course outcomes:
On successful completion of the course the students will be able to

CO1	To understand the system elements and properties
CO2	To understand the system analysis with combined properties
CO3	To understand the impedance concept in physiological system 148imulink148 and periodical signals
CO4	To understand the transient response
CO5	To understand the physiological system models and simulation

CO	PO	PSO

	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
1	H	H			H								H	H		
2	H	H			H								H	H		
3	H	H			H								H	H		
4	H	H			H								H	H		
5	H	H			H								H	H		

H-High, M-Medium, L-Low		
Unit 1	**System Concept & Properties**	**Hours: 15**
Characterization of physiological system, models and analogs, resistive system property, static and dynamic resistance, distributed and lumped systems, Thermal resistance in human systems, System with volume storage capacity and its electrical analog, combined hollow elastic and cylindrical elements, storage in thermal and mechanical systems, non-energized muscle tissue, dual representation of storage property.		
Unit 2	**System analysis with combined properties & Transfer Function**	**Hours: 12**
Step response of resistant-compliant systems, step-function, step-response data, Dye dilution study, pulse response of first order system, System as operator, first order operator, use of Transfer function, Block diagrams of coupled systems, Examples using transformed signals.		
Unit 3	**The Impedance Concept & Periodic Signals**	**Hours: 12**
circuits into transfer function with impedance concept, transfer function from impedance, impedance from transfer function, higher-order systems, Sinusoidal Functions, Analysis of an Instrument system, transfer function and sinusoidal response, sinusoidal analysis of second-order system, sinusoidal impedance, gain and phase plots as a function of frequency, transfer function from frequency-response, Relationship between Phase lag and Time Delay, fourier expansion.		
Unit 4	**Transient response & Feedback**	**Hours: 12**
Transient Response of an Underdamped Second order system, General Description of Natural Frequency Damping, Physical Significance of underdamped responses, underdamped response of a physiological system, constants, resonance, Characterization of Physiological Feedback systems, linearization and analysis of a simple system, stability considerations and system stability.		
Unit 5	**Model & Simulation**	**Hours: 15**
Model of neuronal dynamics, nonlinear model of baroreflex and respiratory modulated heart rate, model of cardiovascular variability, model of circadian rhythms, 149imulink: dynamics of neuromuscular reflex motion, dynamics of glucose-insulin regulation		
	Total Lecture hours	**66**
Text Books		
1	Blesser, W. B. (1969). A Systems Approach to Biomedicine. United Kingdom: McGraw-Hill.	

2	Khoo, M. C. K. (2018). Physiological Control Systems: Analysis, Simulation, and Estimation. United Kingdom: Wiley.
3	Ottesen, J. T., Larsen, J. K., Olufsen, M. S. (2004). Applied Mathematical Models in Human Physiology. Switzerland: Society for Industrial and Applied Mathematics.
Reference Books	
1	Riggs, D. S. (1976). Control Theory and Physiological Feedback Mechanisms. United States: R. E. Krieger Publishing Company.
2	Dukkipati, R. V. (2006). Analysis and design of control systems using MATLAB. India: New Age International.
3	Bishop, R. H. (1993). Modern control systems analysis and design using MATLAB. United Kingdom: Addison-Wesley.
4	Gopal, M. (2002). Control Systems: Principles and Design. India: McGraw-Hill Education (India) Pvt Limited.
5	Handbook of Bioengineering. (1987). United Kingdom: McGraw-Hill.

List of experiments suggested ("X" Component)

Sl. No.	Title	Hours
1	Simulink implementation of any physiological model that is not discussed in the course lecture	4
2	Prototype or working model	4
	Total laboratory hours	**08**

Course Code	Course Name	L	T	P	X	C
213BME3157	NEURAL NETWORK AND PATTERN RECOGNITION	3	0	0	0	3

Prerequisite: Nil	**Syllabus revision:** r.2
Course Category: Program Electives	**Course Type:** Theory

Course description

1	To Understand the concept of ANN
2	To study about various ANN models
3	To Obtain knowledge about the self-organizing maps and competitive networks
4	To Design and apply different types of pattern classification techniques
5	To Analyze about the application of AI in medical field and use feature extraction based on clustering.

Course outcomes:
On successful completion of the course the students will be able to

CO1	Understand the basic concepts of artificial neural networks (ANN)
CO2	Familiarize about various ANN models
CO3	Obtain knowledge about the self-organizing maps and competitive networks
CO4	Design and apply different types of pattern classification techniques
CO5	Analyze about the application of AI in medical field and use feature extraction based on clustering.

CO	PO	PSO

	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
1	S	S											M			
2	S				S		S	S	S	S				S	S	S
3	S	S	L	L	M		M	M	M	M			M	L		
4	S	S	S	S	M		L	M	M	M			S	S		
5			S	L	M		L	M	M	M						

H – High, M – Medium, L – Low

Unit 1	**Introduction And Simple Neural Net**	**Hours: 9**
Elementary neurophysiology and biological neural network- Artificial neural network- Architecture, biases and thresholds, Hebb net, Perceptron, Adaline and Madaline.		
Unit 2	**Back Propagation and Associative Memory**	**Hours: 9**
Back propagation network, generalized delta rule, Bidirectional Associative memory Hopfield Network		
Unit 3	**Neural Networks Based On Competition**	**Hours: 9**
Kohonen Self organizing map, Learning Vector Quantisation, Counter Propagation network.		
Unit 4	**Introduction and Supervised Learning**	**Hours: 9**
Overview of Pattern recognition, Types of Pattern recognition, Parametric and Nonparametric approach, Bayesian classifier, Discriminant function, non parametric density estimation, histograms, kernels, window estimators, k- nearest neighbor classifier, estimation of error rates		
Unit 5	**Unsupervised Learning And Clustering Analysis**	**Hours: 9**
Unsupervised learning- Hierarchial clustering- Single-linkage Algorithm, Complete –linkage Algorithm, Average-linkage algorithm and Ward‟s method. Partitional clustering- Forgy‟s Algorithm, k-means algorithm and Isodata Algorithm		
	Total Lecture hours	**45**

Text Books

1	DudaR.O,Hart P.G, “Pattern Classification and scene analysis”, Wiley Edition 2000
2	Earl Gose, Richard Johnsonbaugh Steve Jost, “Pattern Recognition and Image Analysis”, Prentice Hall of India Pvt Ltd., New Delhi, 1999

3	Hagan, Demuth and Beale, “Neural network design”, Vikas Publishing House Pvt Ltd., New Delhi, 2002
4	Freeman J.A., and Skapura B.M, “Neural networks, algorithms, applications and programming techniques”, Addison- Wesley, 2003.
Reference Books	
1	Robert Schalkoff, “Pattern recognition, Statistical, Structural and neural approaches” John Wiley and Sons(Asia) Pvt Ltd., Singapore, 2005.
2	LaureneFausett, “Fundamentals of neural networks- Architectures, algorithms and applications”, Prentice Hall, 1994.

Course Code	Course Name	L	T	P	X	C
213BME3144	BIOSIGNAL PROCESSING	3	0	0	0	3

Prerequisite: Nil	**Syllabus revision:** NA
Course Category: Program Elective	**Course Type:** Theory

Course description

This course provides variety of mathematical formula and algorithms to process and analysis physiological signals to extract vital information like heart rate, respiration rate, brain activity, muscle functioning etc.,

Course outcomes:
On successful completion of the course the students will be able to

CO1	Understand and design filters to remove artefacts in physiological signals.
CO2	Extract information from the provided biosignal.
CO3	Process and analyze various biosignals using mathematical formula and algorithm.
CO4	Analysis biosignals in frequency domain.
CO5	Model various biological systems using variety of algorithms.

CO	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
1	H	H	M		M								H	H		
2	H	H	M		M								H	H		
3	H	H			M								H	H		
4	H	H			M								H	H		

5	H	H	L		M								H	H		

H – High, M – Medium, L – Low

Unit 1	**Filtering for Removal of Artefacts**	**Hours: 12**

Biomedical signal origin & dynamics. Statistical Preliminaries, Time domain filtering (Synchronized Averaging, Moving Average), Time domain filtering (Moving Average Filter to Integration, Derivative-based operator), Frequency Domain Filtering (Notch Filter), Optimal Filtering: The Weiner Filter, Adaptive Filtering Selecting Appropriate Filter.

Unit 2	**Event Detection**	**Hours: 12**

Derivative based Approaches for QRS, Detection Pan Tompkins Algorithm for QRS Detection, Dicrotic Notch Detection, Correlation Analysis of EEG Signal, Homomorphic Filtering.

Unit 3	**Waveform Analysis**	**Hours: 12**

Illustrations of problem with case studies, Morphological Analysis of ECG, Correlation coefficient, The Minimum phase correspondent.Signal length, Envelop Extraction, Amplitude demodulation, The Envelogram, Analysis of activity– Root Mean Square value, Zero-crossing rate, Turns Count, Form factor.

Unit 4	**Frequency-domain Characterization**	**Hours: 12**

Periodogram, Averaged Periodogram, Blackman-Tukey Spectral Estimator, Daniell's Spectral Estimator, Measures derived from PSD.

Unit 5	**Modelling of Biomedical Systems**	**Hours: 12**

Motor unit firing pattern, Cardiac rhythm, Formants and pitch of speech, Point process, Parametric system modelling, Autoregressive model, Autocorrelation method, Application to random signals, Computation of model parameters, Levinson-Durbin algorithm, Computation of gain factor, Covariance method, Spectral matching and parameterization, Model order selection, Relation between AR and Cepstral coefficients, ARMA model, Sequential estimation of poles and zeros.

	Total Lecture hours	**60**

Text Books

1	Rangayyan, Rangaraj M. *Biomedical signal analysis*. John Wiley & Sons, 2015.

Reference Books

1	Willis J. Tompkins.*Biomedical Digital Signal Processing*. EEE, PHI, 2004
2	D C Reddy. *Biomedical Signal Processing: Principles and Techniques*. Tata McGraw-Hill Publishing Co. Ltd, 2005

Course Code	Course Name	L	T	P	X	C
213BME3142	BioMEMS	3	0	0	0	3

Prerequisite: Microsystems, Microfabrication and Microfluidics	**Syllabus revision:** r.1
Course Category: Program Elective	**Course Type:** Theory

Course description

This course focuses on the various fabrication techniques, principles and application of Microelectromechanical systems (MEMS).

Course outcomes:
On successful completion of the course the students will be able to

CO1	Perceive and implement various steps involved in MEMS and microsystem
CO2	Understand and analyze the principles of microsystem and also to distinguish various types of sensors and actuators.
CO3	Design and microfabricate the material based on various methods and process as per the requirement
CO4	Analyze, compare, and appreciate the performance and merit of different Micro total analysis system.
CO5	Apply MEMS in different field of Biology and Medicine

CO	**PO**												**PSO**			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**	**4**
1	L												L			
2	L					M	M						L			
3	L	L	H										L			

4	M	M	H										M			
5	L	L	M										L			

H – High, M – Medium, L – Low

Unit 1	**Introduction**	**Hours: 09**

MEMS and Microsystems, Typical MEMS and Microsystem Products, Evolution of Microfabrication, Microsystem and Microelectronics, Design, Manufacturing process, Miniaturization and scaling – Geometrical scaling, scaling of forces, scaling of phenomena. Application – Automotive Industry, Healthcare Industry, Aerospace Industry and Telecommunications.

Unit 2	**Principles of Microsystem and BioMEMS Materials**	**Hours: 09**

Microsensors, Microactuation, MEMS with Microactuators, Microaccelerometers, Microfluidics. Classification of electronic Materials, Silicon, Properties of thin Films, Silicon Compounds, Polymeric Materials for MEMS, Material Selection for Medical and Biological Application

Unit 3	**Microfabrication Methods and Process**	**Hours: 09**

Microlithography – Photolithography Process, Photoresists, Photolithography Tools and resolution, photomasks. Doping, Micromachining- Subtractive process, Additive Process, Bulk and surface Micromachining, LIGA, Microstereolithography. Water bonding Methods, Assembly and Packaging, Surface treatments.

Unit 4	**Microfluidics and Micro total analysis system**	**Hours: 09**

Fluid flow, Couette flow, Poiseuille flow, Hydraulic Resistance, Hydrodynamic Capacitance and Inductance, Fluidic Circuit theory, Stokes Drag, Fluid – Transport Phenomena, Laminar Flow in microchannel, Valving, Pumping, Mixing. Lab-on-a-chip – Sample pretreatment, Sample introduction, Separation.

Unit 5	**Biological and Medical Application**	**Hours: 09**

Applications to Cells – Cell culture reactor and adhesion, Retention. Application to Nucleic Acids and Proteins. Clinical Monitoring – Flow cytometry, Mircodialysis, Catheter-Based Sensor, Endoscopy. Implantable MEMS and sensors, Microelectrodes and neural probes, Drug Delivery.

	Total Lecture hours	**45**

Text Books

1	E. Meng, Biomedical Microsystems, CRC Press, 2010, 1st Ed. ISBN-13: 978-1420051223. (Unit II, III, IV, V)

2	Tai Ran Hsu, “MEMS and Microsystems Design and Manufacture”, Tata McGraw Hill Publishing Company, New Delhi, 2002. (Unit I, II).
Reference Books	
1	P. Tabeling, S .Chen, Introduction to microfluidics, Oxford University Press, 2010 , 1st Ed. ISBN-13: 978-0199588169
2	Rai-Choudhury, Prosenjit; Mems and Moems Technology and Applications SPIE 2000
3	Wanjun Wang, Stephen A.Soper, ”BioMEMS: Technologies and Applications”, CRC Press, New York, 2007.

Course Code	Course Name	L	T	P	X	C
213BME3145	DESIGN PROCESS IN BIOMATERIALS AND ARTIFICIAL ORGANS	3	0	0	0	3

Prerequisite: Material Design, Manufacturing	**Syllabus revision:** r.3
Course Category: Program Elective	**Course Type:** Theory

Course description

This course focuses on the process of designing, manufacturing, testing and sterilization of Biomaterials based artificial organs.

Course outcomes:
On successful completion of the course the students will be able to

CO1	Understand the basics of Design process in Artificial organs
CO2	Analyze and compare various Artificial organs available in the market
CO3	Comprehend the selection criteria and process of dental implants design.
CO4	Perceive the Ethical issues involved in implant design.
CO5	Design the Artificial organs based on the standard protocol.

CO	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
1	L					M	L						L			
2	L	L				M	L						L			
3	L	L				M							L			
4	L	L				M		L					L			

5	L						L						L			

H – High, M – Medium, L – Low

Unit 1	**Basics of Design Process**	**Hours: 08**
Introduction, Adoptive and Adaptive Design, Introduction to Machine Design, Mechanism – Materials, Load, Process. Safety of products, Manufacturability, Standardization, Customization.		
Unit 2	**Artificial Pancreas design process**	**Hours: 10**
Pancreas – Artificial Pancreas, Intensive insulin therapy and insulin pump. Bioengineering approach, Gene therapy approach, Medical Equipment approach, Clinical Tests, Insulin and Amylin Combination, Feedback of Real-Time Blood Glucose Data to an Insulin Pump for Bolus Control, Glucagon Combination		
Unit 3	**Dental Implants Design and manufacture**	**Hours: 10**
Dental Implants – Components, types in use. Biting force, Implants shape, Surface characteristics, Bone factors, Loading Conditions, Number, Distribution, Orientation and design, Placement of implants, Clinical and biomechanical consideration.		
Unit 4	**Artificial Replacements of Liver and Ethical Issues in Implants Design**	**Hours: 09**
Liver – Lobes, Synthesis, Breakdown. Bio-artificial Liver Device – Function, Hollow Fiber system, Comparison to liver dialysis. Progress toward an Artificial liver Transplant. Ethical Issues of Implants – Treatment Modality, Transplants and Implants, Implant Failure, Clinical Trials, Ethical Issues of Dental Implants.		
Unit 5	**Manufacturing, Testing, and Sterilization of Implants**	**Hours: 09**
Casting, Forging, Metal-Shaping Machine Tools, Manufacturing Implants at a High Speed, Rapid Prototyping, Nonconventional Machining, Nondestructive Testing, Sterilization – Physical Agent.		
	Total Lecture hours	**45**

Text Books

1	Pal, Subrata. Design of artificial human joints & organs. Vol. 1. Boston, MA: Springer US, 2014.

Reference Books

1	Hench, L., and J. Jones, eds. Biomaterials, artificial organs and tissue engineering. Elsevier, 2005.

Course Code	Course Name	L	T	P	X	C
213BME3160	TISSUE ENGINEERING	3	0	0	0	3

Prerequisite: Nil	**Syllabus revision:** r.1
Biosignal **Course Category:** Program Elective	**Course Type:** Theory

Course Objective

To impart knowledge on the concepts of Tissue engineering, new tissue generation and organ transplantation.

Course outcomes:
On successful completion of the course the students will be able to

CO1	Describe and understand the basics of tissue engineering and principles of engineering a tissue in vitro and its testing
CO2	Understand the aspects of cell culture and bioreactor
CO3	Understand the design, fabrication of scaffold and cell-biomaterial interaction.
CO4	Describe the biomaterials for tissue engineering and various tissue transplants.
CO5	Understand the ethical and regulatory issues and case studies on various transplantation.

CO	PO												PSO			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**	**4**
1	M	L	L	M		M	L		L	L			H	H	H	H
2	M	L	L	M		M	L		L	L			M	M	M	H
3	M				H			M								H

4	M				H	M									H	H
5	M					M										H

H - High, M - Medium, L – Low

Unit 1	**INTRODUCTION**	**Hours: 9**

Introduction to tissue engineering, Structural organization of tissues: Epithelial, connective; vascularity and angiogenesis, basic wound healing, cell migration, Principles of engineering a tissue in vitro, current scope of development and use in therapeutic and in-vitro testing.

Unit 2	**CELL CULTURE**	**Hours: 09**

Different cell types, progenitor cells and cell differentiations, different kind of matrix, cell-cell interaction. Aspect of cell culture: cell expansion, cell transfer, cell storage and cell characterization, Tissue microenvironment and bioreactor Cell signaling molecules, Receptor-ligand binding kinetics, Cell surface markers.

Unit 3	**SCAFFOLD & CELL-BIOMATERIAL INTERACTION**	**Hours: 09**

Scaffold:Design, fabrication, properties and characterization, cells and in vitro culture of cells, cell seeding
cell-biomaterial interaction: cell adhesion, migration, aggregation, Cell proliferation and differentiation, cell–scaffold construct & its characterization,

Unit 4	**SCAFFOLD AND TRANSPLANT**	**Hours: 09**

Engineering biomaterials for tissue engineering, Degradable materials (collagen, silk and polylactic acid), porosity, mechanical strength, 3-D architecture and cell incorporation. Engineering tissues for replacing bone, cartilage, tendons, ligaments, skin and liver. Basic transplant immunology stems cells: introduction, hepatopoiesis

Unit 5	**CASE STUDY AND REGULATORY ISSUES**	**Hours: 09**

Case study of multiple approaches: cell transplantation for liver, musculoskeletal, cardiovascular, neural, visceral tissue engineering. Ethical, FDA and regulatory issues of tissue engineering.

	Total Lecture hours	**45**

Text Books

1	B. Palsson, S. Bhatia, Tissue Engineering, Pearson Prentice Hall, 2003

Reference Books

1	G. Vunjak-Novakovic, R. Ian Freshney, Culture of Cells for Tissue Engineering, WIS, 2006

2	B. Palsson, J.A. Hubbell, R. Plonseyand J.D. Bronzino, Tissue Engineering, CRC- Taylor&Francis
3	R. P. Lanza, R. Langerand W. L. Chick, Principles of tissue engineering, Academic press, 1997
4	Clemens van Blitterswijk, Tissue Engineering", Academic Press, 2008
5	Bernhard O.Palsson, "Tissue Engineering", Pearson Education, 1st Edition, 2016
6	John P.Fisher, antoniosG.Mikos, Joseph D.Bronzino, "Tissue Engineering", CRC Press, 2007
7	Robert Lanza, Robert Langer, Joseph P.vacanti, "Principles of Tissue Engineering", Academic Press, 2011.

Course Code	Course Name	L	T	P	X	C
213BME3156	BIOMEDICAL NANOTECHNOLOGY	3	0	0	0	3

Prerequisite: Nil	**Syllabus revision:** r.3
Course Category: Program Elective	**Course Type:** Theory

Course description

This course provides an overview of nanotechnology, fabrication, characterization and functions of nanoscale structures, and serves as an introduction to major areas in biomedical sectors influenced by developments in nanotechnology.

Course outcomes:
On successful completion of the course the students will be able to

CO1	Describe and understand the synthesis, characterization, and properties of nanoparticles.
CO2	Understand about the protein and DNA nanotechnology and in vitro methods to study antibacterial and anticancer properties of nanomaterials
CO3	Describe the nanoparticles used to diagnosis and its ethical issues and toxicology.
CO4	Describe the nanoparticles used in therapeutics.
CO5	Understand the applications of nanotechnology in medical field.

CO	PO												PSO			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**	**4**
1	M	L	L	M	H	M	L		L	L			H	H	H	H
2	M	L	L	M	H	M	L		L	L			M	M	M	M
3	M							M								

4	M					M										H
5	M					M										H

H - High, M - Medium, L – Low

Unit 1	**FUNDAMENTALS OF NANOPARTICLES**	**Hours: 9**
Overview of nanotechnology from medical perceptive, Introduction to nano, Nano-biomimicry, Synthesis of nanomaterials by physical and chemical methods, Synthesis of nanomaterials by biological methods, Characterization of nanomaterials.		
Unit 2	**BIOFUNCTIONALIZATION**	**Hours: 09**
DNA nanotechnology, Protein &glyco nanotechnology, Lipid nanotechnology, Bio-nanomachines, Carbon nanotube and its bio-applications. Cellular uptake mechanisms of nanomaterials, Nanopharmacology& drug targeting, In vitro methods to study antibacterial and anticancer properties of nanomaterials		
Unit 3	**NANOPARTICLES IN DIAGNOSIS**	**Hours: 09**
Introduction to nanoparticles in diagnostics nuclear imaging, optical imaging, PET, Micro PET, cardio vascular disease studies, imaging and therapy of thrombosis, emerging Ethical issues and toxicology of nanomaterials.		
Unit 4	**NANOTHERAPEUTICS**	**Hours: 09**
Nanoparticles as carriers in drug delivery- design, manufacture and physiochemical properties, transport across biological barriers, nanotechnology in Cancer therapy, lung infectious disease, bone treatment, nano particles for oral vaccination and skin disease.		
Unit 5	**POTENTIAL APPLICATIONS OF NANOTECHNOLOGY IN MEDICINE**	**Hours: 09**
Nanotubes, nanowires, and nanodevices-introduction - Functional Nanostructures – Introduction to molecular electronics - Field emission and Shielding - Nanoelectromechanical systems (NEMs). Nanotechnology in tissue engineering, Nano artificial cells, Nanotechnology in organ printing		
	Total Lecture hours	**45**

Text Books

1	Malsch, N.H., “Biomedical Nanotechnology”, CRC Press. (2005).

Reference Books

1	Kumar, C. S. S. R., Hormes, J. and Leuschner C., “Nanofabrication Towards Biomedical Applications: Techniques, Tools, Applications, and Impact”,

	WILEY -VCH Verlag GmbH & Co. (2005).
2	Mirkin, C.A. and Niemeyer, C.M., "Nanobiotechnology II: More Concepts and Applications", Wiley-VCH. (2007).
3	Lamprecht, A., "Nanotherapeutics: Drug Delivery Concepts in Nanoscience", Pan Stanford Publishing Pte. Ltd. (2009).
4	Jain, K.K., "The Handbook of Nanomedicine", Humana press. (2008).
5	CM, Niemeyer, C.A. Mirkin, "Nano biotechnology Concepts, Applications and Perspectives", Wiley, 2004.
6	Challa, S.S.R. Kumar, Josef Hormes, Carola Leuschaer., "Nanofabrication towards Biomedical Applications, Techniques, Tools, Applications and Impact" Wiley, 2005.
7	Harry F. Tibbals, Medical Nanotechnology and Nanomedicine, CRC Press, 2010
8	Vinod Labhasetwar, Diandra L. Leslie-Pelecky, "Biomedical Applications of Nanotechnology", John Wiley & Sons, 2007.

UNIVERSITY ELECTIVE COURSES

Course Code	Course Name	L	T	P	X	C
214BME2133	Medical Optics & Lasers	3	0	0	0	3

Prerequisite: have to include any basic science course	**Syllabus revision:** r.3
Course Category: University Elective	**Course Type:** Theory

Course description

1	To understand the basics of tissue optics
2	To analyze the principles of photonic detection methods
3	To understand the biomedical diagnostic applications
4	To analyze the optical biopsy techniques
5	To apply and evaluate the intervention and diagnostic techniques

Course outcomes:
On successful completion of the course the students will be able to

CO1	Demonstrate an understanding of the tissue optical properties and its instrumentation
CO2	Enlighten the principles of photonic detection techniques and the usage of the same in biomedical imaging
CO3	Understand the various biomedical diagnostic applications in the field of biomedical engineering
CO4	Analyze the concepts involved in various fluoroscopy based biomedical diagnostics

CO5	Evaluate and expound the diagnostic methodologies followed in biomedical photonics	
CO	**PO**	**PSO**

	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
1	H				H								H			
2	H				H								H			
3	H				H								H			
4	H				H								H			
5	H				H								H			

H - High, M - Medium, L - Low

Unit 1	**Tissue Optics & Photonic Devices**	**Hours: 9**
Optical properties of tissue, light-tissue interactions, Optical Diffusion Tomography, Laser light in Medicine, Basic Instrumentation in Photonics		
Unit 2	**Photonic Detection and Imaging Techniques**	**Hours: 9**
Lifetime based imaging, near-field imaging in biological and biomedical applications, Optical Coherence Tomography imaging, Laser doppler perfusion monitoring and imaging, thermal imaging for biological and medical diagnostics		
Unit 3	**Biomedical Diagnostics**	**Hours: 9**
Glucose diagnostics, In vitro clinical diagnostic instrumentation, biosensors for medical applications, functional imaging with diffusing light		
Unit 4	**Optical Biopsy**	**Hours: 9**
Optoacoustic Tomography, Ultrasonically modulated optical imaging, quantitative characterization of biological tissue using optical spectroscopy, Fluorescence spectroscopy for biomedical diagnostics		
Unit 5	**Intervention and Diagnostic Techniques**	**Hours: 9**
Principles of PDT and its clinical applications, laser tissue welding, laser in dermatology, ophthalmology, Laser treatment for breast tumors, image guided surgery		
	Total Lecture hours	**45**

Text Books	
1	Biomedical Photonics Handbook. (2003). United Kingdom: Taylor & Francis.
Reference Books	
1	Biomedical Photonics Handbook, Second Edition: Fundamentals, Devices, and Techniques. (2014). United States: Taylor & Francis.
2	Biomedical Photonics Handbook, Second Edition: Biomedical Diagnostics. (2014). United States: Taylor & Francis.
3	Biomedical Photonics Handbook, Second Edition: Therapeutics and Advanced Biophotonics. (2014). United Kingdom: Taylor & Francis.
4	Biomedical Photonics Handbook, 3 Volume Set. (2014). United States: CRC Press.

Course Code	Course Name	L	T	P	X	C
214BME2132	COMPUTERS IN MEDICINE	3	0	0	0	3

Prerequisite: Nil	**Syllabus revision:** r.3
Course Category: University Elective	**Course Type:** Theory

Course description

1	Describe general functions, purposes and benefits of health information systems.
2	Describe the evolution and adoption of health information systems
3	Compare health information systems in terms of their ability to support the requirements of a healthcare enterprise.
4	Propose the hardware, software, operating system and networking considerations necessary for effective data storage and use in healthcare organizations
5	Utilize the tools and techniques for collecting, storing, securing, retrieving, and reporting healthcare data.

Course outcomes:
On successful completion of the course the students will be able to

CO1	To understand the system of information managed in the hospital.
CO2	To demonstrate the application of software employed in medical data management.
CO3	To examine medical imaging data with an assist of computers.
CO4	To understand the concept of maintaining digital patient records.
CO5	To acquire knowledge in delivering instructions in medicine using computers.

CO	PO	PSO

	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
1	M				M								L			
2	L				M								L			
3	L	L			M	L	L						L			
4	M	L			M	M						L	L			
5	L	M			M	M							L			

H - High, M - Medium, L – Low

Unit 1	**HOSPITAL INFORMATION SYSTEM**	**Hours: 9**

Introduction –Foundations of Health-care Informatics- Ethics- Electronic Health Records- Information Infrastructure- computer based medical information retrieval.

Unit 2	**COMPUTERISED PATIENT DATABASE MANAGEMENT**	**Hours: 9**

Data base approach -EHR Functionality including Online Use of an EHRGovernment EHR Certification - Technical Infrastructure -Security - Interoperability & Health Information Exchanges - EHR Deployment & Project Management -Patient Centered EHR

Unit 3	**COMPUTER ASSISTED MEDICAL IMAGING AND DECISION MAKING**	**Hours: 9**

Computer Assisted Medical Decision Making-Model of CMD-Approaches-Decision Support Systems Algorithms –Analysis –CBR-Production Rule Systems-Cognitive Models-Semantic Networks – Decision Analysis in Clinical Medicine –Clinical Decision Support.

Unit 4	**COMPUTERISED PATIENT RECORD**	**Hours: 9**

Computerised Patient Record –Introduction-History Taking By Computer-Dialogue With The Computer - Computerised Prescriptions For Patients-Introduction-Adverse Drug Reactions-Computer Assisted Patient Education And Health Care Information –Introduction –Health Online –Electronic Communication With Patients-Importance Of Behaviour Modification.

Unit 5	**COMPUTER ASSISTED INSTRUCTION IN MEDICINE**	**Hours: 9**

Computer Assisted Drug Discovery And Development, Molecular Modelling By Computer-Computational Representation Of Molecules-Modelling GPCRS-Pharmacophores-New Drugs For Cancer-0 from Gene To Screen.

Total Lecture hours	**45**
Text Books	
1	R. D. Lee, Computers in Medicine, Tata McGraw Hill Publishing Company Limited, New Delhi, 1993.
Reference Books	
1	Harold Sackamn, Biomedical Information Technology, Academic Press, New York.
2	S.K.Chachan, PC Organisation, S.K. Kataria and Sons, Delhi 2000.

Course Code	Course Name	L	T	P	X	C
214BME1109	BIOMEDICAL INSTRUMENTATION	3	0	0	0	3

Prerequisite: Nil	**Syllabus revision:** r.1
Course Category: University Elective	**Course Type:** Theory

Course description

The course offers basic concepts and understanding of Instrumentation involved in medical field and human physiology. Biomedical Instrumentation is application of technology for medical field. During the course, students will explore Electro- physiological measurements, basic medical equipment etc.

Course outcomes:
On successful completion of the course the students will be able to

CO1	Describe and understand the origin of biopotentials and different types of electrodes used in bio-potential recording.
CO2	Understand and design the basic bioelectric signal recording systems and bio amplifiers.
CO3	Illustrate and design the medical instrument used to measure non electrical parameters.
CO4	Understand and illustrate the working principle of basic life supporting instruments.
CO5	Describe the working and usage of analytical equipment and electrical hazards and safety in handling medical equipment.

CO	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
1	H												H			

2		L												L		
3			H			H									H	H
4							L						H			H
5			M			H		H				H	H			H

H - High, M - Medium, L – Low

Unit 1	**BIOPOTENTIAL AND ELECTRODES**	**Hours: 09**

Components of Medical Instrumentation System- Origin of Biopotentials, Electrical Activity of Cells, Electrode Skin interface, Electrode-Electrolyte interface, motion artifact, half-cell potentialPolarization effects of electrode – Nonpolarizable electrodes. Types of electrodes - Surface; needle and micro electrodes – ECG – EMG - EEG Electrodes.

Unit 2	**BIOELECTRIC SIGNALS RECORDING AND BIOAMPLIFIERS**	**Hours: 09**

Recording of ECG, EEG and EMG - Einthoven triangle, Standard 12-lead configurations - ECG Machine - EMG machine – 10-20 electrodes placement system for EEG - EEG machine.
Bioamplifiers- Carrier Amplifier, - Isolation Amplifier - Differential amplifier - Chopper Amplifier - Instrumentation Amplifier

Unit 3	**MEASUREMENT OF NON-ELECTRICAL PARAMETERS**	**Hours: 09**

Human body Temperature, Measurement of blood pressure – Measurement of Cardiac output Measurement of Heart rate, Measurement of Heart sound
Pulmonary function measurements – spirometer, Blood Gas analysers: finger-tip oxymeter - ESR, GSR measurements.

Unit 4	**LIFE SUPPORT INSTRUMENTS**	**Hours: 09**

Pacemaker-Types of Pacemakers, mode of pacing and its application, Defibrillator-AC and DC Defibrillators and their application, Heart Lung machine and its application during surgery, Hemodialysis system and the precautions to be taken during dialysis.

Unit 5	**ANALYTICAL INSTRUMENTAION AND ELECTRICAL SAFETY**	**Hours: 09**

Principle of colorimetry, photometry and pH measurement. Spectrophotometer; Spectrofluorometer; pH meter. Blood Cell counter; Biochemical analyzers; Na-K analyzer, Physiological effects of electrical current, Shock Hazards from electrical equipment and methods of accident prevention

Total Lecture hours	**45**

Text Books	
1	Khandpur R.S, “Handbook of Biomedical Instrumentation”, Tata McGraw Hill, New Delhi, 2014
Reference Books	
1	Leslie Cromwell, “Biomedical Instrumentation and Measurement”, Prentice Hall of India, New Delhi, 2007
2	John G. Webster, “Medical Instrumentation Application and Design”, John Willey and Sons, 2009.
3	Carr, J.J. and Brown, J.M., Introduction to Biomedical Equipment Technology, Prentice Hall (2000) 4th edition or current.
4	Geddes, L.A., and Baker, L.E., Principles of Applied Biomedical Instrumentation, Wiley InterScience (1989) 3rd or current Edition.

Course Code	Course Name	L	T	P	X	C
214BME2134	REHABILITATION ENGINEERING	3	0	0	0	3

Prerequisite: Nil	**Syllabus revision:** r.1
Course Category: University Elective	**Course Type:** Theory

Course description

This course discuss the broad area of rehabilitation engineering solutions and their limitations for persons who suffer from physical or sensory impairments and its application to assist people with impairments in sensing, communication, seating, manipulation, and mobility.

Course outcomes:
On successful completion of the course the students will be able to

CO1	Have basic knowledge about the principles of rehabilitation.
CO2	Describe the features of human movement in health and disability and discuss the application of these properties in rehabilitation engineering design.
CO3	Learn therapeutic Exercise Techniques.
CO4	Discuss the various rehabilitation communication techniques.
CO5	Understand orthopedic prosthetics and orthotics in rehabilitation

CO	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
1	M	L	L	L		M						H	M	M	H	M
2	M	M	M	M	L	H	L	M	M	L		H	M	M	H	M
3	M	H	H	M	M	H	L	M	M	M		H	M	H	H	M

4	M	H	H	M	M	H	L	M	M	H		H	M	H	H	M
5	M	H	H	M	M	H	L	M	H	M		H	M	H	H	M

H-High, M-Medium, L-Low

Unit 1	**INTRODUCTION TO REHABILITATION & REHABILITATION TEAM**	**Hours: 09**

What is Rehabilitation, Epidemiology of Rehabilitation, Health, Levels of Prevention, Preventive Rehabilitation, Diagnosis of Disability, Functional Diagnosis, Importance of Psychiatry in Functional diagnosis, Impairment disability handicap, Primary & secondary Disabilities, Rehabilitation team-Classification of members. HAAT – Human Activity Assistive Technology.

Unit 2	**PRINCIPLES OF REHABILITATION**	**Hours: 09**

Introduction, The Human Component, Principles of Assistive Technology Assessment, Principles of Rehabilitation Engineering- Key Engineering Principles, Key Ergonomic Principles - Practice of Rehabilitation and Assistive Technology.

Unit 3	**THERAPEUTIC EXERCISE TECHNIQUE**	**Hours: 09**

Co-ordination exercises, Frenkels exercises, Gait analyses-Pathological Gaits, Gait Training, Relaxation exercises-Methods for training Relaxation, Strengthening exercises-Strength training, Types of Contraction, Mobilization exercises, Endurance exercises.

Unit 4	**SENSORY REHABILITATION SYSTEMS**	**Hours: 09**

Engineering concepts in sensory rehabilitation, Sensory Augmentation & substitution: Visual System- types of visual aids Auditory system- Hearing aids, Types of conventional hearing aid, Writing aids.

Unit 5	**ORTHOTIC & PROSTHETIC DEVICES**	**Hours: 09**

General orthotics, Classification of orthotics-functional & regional, General principles of Orthosis. Calipers. Prosthetic devices: Hand and arm replacement, Body powered prosthetics, Myoelectric controlled prosthetics and Externally powered limb prosthetics.

	Total Lecture hours	**45**

Text Books

1	Dr. S. Sunder, Rehabilitation Medicine-, 3rd Edition, Jaypee Medical Publications, New Delhi. 2010 (Units I, III, IV & V)

2	Joseph D.Bronzino, The Biomedical Engineering Handbook, Third Edition: Three Volume Set, CRC Press, 2006 (Units II & V).
Reference Books	
1	Rory A Cooper, An Introduction to Rehabilitation Engineering, Taylor & Francis, CRC press, 2006.
2	Susan B O'Sullivan, Thomas J Schmitz, Physical Rehabilitation. 5th Edition, Davis publications, 2007.

Course Code	Course Name	L	T	P	X	C
214BME3163	TELEMEDICINE	3	0	0	0	3

Prerequisite: Nil	**Syllabus revision:** r.3
Course Category: University Elective	**Course Type:** Theory

Course description

This course covers the role of information and communications technologies in enabling remote patient care, health professional collaboration at a distance, and in supporting patient-self management. Also enables the students to evaluate business and technology infrastructure models required for supporting telehealth services.

Course outcomes:
On successful completion of the course the students will be able to

CO1	Know the essential parameters, scope, benefits and limits of telemedicine.
CO2	Explain the application of multimedia and needs of communication networks in telemedicine.
CO3	Understand the use and necessity of various security and standards in telehealth modules.
CO4	Describe the needs of acquisition devices in telehealth monitoring and diagnosis.
CO5	Apply telehealth in healthcare.

CO	PO												PSO			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**	**4**
1			M											L		
2	L	L	M										L	L		

3			M			M										M
4	L	L	M										L	L		
5	L	L	M										L	L		

H - High, M - Medium, L - Low

Unit 1	**Fundamentals of Telemedicine**	**Hours: 9**

History of telemedicine, definition of telemedicine, tele-health, tele-care, scope, Telemedicine Systems, benefits & limitations of telemedicine.

Unit 2	**Technology of Telemedicine Systems**	**Hours: 9**

Audio, video, still images, text and data, fax-type of communications and network: PSTN, POTS, ANT, ISDN, internet, air/ wireless communications, GSM satellite, micro wave, Mobile health and ubiquitous healthcare.

Unit 3	**Ethical and Legal Aspects of Telemedicine**	**Hours: 9**

Confidentiality, patient rights and consent: confidentiality and the law, the patient-doctor relationship, access to medical records, consent treatment - data protection & security, jurisdictional issues, intellectual property rights.

Unit 4	**Picture Archiving and Communication System**	**Hours: 9**

Introduction to radiology information system and ACS, DICOM, PACS strategic plan and needs assessment, technical Issues, PACS architecture.

Unit 5	**Applications of Telemedicine**	**Hours: 9**

Teleradiology, Telepathology, Telecardiology, Teleoncology, Teledermatology, Telesurgery, e Health and Cyber Medicine.

Total Lecture hours	**45**

Text Books

1	Norris A C, “Essentials of Telemedicine and Telecare”, John Wiley, New York, 2002.
2	H K Huang, “PACS and Imaging Informatics: Basic Principles and Applications” Wiley, New Jersey, 2010.

Reference Books

1	Olga Ferrer Roca, Marcelo Sosa Iudicissa, “Handbook of Telemedicine”, IOS Press, Netherland, 2002.
2	Khandpur R S, “Handbook of Biomedical Instrumentation”, Tata McGraw Hill, New Delhi, 2003.
3	Khandpur R S, “TELEMEDICINE – Technology and Applications”, PHI Learning Pvt Ltd., New Delhi, 2017.

Course Code	Course Name	L	T	P	X	C
214BME3163	TISSUE ENGINEERING	3	0	0	0	3

Prerequisite: Nil	**Syllabus revision:** r.1
Course Category: University Elective	**Course Type:** Theory

Course Objective

To impart knowledge on the concepts of Tissue engineering, new tissue generation and organ transplantation.

Course outcomes:
On successful completion of the course the students will be able to

CO1	Describe and understand the basics of tissue engineering and principles of engineering a tissue in vitro and its testing
CO2	Understand the aspects of cell culture and bioreactor
CO3	Understand the design, fabrication of scaffold and cell-biomaterial interaction.
CO4	Describe the biomaterials for tissue engineering and various tissue transplants.
CO5	Understand the ethical and regulatory issues and case studies on various transplantation.

CO	PO												PSO			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**	**4**
1	M	L	L	M		M	L		L	L			H	H	H	H
2	M	L	L	M		M	L		L	L			M	M	M	H
3	M				H			M								H

4	M				H	M									H	H
5	M					M										H

H - High, M - Medium, L – Low

Unit 1	**INTRODUCTION**	**Hours: 9**

Introduction to tissue engineering, Structural organization of tissues: Epithelial, connective; vascularity and angiogenesis, basic wound healing, cell migration, Principles of engineering a tissue in vitro, current scope of development and use in therapeutic and in-vitro testing.

Unit 2	**CELL CULTURE**	**Hours: 09**

Different cell types, progenitor cells and cell differentiations, different kind of matrix, cell-cell interaction. Aspect of cell culture: cell expansion, cell transfer, cell storage and cell characterization, Tissue microenvironment and bioreactor Cell signaling molecules, Receptor-ligand binding kinetics, Cell surface markers.

Unit 3	**SCAFFOLD & CELL-BIOMATERIAL INTERACTION**	**Hours: 09**

Scaffold:Design, fabrication, properties and characterization, cells and in vitro culture of cells, cell seeding
cell-biomaterial interaction: cell adhesion, migration, aggregation, Cell proliferation and differentiation, cell–scaffold construct & its characterization,

Unit 4	**SCAFFOLD AND TRANSPLANT**	**Hours: 09**

Engineering biomaterials for tissue engineering, Degradable materials (collagen, silk and polylactic acid), porosity, mechanical strength, 3-D architecture and cell incorporation. Engineering tissues for replacing skin and liver. Basic transplant immunology stems cells: introduction, hepatopoiesis

Unit 5	**CASE STUDY AND REGULATORY ISSUES**	**Hours: 09**

Case study of multiple approaches: cell transplantation for liver, musculoskeletal, cardiovascular, neural, visceral tissue engineering. Ethical, FDA and regulatory issues of tissue engineering.

	Total Lecture hours	**45**

Text Books

1	B. Palsson, S. Bhatia, Tissue Engineering, Pearson Prentice Hall, 2003

Reference Books

1	G. Vunjak-Novakovic, R. Ian Freshney, Culture of Cells for Tissue Engineering, WIS, 2006

2	B. Palsson, J.A. Hubbell, R. Plonseyand J.D. Bronzino, Tissue Engineering, CRC- Taylor&Francis
3	R. P. Lanza, R. Langerand W. L. Chick, Principles of tissue engineering, Academic press, 1997
4	Clemens van Blitterswijk, Tissue Engineering", Academic Press, 2008
5	Bernhard O.Palsson, "Tissue Engineering", Pearson Education, 1st Edition, 2016
6	John P.Fisher, antoniosG.Mikos, Joseph D.Bronzino, "Tissue Engineering", CRC Press, 2007
7	Robert Lanza, Robert Langer, Joseph P.vacanti, "Principles of Tissue Engineering", Academic Press, 2011.

Course Code	Course Name	L	T	P	X	C
214BME2135	WEARABLE SYSTEMS	3	0	0		3

Prerequisite: Nil	**Syllabus revision:** r.3
Course Category: University Elective	**Course Type:** Theory

Course description

1	To introduce basic sensors for wearable systems
2	To analysis signals acquired by wearable sensors
3	To use different sources of energy for wearable system
4	To analyze the technical aspects of wireless health systems
5	To apply the inculcated knowledge in wearable sensors for developing simple medical applications

Course outcomes:
On successful completion of the course the students will be able to

CO1	Differentiate the sensors that can be used for wearable systems
CO2	Process the signals picked by the wearable sensors
CO3	Utilize different sources of energy to be used for wearable systems
CO4	Analyze the technical aspects of wireless health systems
CO5	Apply the wearable sensors into novel medical applications.

CO	PO	PSO

	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
1	L												M	M		
2		M	M										M	M		
3		S	M										M	M		
4		S	S			M		M					M	M		
5		S	M			S		S					M	M		

H - High, M - Medium, L - Low

Unit 1	**Sensors**	**Hours: 9**

Need for wearable systems, Sensors for wearable systems-Inertia movement sensors, Respiration activity sensor, Inductive plethysmography, Impedance plethysmography, pneumography, Wearable ground reaction force sensor, GSR, Radiant thermal sensor, Wearable motion sensors, CMOS – Based Biosensors, E-Textiles, Bio compatibility.

Unit 2	**Signal processing**	**Hours: 9**

Wearability issues -physical shape and placement of sensor, Technical challenges - sensor design, signal acquisition, Constraint on sampling frequency for reduced energy consumption, light weight signal processing, Rejection of irrelevant information, Data mining.

Unit 3	**Energy harvesting for wearable devices**	**Hours: 9**

Solar cell, Vibration based, Thermal based human body as a heat source for power generation, Hybrid thermoelectric photovoltaic energy harvests, Thermopiles.

Unit 4	**Wireless health systems**	**Hours: 9**

Need for wireless monitoring, ISO/OSI layer architecture, Definition of Body area network, BAN and Healthcare, Technical Challenges- System security and reliability, BAN Architecture – Introduction, Wireless communication techniques.

Unit 5	**Applications of wearable systems**	**Hours: 9**

Medical Diagnostics, Medical Monitoring-Patients with chronic disease, Hospital patients, Elderly patients, Multi parameter monitoring, Neural recording, Gait analysis, Sports Medicine, Smart Fabrics.

	Total Lecture hours	**45**

Text Books	
1	Annalisa Bonfiglio,Danilo De Rossi ,"Wearable Monitoring Systems", Springer, 2011.
2	Sandeep K.S. Gupta,TridibMukherjee,Krishna Kumar Venkatasubramanian, "Body Area Networks Safety,Security, and Sustainability," Cambridge University Press, 2013.
Reference Books	
1	Hang,Yuan-Ting,"wearable medical sensors and systems",Springer-2013
2	Mehmet R. Yuce,JamilY.Khan, "Wireless Body Area Networks Technology, Implementation and Applications",Pan Stanford Publishing Pvt.Ltd, Singapore, 2012.
3	Guang-Zhong Yang(Ed.), "Body Sensor Networks, "Springer, 2006
4	Andreas Lymberis, Danilo de Rossi ,'Wearable eHealth systems for Personalised Health Management - State of the art and future challenges ' IOS press, The Netherlands, 2004.

Course Code	Course Name	L	T	P	X	C
214BME3162	NANOTECHNOLOGY IN MEDICINE	3	0	0	0	3

Prerequisite: Nil	**Syllabus revision:** r.1
Course Category: University Elective	**Course Type:** Theory

Course description

This course provides an overview of nanotechnology, fabrication, characterization and functions of nanoscale structures, and serves as an introduction to major areas in medical sectors influenced by developments in nanotechnology

Course outcomes:
On successful completion of the course the students will be able to

CO1	Describe and understand the synthesis, characterization, and properties of nanoparticles and identify different types of nano biomaterials.
CO2	Understand about the protein and DNA based nanostructures
CO3	Describe the nanoparticles used to diagnosis and its ethical issues and toxicology.
CO4	Describe the nanoparticles used in therapeutics.
CO5	Understand the applications of nanotechnology in medical field.

CO	PO												PSO			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**	**4**
1	M	L	L	M	H	M	L		L	L			H	H	H	H
2	M	L	L	M	H	M	L		L	L			M	M	M	M
3	M							M								

4	M					M										H
5	M					M										H

H - High, M - Medium, L – Low

Unit 1	**FUNDAMENTALS OF NANOSCIENCE AND NANOPARTICLES**	**Hours: 9**
Overview of nanotechnology from medical perceptive, different types of nano biomaterials and nanostructure interactions. Synthesis, characterization, and properties of smart nanomaterials.		
Unit 2	**BIOFUNCTIONALIZATION OF NANOMATERIALS**	**Hours: 09**
Nanocarriers, liposomes, polymer capsules, polymer nanoparticles. Protein based nanostructures; DNA based nanostructures.		
Unit 3	**NANOPARTICLES IN DIAGNOSIS**	**Hours: 09**
Introduction to nanoparticles in diagnostics nuclear imaging, optical imaging, PET, Micro PET, cardio vascular disease studies, imaging and therapy of thrombosis, emerging Ethical issues and toxicology of nanomaterials.		
Unit 4	**NANOTHERAPEUTICS**	**Hours: 09**
Nanoparticles as carriers in drug delivery- design, manufacture and physiochemical properties, transport across biological barriers, nanotechnology in Cancer therapy, lung infectious disease, bone treatment, nano particles for oral vaccination and skin disease.		
Unit 5	**POTENTIAL APPLICATIONS OF NANOTECHNOLOGY IN MEDICINE**	**Hours: 09**
Nanotubes, nanowires, and nanodevices-introduction - Functional Nanostructures-Introduction to molecular electronics - Field emission and shielding, Nanoelectromechanical systems (NEMs) - Nanotechnology in tissue engineering, Nano artificial cells, Nanotechnology in organ printing		
	Total Lecture hours	**45**

Text Books

1	CM, Niemeyer, C.A. Mirkin, “Nano biotechnology Concepts, Applications and Perspectives”, Wiley, 2004.

Reference Books

1	Challa, S.S.R. Kumar, Josef Hormes, Carola Leuschaer., “Nanofabrication towards Biomedical Applications, Techniques, Tools, Applications and Impact” Wiley, 2005.
2	Harry F. Tibbals, Medical Nanotechnology and Nanomedicine, CRC Press, 2010

3	Nicholas A. Kotov, “Nanoparticles Assemblies and Superstructures”, CRC, 2006
4	T. Pradeep, “Nano: The Essentials”, McGraw Hill education 2007.
5	Vinod Labhasetwar, Diandra L. Leslie-Pelecky, “Biomedical Applications of Nanotechnology”, John Wiley & Sons, 2007.

Course Code	Course Name	L	T	P	X	C
214BME3161	BIOMETRIC SYSTEMS	3	0	0	0	3

Prerequisite: Nil	**Syllabus revision:** r.3
Course Category: University Elective	**Course Type:** Theory

Course description

1	To understand the technologies of fingerprint, iris, face.
2	To understand the general principles of design of biometric systems and the underlying trade-offs.
3	To recognize personal privacy and security implications of biometrics based identification technology.
4	To identify issues in the realistic evaluation of biometrics based systems.
5	To understand the technologies of speech recognition.

Course outcomes:
On successful completion of the course the students will be able to

CO1	Understand the concept of Biometrics and its applications
CO2	Illustrate the various methodologies involved in fingerprint technology
CO3	Develop techniques for face recognition and hand geometry biometrics
CO4	Demonstrate the multimodal biometrics and the methods for evaluating the performance
CO5	Distinguish the authentication mechanism of the biometric systems

CO	PO	PSO

	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
1	L	L			L								H			
2	M												H			
3		H														
4						M						L		M		
5					L								H	M		

H - High, M - Medium, L - Low

Unit 1	**INTRODUCTION TO BIOMETRICS**	**Hours: 9**

Biometric technologies – passive biometrics – active biometrics –Biometric systems – Enrollment – templates – algorithm – verification – Biometric applications –biometric characteristics- Authentication technologies –Need for strong authentication – Protecting privacy and biometrics and policy-Biometric systems.

Unit 2	**FINGERPRINT TECHNOLOGY**	**Hours: 9**

Finger print feature processing techniques - fingerprint sensors using RF imaging techniques – fingerprint quality assessment – computer enhancement and modeling of fingerprint images – fingerprint enhancement – Feature extraction – fingerprint classification – fingerprint matching.

Unit 3	**FACE RECOGNITION AND HAND GEOMETRY**	**Hours: 9**

Face recognition from correspondence maps – Hand geometry – scanning – Feature Extraction - Adaptive Classifiers -Visual- Based Feature Extraction and Pattern Classification - feature extraction – types of algorithm.

Unit 4	**MULTIMODAL BIOMETRICS AND PERFORMANCE EVALUATION**	**Hours: 9**

Behavioral Biometrics - Introduction to multimodal biometric system – Integration strategies – Architecture – level of fusion – combination strategy –training and adaptability – examples of multimodal biometric systems – Performance evaluation- Statistical Measures of Biometrics.

Unit 5	**BIOMETRIC AUTHENTICATION**	**Hours: 9**

Biometric Authentication Systems – Biometric authentication by fingerprint -Biometric Authentication by Face Recognition. -. Expectation- Maximization theory - Support Vector Machines. Biometric authentication by fingerprint –biometric authentication by hand geometry- Securing and trusting a biometric transaction – matching location.

Total Lecture hours	**45**
Text Books	
1	James Wayman, Anil Jain, Davide Maltoni, Dario Maio, “Biometric Systems, Technology Design and Performance Evaluation”, Springer, 2005
2	S.Y. Kung, S.H. Lin, M.W.Mak, “Biometric Authentication: A Machine Learning Approach”Prentice Hall, 2005
Reference Books	
1	Paul Reid, “Biometrics for Network Security”, Pearson Education, 2004.
2	Nalini K Ratha, Ruud Bolle, “Automatic fingerprint Recognition System”, Springer, 2003

Course Code	Course Name	L	T	P	X	C
214BME1110	BIOMEDICAL WASTE MANAGEMENT	3	0	0	0	3

Prerequisite: Nil	**Syllabus revision:** r.3
Course Category: University Elective	**Course Type:** Theory

Course description

This course deals with the general and hazardous health care waste: Infectious waste, geno-toxic waste, Sharps, categorization and composition of biomedical waste, major and minor sources of biomedical waste, Segregation of waste, Color coding, waste handling and disposal, Hazard of Biomedical Waste, Treatment Technologies for Wastes**,** Laws OF Biomedical Waste Handling, Guidelines.

Course outcomes:
On successful completion of the course the students will be able to

CO1	Distinguish the different types of hazardous biomedical waste, its handling and disposal methodologies
CO2	Enumerate the hazards caused by non disposal of medical waste
CO3	Analyze the various treatment techniques of processing biomedical waste
CO4	Illustrate the laws for handling the biomedical waste
CO5	Demonstrate the guidelines provided by WHO for management of hospital waste

CO	PO												PSO			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**	**4**
1	M	L	L	L		H	H	L	M	L	L	M	L	L	H	M
2	M	L	L	L	L	H	H	L	M	L	L	M	L	M	H	H
3	M	M	M	H	M	H	H	M	H	M	H	M	M	M	H	M

4	M	M	L	M	L	H	H	M	H	M	H	M	M	L	H	M
5	M	M	L	M	L	H	H	M	H	M	H	M	M	L	H	M

H-High, M-Medium, L-Low

Unit 1	**INTRODUCTION**	**Hours: 09**
Definition of general and hazardous health care waste, Infectious waste, geno-toxic waste, waste sharps, categorization and composition of Biomedical waste, major and minor sources of biomedical waste, Segregation of waste, Color coding, waste handling and disposal		
Unit 2	**HAZARD OF BIOMEDICAL WASTE**	**Hours: 09**
Need for disposal of biomedical waste, Specifically Communicable diseases, Diseases epidemiology and mode of transmission of disease, Environmental pollution by biomedical waste - causes, consequences, mitigation and remedies.		
Unit 3	**TREATMENT TECHNOLOGIES FOR WASTES**	**Hours: 09**
Mechanical Treatment & Chemical Disinfections, Conventional Treatment Technologies: Wet thermal technology, Incineration, Microwave Technology, Autoclave system, Hydro clave system, Electro Thermal Reactivation (ETP), Treatment Process Electron beam Technology, Plasma Pyrolysis/ Gasificaton systems		
Unit 4	**LAWS OF BIOMEDICAL WASTE HANDLING**	**Hours: 09**
Legislation, policies and law regarding environment on Health care waste management, Biomedical waste management and handling rules 1998 and its amendment.		
Unit 5	**GUIDELINES**	**Hours: 09**
CPCB guidelines. World Health Organization guidelines on Management of wastes from Hospital wastes		
	Total Lecture hours	**45**

Reference Books

1	Anantpreet Singh, Sukhjit Kaur, “Biomedical Waste Disposal”, 1st ed., Jaypee Publishers (P) Ltd, India, 2012.
2	Sushma Sahai, “Bio-Medical Waste Management”, APH Publishing Corporation, India, 2009.
3	Sanskriti Sharma, “Hospital Waste Management and Its Monitoring”, Jaypee Publishers (P) Ltd, India, 2002.

Course Code	Course Name	L	T	P	X	C
214BME1108	BIOETHICS, IPR AND STANDARDS	3	0	0	0	3

Prerequisite: Nil	**Syllabus revision:** r.3
Course Category: University Elective	**Course Type:** Theory

Course description

1	To discuss about various aspects of biosafety regulations
2	To discuss about various aspects of IPR
3	To discuss about various aspects of bioethic
4	Risk Assessment and Management
5	IPR rights

Course outcomes:
On successful completion of the course the students will be able to

CO1	Understand the biomedical ethics
CO2	Analyze the issues arise in biomedical devices
CO3	Know about the basic principles of IPR law
CO4	Describe about the safety measures in order to use a biomedical device
CO5	Understand the biomedical standards.

CO	PO	PSO

	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
1	H	H			L			H					H			L
2	H	H						H					H			L
3								H								L

4								H								L
5								H					H			L

H - High, M - Medium, L - Low

Unit 1	**BIOMEDICAL ETHICS**	**Hours: 9**
Biosafety and risk assessment issues; Regulatory framework; National biosafety policies and law, The Cartagena protocol on biosafety, WTO and other international agreements related to biosafety		
Unit 2	**ETHICAL ISSUES IN DESIGN AND MANUFACTURE OF MEDICAL DEVICES**	**Hours: 9**
General principles for the laboratory and environmental biosafety; Health aspects; toxicology, allergenicity, antibiotic resistance, etc; Impact on environment: gene flow in natural and artificial ecologies; .		
Unit 3	**BASIC PRINCIPLES OF IPR LAWS**	**Hours: 9**
History of IPR-GATT,WTO,WIPO & TRIPs, Role of IPR in Research & Development, Concept of property, Different forms of IPR, Layout designs of Integrated circuits, Patents, Geographical Indications, Plant varieties, Trade secrets.		
Unit 4	**SAFETY**	**Hours: 9**
Ecological aspects of GMOs and impact on biodiversity; Monitoring strategies and methods for detecting transgenics; Radiation safety and nonradio isotopic procedure; Benefits of transgenics to human health		
Unit 5	**STANDARDS**	**Hours: 9**
Safety and standardization for risk management, Indian patent act and amendments, patent filing; Convention on biological diversity; Implications of intellectual property rights on the commercialization of biotechnology products.		
	Total Lecture hours	**45**

Text Books

1	Daniel A Vallero, "Biomedical ethics for Engineers", Academic Press, New York, 2007.

Reference Books

1	PrabuddghaGanguli, "Intellectual Property Rights", TMH Publishing Co. Ltd., 2001.
2	Patents by N.R. Subbaram, Pharma Book Syndicate, Hyderabad, India, 2006.

HONOR ELECTIVE COURSES

Course Code	Course Name	L	T	P	X	C
214BME1108	BIOMECHATRONICS	3	0	0	0	3

Prerequisite: Nil	**Syllabus revision:** NA
Course Category: Honor Elective	**Course Type:** Theory

Course description

This course aims to build prosthesis arms and legs. This course aims to provide an understanding of biomechanical and neuro-scientific principles underlying human movement. Additionally, the course will cover state-of-the-art in the field of Bio mechatronics including assistive technologies, prosthetic devices, rehabilitation robots, and exoskeletons.

Course outcomes:
On successful completion of the course the students will be able to

CO1	To understand the basics of bio mechanics
CO2	To have adequate knowledge on sensors and actuator
CO3	To study about the medical instruments
CO4	To learn about the sensory assist devices and wearable mechatronics.
CO5	To know the concepts of active and passive prosthetic limbs

CO	PO												PSO			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**	**4**
1	H	H	L	M	L	M	L	L				M	H	M	M	L
2	H	H	H	M	H	M	L	M	M	M		H	M	H	H	M
3	H	H	H	M	H	M	L	M	M	M		H	M	H	H	M

4	H	H	H	M	H	M	L	M	M	M		H	M	H	H	M
5	H	H	H	M	H	M	L	M	M	M		H	M	H	H	H

H-High, M-Medium, L-Low

Unit 1	**BIO MECHANICS AND SIGNAL PROCESSING**	**Hours: 09**
Cardiovascular biomechanics, Musculoskeletal and orthopedic biomechanics, human ergonomic, Rehabilitation. Bio-medical signals, Signal acquisition and signal processing-Isolation barriers, Bio-image processing.		
Unit 2	**BIO SENSORS AND ACTUATORS**	**Hours: 09**
Introduction to Bio mechatronics, Electrodes - Types, - Measurement of blood pressure - Blood Gas analyzers: pH of blood, Smart actuators for biological applications		
Unit 3	**MEDICAL MEASUREMENTS**	**Hours: 09**
Heart rate - Heart Sound - Pulmonary Function Measurements – Spirometer-Fingertip oximeter - ESR, GSR Measurements		
Unit 4	**SENSORY ASSIST DEVICES & WEARABLE MECHATRONICS**	**Hours: 09**
Hearing aids- implants- Optical Prosthetics, Visual Neuroprosthesis - Sonar based Systems, Respiratory aids, Tactile devices for visually challenged. Wearable mechatronics devices Wearable Artificial Kidney, Wireless capsule endoscope, Wearable Exoskeletal rehabilitation system, Wearable hand rehabilitation.		
Unit 5	**ACTIVE AND PASSIVE PROSTHETIC LIMBS**	**Hours: 09**
Introduction to prosthetics, Passive Prosthetics-Walking Dynamics, Knee and Foot Prothesis, Active Prosthesis-Control of Prosthetic arms and hands, Leg Mechanisms, Ankle-Foot Mechanisms, Prosthesis Suspension		
	Total Lecture hours	**45**

Text Books	
1	Graham M. Brooker, “Introduction to Bio-Mechatronics”, Sci Tech Publishing, 2012.
Reference book	
1	Leslie Cromwell, Fred J. Weibell, Erich A. Pfeiffer, ―Bio-Medical Instrumentation and Measurements‖, II edition, Pearson Education, 2009.
2	Raymond Tong Kaiyu . ―Bio-mechatronics in Medicine and Healthcare‖ Pan Stanford Publishing, CRC Press, 2011.

Course Code	Course Name	L	T	P	X	C
216BME4177	COGNITIVE NEUROSCIENCE	3	0	0	0	3

Prerequisite: Nil	**Syllabus revision:** NA
Course Category: Honor Elective	**Course Type:** Theory

Course description

This course explores the cognitive and neural processes that support sound, speech, music, attention, sleep, and consciousness. It introduces basic neuroanatomy and behavioral measures of cognition, and discusses methods by which inferences about the brain bases of cognition are made.

Course outcomes:
On successful completion of the course the students will be able to

CO1	Describe the functional neuroanatomy, pathways and its connectivity.
CO2	Explain the mechanism of learning, control and loss of memory.
CO3	Illustrate the process of sound, speech and music perception.
CO4	Describe sleep, levels of consciousness and sleeping disorders
CO5	Illustrate exceptional states of mind and purposeful thoughts and actions.

CO	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
1	H		M										H			H
2	H												H			H
3	H												H			H
4	H												H			H
5	H												H			H

H - High, M - Medium, L – Low		
Unit 1	**A FRAMEWORK FOR MIND AND BRAIN**	**Hours: 09**
Consciousness, Cortical Core, Connectivity, and Consistency. Brain Function-Functional Neuroanatomy, Brain Pathways-Neuro connectivity, Brain Dynamics-Brain Rhythms and Oscillations		
Unit 2	**LEARNING AND REMEMBERING**	**Hours: 09**
Episodic Learning and Memory,Memory Trace Formation and Consolidation, Memory Traces and Models, Control of Memory, Loss of memory		
Unit 3	**SOUND, SPEECH, AND MUSIC PERCEPTION**	**Hours: 09**
Introduction, A Model for Sound Processing, Sound and Hearing Basics, Pathways to Auditory Cortex, Cortical Auditory Functions and Pathways, Speech and Music Perception		
Unit 4	**SLEEP AND LEVELS OF CONSCIOUSNESS**	**Hours: 09**
Introduction, Daily Rhythms for Sleep, Architecture of Sleep, Memory and Sleep, Dreaming, Sleep Disorders.		
Unit 5	**ATTENTION, CONSCIOUSNESS AND BRAIN DISORDERS**	**Hours: 09**
Waking: Purposeful Thoughts and Actions, Consciousness, Attention, Exceptional States of Mind. **Brain Disorders:**Acute spinal cord injury, Alzheimer's Disease, Amyotrophic Lateral Sclerosis,Ataxia, Bell's Palsy, Brain Tumors, Cerebral Aneurysm, Epilepsy and Seizures.		
	Total Lecture hours	**45**
Text Books		
1	Baars B, Gage NM. Fundamentals of cognitive neuroscience: a beginner's guide. Academic Press; 2018.	
Reference Books		
1	Eagleman D, Downar J. Brain and behavior: a cognitive neuroscience perspective. New York: Oxford University Press; 2016.	
2	Baars B, Gage NM. Fundamentals of cognitive neuroscience: a beginner's guide. Academic Press; 2013.	
3	Passingham R. Cognitive neuroscience: a very short introduction. Oxford University Press; 2016 Sep 15.	

Course Code	Course Name	L	T	P	X	C
216BME4175	BIOPHOTONICS	2	1	0	0	3

Prerequisite: BME21… Medical optics and lasers	**Syllabus revision:** NA
Course Category: Honor Elective	**Course Type:** Theory

Course description

To understand the techniques and applications of photonics in the field of Biology and medicine

Course outcomes:
On successful completion of the course the students will be able to

CO1	To understand the basics of light interaction techniques and its properties
CO2	To understand the instrumentation in the optical sources and fibers
CO3	To understand the instrumentation in the optical detectors
CO4	To understand and analyze the microscopic and spectroscopic techniques
CO5	To analyze the major recent applications of photonics in biology

CO	**PO**												**PSO**			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**	**4**
1	H	H		H									H	M		
2	H	H		H									H	M		

3	H	H		H									H	M		
4	H	H		H									H	M		
5	H	H		H									H	H		

H-High, M-Medium, L-Low

Unit 1	**Introduction and concepts**	**Hours: 12**
Biophotonics, spectral windows, light absorption, signal attenuation, biological cells and tissues, lightwave characteristics, polarization, photon energy and momentum, reflection, refraction, interference, optical coherence, light-wave molecular dipole interaction		
Unit 2	**Optical fibers and sources**	**Hours: 12**
Light-guiding principles, graded-index optical fibers, characteristics of general optical fibers, solid-core fibers, crystal fibers, silica fibers, plastic, glowing fibers, radiometry, arc lamps, LED's, laser diodes, superluminescent diodes		
Unit 3	**Detectors & probes**	**Hours: 12**
Pin photodetector, avalanche photodiode, multitude detectors, PMT, filters, couplers, circulators, fiber probe configuration and tip geometry, optical sensors, interferometric sensors, crystal fiber biosensors, fiberbragg grating sensor, fiber nanoprobes		
Unit 4	**Microscopic & spectroscopic techniques**	**Hours: 12**
Concepts and principles of microscopy, resolution, diffraction limit, confocal, fluorescence, multiphoton, Raman microscopy, FTIR, photon correlation, elastic and diffuse correlation spectroscopy		
Unit 5	**Application**	**Hours: 12**
Nano biophotonics, optical manipulation, microscope in a needle, neurophotonics, single nanoparticle detection		
	Total Lecture hours	**60**
Text Books		
1	Keiser, G. (2016). Biophotonics: Concepts to Applications. Singapore: Springer Singapore.	

Reference Books	
1	Handbook of Biophotonics. (2011). Germany: Wiley-VCH.
2	Nano Biophotonics: Science and Technology. (2007). Netherlands: Elsevier Science.
3	Shoham, S. (2020). Handbook of Neurophotonics. United States: CRC Press.

Course Code	Course Name	L	T	P	X	C
216BME4176	BRAIN-COMPUTER INTERFACE	2	1	0	0	3

Prerequisite: Medical electronics, signal processing	**Syllabus revision:** r.1
Course Category: Honor Elective	**Course Type:** Theory

Course description

To understand, apply and analyze the Brain-Computer interface and its associated techniques in the effective usage of humans

Course outcomes:
On successful completion of the course the students will be able to

CO1	To understand the brain signals and its attributes
CO2	To design and implement brain signal acquisition via feature extraction and translation
CO3	To analyze the instrumentation in BCIs
CO4	To understand and analyze the application of BCIs in motor control
CO5	To understand and analyze the application of BCIs in gadget control using LABVIEW environment

CO	**PO**												**PSO**			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**	**4**
1	H	H											H	H		

2	H	H											H	H		
3	H	H	H	H									H	H		
4	H	H											H	H		
5	H	H			H								H	H		

H-High, M-Medium, L-Low

Unit 1	**Introduction**	**Hours: 12**
Brain signals and features, recording EEG, signal processing, BCI types, components of interest, noninvasive and electromagnetic methods		
Unit 2	**Design & Implementation**	**Hours: 12**
Acquiring brain signals from within and outside the brain, feature extraction, feature translation		
Unit 3	**BCIs**	**Hours: 12**
BCIs that use P300 event-related potential, sensorimotor rhythms, brain metabolic signals		
Unit 4	**Applications**	**Hours: 12**
A two-dimensional brain-computer interface associated with human natural motor control, visuomotor tasks in a brain-computer interface analysis, BCI to improve communication and rehabilitation after brain damage		
Unit 5	**Applications**	**Hours: 12**
BCI to control a mobile vehicle and using LabVIEW environment, BCI in the completely locked-in state and chronic stroke, BCI for patients with disorders of consciousness		
	Total Lecture hours	**60**
Textbooks		
1	Azar, A. T. (2014). Brain-Computer Interfaces: Current Trends and Applications. Germany: Springer International Publishing.	

2	Schalk, G., Mellinger, J. (2010). A Practical Guide to Brain–Computer Interfacing with BCI2000: General-Purpose Software for Brain-Computer Interface Research, Data Acquisition, Stimulus Presentation, and Brain Monitoring. United Kingdom: Springer London.
3	Wolpaw, E. W. (2012). Brain-Computer Interfaces: Principles and Practice. United Kingdom: Oxford University Press.
Reference Books	
1	Recent Advances in Brain-Computer Interface Systems. (2011). Croatia: InTech.
2	Brain-Computer Interfaces: Lab Experiments to Real-World Applications. (2016). Netherlands: Elsevier Science.
3	Paszkiel, S. (2019). Analysis and Classification of EEG Signals for Brain-Computer Interfaces. Germany: Springer International Publishing.

Course Code	Course Name	L	T	P	X	C
216BME4176	ARTIFICIAL ORGANS	3	0	0	0	3

Prerequisite: Nil	**Syllabus revision:** NA
Course Category: Honors Elective	**Course Type:** Theory

Course description

This course is to teach technologies that will maintain, improve or even restore the function of diseased organs. The growing need for these technologies is substantial. Improved health care has resulted in an increased life span for the general population and, when coupled with a growing shortage of donor organs, makes it clear that organ assistance and substitution devices will play a larger role in managing patients with end-stage disease by providing a bridge to recovery or transplantation.

Course outcomes:
On successful completion of the course the students will be able to

CO1	To understand the basic introduction about the artificial organs.
CO2	To apply the engineering design in the artificial heart and circulatory assist devices
CO3	To understand and design the artificial kidney and blood.
CO4	To design and develop the artificial lungs and pancreas.
CO5	To apply the engineering design in the cardiac valve prosthesis.

CO	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
1	M		M		L	M			M	M		H	M	H	L	L

2	M		H	H	H	H	M	M	M	M		H	M	H	M	M
3	M		H	H	H	H	M	M	M	M		H	M	H	M	M
4	M		H	H	H	H	M	M	M	M		H	M	H	M	M
5	M		H	H	H	H	M	M	M	M		H	M	H	M	M

H-High, M-Medium, L-Low

Unit 1	**INTRODUCTION TO ARTIFICIAL ORGANS**	**Hours: 09**

Introduction to artificial organs: Biomaterials used in artificial organs and prostheses, inflammation, rejection, correction. problems associated with extracorporeal blood low: Substitutive medicine, outlook for organ replacement, design consideration, evaluation process.

Unit 2	**ARTIFICIAL HEART AND CIRCULATORY ASSIST DEVICES**	**Hours: 09**

Engineering design of artificial heart and circulatory assist devices, blood interfacing implants – introduction, total artificial hearts & ventricular assist devices, vascular prostheses, non-blood interfacing implants for soft tissues- sutures and allied augmentation devices, percutaneous and skin implants, maxillofacial implants, eye and ear implants

Unit 3	**ARTIFICIAL KIDNEY AND ARTIFICIAL BLOOD**	**Hours: 09**

ARTIFICIAL KIDNEY: Functions of the kidneys, kidney disease, renal failure, renal transplantation, artificial kidney, dialyzers, membranes for haemodialysis, haemodialysis machine, peritoneal dialysis equipment-therapy format, fluid and solute removal. ARTIFICIAL BLOOD: Artificial oxygen carriers, fluorocarbons, hemoglobin for oxygen carrying plasma expanders, hemoglobin based artificial blood.

Unit 4	**ARTIFICIAL LUNGS AND ARTIFICIAL PANCREAS**	**Hours: 09**

ARTIFICIAL LUNGS: liver Gas exchange systems, Cardiopulmonary bypass (heart-lung machine)-principle, block diagram and working, artificial lung versus natural lung. Liver functions, hepatic failure, liver support systems, general replacement of functions. ARTIFICIAL PANCREAS: Structure and functions of pancreas, endocrine pancreas and insulin secretion, diabetes, insulin, insulin therapy, insulin administration systems. Tracheal replacement devices,

laryngeal replacement devices, Artificial esophagus Artificial Skin: Vital functions of skin, current treatment of massive skin loss, design principles for permanent skin replacement.		
Unit 5	**CARDIAC VALVE PROSTHESES**	**Hours: 09**
CARDIAC VALVE PROSTHESES: Mechanical valves, tissue valves, current types of prostheses, tissue versus mechanical, engineering concerns and hemodynamic assessment of prosthetic heart valves, implications for thrombus deposition, durability, current trends in valve design, vascular grafts-history, synthetic grafts, regional patency, thrombosis, neointimal hyperplasia, graft infections		
	Total Lecture hours	**45**
Text Books		
1	Biomedical Engineering Handbook-Volume 1, 2nd Edition - by J.D.Bronzino, CRC.	
2	Biomedical Engineering Handbook-Volume 2 (2nd Edition) - by J.D.Bronzino, CRC	
3	Handbook of Biomedical Engineering. Bronzino. Joseph	
4	Handbook of Biomedical Instrumentation. R.S.Khandpur	
5	Artificial Organs. Erie.D.Blom, Howard.B.Rotham. Biomedical Engineering Principles (Volume – II). David O. Cooney., Marcel Dekker Inc	

Course Code	Course Name	L	T	P	X	C
216BME4178	E-HEALTH SYSTEMS	3	0	0		3

Prerequisite: Nil	**Syllabus revision:**
Course Category: Honor Elective	**Course Type:** Theory

Course description

1	Understand the basic concepts in Biomedical Informatics
2	Apply the various aspects of health informatics and medical standards.
3	Develop clinical decision support systems.
4	Comprehend the basics of bioinformatics and the resources in the field
5	Design and implement the construction standards in a hospital.

Course outcomes:
On successful completion of the course the students will be able to

CO1	To gain knowledge in various aspects of health informatics and medical standards.
CO2	To apply these techniques in proper health care delivery
CO3	Analyze various bioinformatics tools and explore the databases.
CO4	Implementation of Standard in hospital.

CO5	Apply the standards in proper health care delivery

CO	PO	PSO

	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
1	M	M		M	M	L		L	L	L		L	M			
2	M	M		M	M	L		L	L	L		L		M		
3	M			M	M	L		L	L	L		L			L	
4	H	M										L				M
5	H	H	L	M	M	L	L					L				H

H-High, M-Medium, L-Low

Unit 1	**Biomedical Informatics**	**Hours: 9**

Historical highlights and Evolution, Hospital Information System, its characteristics and functional online and offline modules, Health Informatics, Medical Informatics, Clinical Informatics, Nursing Informatics, Public Health Informatics, Imaging informatics.

Unit 2	**Electronic Patient Record and Standards**	**Hours: 9**

Electronic Patient Record, Medical data formats, Medical Standards, HL7, DICOM, LOINC, PACS, Medical Standards for Vocabulary, ICD 10, DRG, MeSH, UMLS, SNOMED. Healthcare Standards -JCAHO, HIPAA

Unit 3	**Electronic Decision Support Systems**	**Hours: 9**

Biomedical decision making. Probabilistic clinical reasoning. Medical Knowledge and Decision Support, Methods for decision support, Clinical decision-support systems, Strategies for medical knowledge acquisition, Predictive tools for clinical decision support

Unit 4	**Bioinformatics Tools**	**Hours: 9**

NCBI, Human Genome Project, GenBank, Sequence alignment, BLAST, FASTA, CLUSTALW, Phylogenetic analyses.

Unit 5	**Norms for Hospitals**	**Hours: 9**

Design and construction standards for the hospitals, BIS –India, JCIA, AIA and NHS, general guidelines and standard for out-patient area, in-patient area and diagnostic area in the hospitals.

	Total Lecture hours	**45**

Text Books	
1	Edward H. Shortliffe, James J. Cimino, “Biomedical Informatics: Computer Applications in Health Care and Biomedicine (Health Informatics)”, 2014, 4th edition, Springer, New York.
Reference Books	
1	Kenneth R. Ong, “Medical Informatics: An Executive primer”, 2015, 1stedition, HIMSS Publishing, Chicago
2	Lazakidou, Athina A., “Web-Based Applications in Healthcare and Biomedicine, Annals of Information Systems”, 2010, 7thedition, Springer, New York.

Course Code	Course Name	L	T	P	X	C
216BME4180	MICROFLUIDICS	3	0	0	0	3

Prerequisite: Nil	**Syllabus revision:** NA
Course Category: Honor Elective	**Course Type:** Theory

Course description

This course addresses the physical foundations, tools, methods and devices to design microfluidic systems and its applications in healthcare.

Course outcomes:
On successful completion of the course the students will be able to

CO1	Understand the basic concepts of physics in microfluidics.
CO2	Identify the materials and fabrication techniques for prototyping and producing microfluidic devices.
CO3	Evaluate the system using numerical simulations.
CO4	Understand and design digital microfluidic systems.
CO5	Understand the fundamentals of computational microfluidics with applications in pulmonary and arterial drug delivery.

CO	PO												PSO			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**	**4**
1	H	H											H			

2	L		M											L		
3	H	H		L	M							L	H	H		
4			M											L		
5	H	H		L	M							L	H	H		

H - High, M - Medium, L - Low

Unit 1	**Fundamental Concepts and Physics in Microfluidics**	**Hours: 9**

Basic Concepts of Liquids and Gases, Mass and Heat Transfer Principles for Fluid, Surfaces and Interfaces in Microfluidics, Development of Driving Forces for microfluidic Processes, Construction Materials Considerations.

Unit 2	**Microfluidics Devices: Fabrication and Surface Modification**	**Hours: 9**

Microfluidics Device Fabrication – Silicon and Glass Fabrication Process, Polymer Fabrication Process, Fabrication for Emerging Microfluidics Devices.
Surface Modification in Microfluidics Fabrication - Plasma Treatment, Surface Modification Using Surfactant, Surface Modification with Grafting Polymers, Nanomaterials for Bulk Modification of Polymers.

Unit 3	**Numerical Simulation in Microfluidics**	**Hours: 9**

Numerical Simulation Models in Microfluidics - Molecular Dynamics (MD), The Direct Simulation Monte Carlo (DSMC) Method, The Dissipative Particle Dynamics (DPD), Continuum Method (CM), The Lattice Boltzmann Method (LBM), Computational Fluid Dynamics (CFD).
Numerical Simulation Software in Microfluidics - CFX Software:Microfluidics Applications, FLOW-3D Software: Microfluidics Applications, Other Software:Microfluidics Applications.

Unit 4	**Digital Microfluidic Systems**	**Hours: 9**

Comparison between the processes using traditional automation methods versus microfluidics systems, Types of Digital Microfluidic Systems, DMF Chip Fabrication Techniques, Different Electrode Configurations in DMF Systems, Digital Microfluidic Working Principle, Electrical Signals Used and Their Effect on the DMF Operations, Droplet Metering and Dispensing Techniques in DMF Systems, The Effect of the Gap Height between the Top Plate and the Bottom Plate in DMF Systems, Modeling and Controlling Droplet Operations in DMF Systems, Examples for Chemical and Biological Applications
Performed on the DMF Platform

Unit 5	**Computational Microfluidics Applied to Drug Delivery in Pulmonary and Arterial Systems**	**Hours: 9**
Modeling Methods – Governing equations, model closure, Fluid–Particle Dynamics Modeling, Ferrofluid Dynamics, Nonspherical Particle Dynamics, Flow through Porous Media, Pulmonary Drug Delivery, Intravascular Drug Delivery.		
	Total Lecture hours	**45**
Text Books		
1	Song, Yujun, Daojian Cheng, and Liang Zhao, eds. *Microfluidics: Fundamentals, Devices, and Applications*. John Wiley & Sons, 2018.	
Reference Books		
1	Tabeling, Patrick. *Introduction to microfluidics*. OUP Oxford, 2005.	

Course Code	Course Name	L	T	P	X	C
216BME4179	MACHINE LEARNING	3	0	0		3

Prerequisite: Nil	**Syllabus revision:** NA
Course Category: Honor Elective	**Course Type:** Theory

Course description

1	To introduce students to the basic concepts and techniques of Machine Learning
2	To have a thorough understanding of the Supervised and Unsupervised learning techniques
3	To study the various probability based learning techniques
4	To understand graphical models of machine learning algorithms
5	To apply the knowledge for developing Probabilistic Learning.

Course outcomes:
On successful completion of the course the students will be able to

CO1	Distinguish between, supervised, unsupervised and semi-supervised learning
CO2	Apply the appropriate machine learning strategy for any given problem
CO3	Suggest supervised, unsupervised or semi-supervised learning algorithms for any given problem
CO4	Design systems that uses the appropriate graph models of machine learning

CO5	Modify existing machine learning algorithms to improve classification efficiency

CO	PO	PSO

	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
1	M	M		M	M	L		L	L	L		L	M			
2	M	M		M	M	L		L	L	L		L		M		
3	M			M	M	L		L	L	L		L			L	
4	H	M										L				M
5	H	H	L	M	M	L	L					L				H

H-High, M-Medium, L-Low

Unit 1	Introduction	Hours: 9

Learning –Types of Machine Learning –Supervised Learning –The Brain and the Neuron – Design a Learning System –Perspectives and Issues in Machine Learning –Concept Learning Task –Concept Learning as Search –Finding a Maximally Specific Hypothesis – Version Spaces and the Candidate Elimination Algorithm –Linear Discriminants – Perceptron –Linear Separability –Linear Regression.

Unit 2	LINEAR MODELS	Hours: 9

Multi-layer Perceptron –Going Forwards –Going Backwards: Back Propagation Error – Multi-layer Perceptron in Practice –Examples of using the MLP –Overview –Deriving Back-Propagation –Radial Basis Functions and Splines –Concepts –RBF Network –Curse of Dimensionality –Interpolations and Basis Functions –Support Vector Machines-Deep Learning.

Unit 3	TREE AND PROBABILISTIC MODELS	Hours: 9

Learning with Trees –Decision Trees –Constructing Decision Trees –Classification and Regression Trees –Ensemble Learning –Boosting –Bagging –Different ways to Combine Classifiers –Probability and Learning –Data into Probabilities –Basic Statistics –Gaussian Mixture Models –Nearest Neighbor Methods –Unsupervised Learning –K means Algorithms –Vector Quantization.

Unit 4	DIMENSIONALITY REDUCTION AND EVOLUTIONARY MODELS	Hours: 9

Dimensionality Reduction –Linear Discriminant Analysis –Principal Component Analysis – Factor Analysis –Independent Component Analysis –Locally Linear Embedding –Isomap – Self Organizing Feature Map -Least Squares Optimization –Evolutionary Learning –Genetic

algorithms –Genetic Offspring: -Genetic Operators –Using Genetic Algorithms – Reinforcement Learning –Overview –Getting Lost Example –Markov Decision Process		
Unit 5	**PROBABILISTIC LEARNING**	**Hours: 9**
Bayesian Learning, Bayes Optimal Classifier, Naïve Bayes Classifier, Bayesian Belief Networks, Mining Frequent Patterns		
	Total Lecture hours	**45**
Text Books		
1	EthemAlpaydin, ―Introduction to Machine Learning 3e (Adaptive Computation and Machine Learning Series)‖, Third Edition, MIT Press, 2014	
Reference Books		
1	Jason Bell, ―Machine learning –Hands on for Developers and Technical Professionals‖, First Edition, Wiley, 2014	
2	Peter Flach, ―Machine Learning: The Art and Science of Algorithms that Make Sense of Data‖, First Edition, Cambridge University Press, 2012	
3	Stephen Marsland, ―Machine Learning –An Algorithmic Perspective‖, Second Edition, Chapman and Hall/CRC Machine Learning and Pattern Recognition Series, 2014	
4	Tom M Mitchell, ―Machine Learning‖, First Edition, McGraw Hill Education, 2013	

Course Code	Course Name	L	T	P	X	C
216BME4172	ADVANCED OPTICAL IMAGING	3	0	0	0	3

Prerequisite: Medical Optics & Lasers	**Syllabus revision:** NA
Course Category: Honor Elective	**Course Type:** Theory

Course description

To understand the advanced optical imaging techniques in the domain of biology and medicine

Course outcomes:
On successful completion of the course the students will be able to

CO1	To understand and analyze the diffuse optical imaging techniques
CO2	To understand the optics involved in endoscopy techniques
CO3	To understand the advancement of polarization-based imaging
CO4	To understand the techniques in confocal imaging
CO5	To understand the techniques in optical coherence tomography

CO	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
1	H	H											H	H		
2	H	H											H	H		
3	H	H											H	H		
4	H	H											H	H		
5	H	H											H	H		

H - High, M - Medium, L - Low

Unit 1	**DOI**	**Hours: 12**
Tissue optics, instrumentation, DOT, DOI combined with other imaging modalities		
Unit 2	**Endoscope Optics**	**Hours: 12**
Basic optics, ray lenses, objective lenses, illumination systems, wireless endoscopes		
Unit 3	**Polarization Imaging**	**Hours: 12**
Polarized light-tissue interaction with tissues, imaging systems, polarizers, retarders, polarization effects in optical system		
Unit 4	**Confocal Imaging**	**Hours: 12**
Components and requirements, scanning systems, optical design, fiber-optic confocal imaging system		
Unit 5	**OCT**	**Hours: 12**
Introduction and comparison with other imaging modalities, imaging uses light versus sound, measuring light echoes using interferometry, image resolution, detection sensitivity, image generation, OCT system, OCT and optical biopsy, application in cancer diagnosis and ophthalmology		
	Total Lecture hours	**60**
Text Books		
1	Liang, R. (2010). Optical Design for Biomedical Imaging. United States: Society of Photo Optical.	
2	Liang, R. (2013). Biomedical Optical Imaging Technologies: Design and Applications. Germany: Springer Berlin Heidelberg.	
Reference Books		
1	Fujimoto, J. G., Farkas, D. (2009). Biomedical Optical Imaging. United Kingdom: Oxford University Press, USA.	

Course Code	Course Name	L	T	P	X	C
216BME4182	PROSTHETIC SCIENCE	3	0	0	0	3

Prerequisite: Nil	**Syllabus revision:** NA
Course Category: HonorElective	**Course Type:** Theory

Course description

This course introduces the technologically advanced solution to improve the mobility of lower limb amputees.

Course outcomes:
On successful completion of the course the students will be able to

CO1	Understand the general issues with motor control and coordinated movements.
CO2	Design and develop hydraulic power and control system.
CO3	Model and simulate biologically inspired systems.
CO4	Design and develop the below- and above-knee prostheses.
CO5	Conduct experiments to evaluate the prosthetic leg.

CO	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
1	M	M											M			
2	H	H	M			L							H	H		

3	H	H	M		L								H	H		
4	H	H	M			L							H	H		
5	H	H			L									H		

H - High, M - Medium, L – Low

Unit 1	**Human motor system**	**Hours: 9**

Human motor control, Motor redundancy and optimization, Adaptability of the human motor system, Motor memory and learning, Postural control, Biomechanical analysis of movement - Human movement transition from sitting to climbing, Kinematic analysis of the above-knee prosthetic device, Simulation of climbing various types of stairs.

Unit 2	**Hydraulic power and control system**	**Hours: 9**

Parameter definition and design of the hydraulic linear actuatorfor mechanization of the above-knee prosthesis, constructive concept of a linear actuator, global hydraulic system for linear actuators, Power supply selection for hydraulic power unit, Hydraulic control of an intelligent active robotic prosthesis.

Unit 3	**Prosthetic modelling and simulation**	**Hours: 9**

General procedure for simulations, Modelling biologically inspired systems, Analytical model of the above-knee prosthesis, Model of hydraulic actuator for knee and ankle joints, Modelling of the DC engine, Robotic manipulator control techniques, Robust control theory based on the passivity principle, Simulation results of the dynamic model and controller.

Unit 4	**Prosthetic design and prototypedevelopment**	**Hours: 9**

SmartLeg overview, Artificial foot, Prototype development, Experimental investigation into the kinematics of the above-kneeprosthesis, Motion analysis and finite element analysis, Foot pressure research, Dynamics-based action recognitionfor motor intention prediction.

Unit 5	**Experimental validation of theprosthetic leg**	**Hours: 9**

Adaptive changes in motor patterns, Testing of the hydraulic actuator, Measurements on subjects with and without amputation, Testing the first prototype with actuated knee and ankle joints, Prototype with actuated knee and ankle joints.

	Total Lecture hours	**45**

Text Books

1	Jelacic, Zlata, RemzoDedic, and HarisDindo. *Active Above-Knee Prosthesis: A Guide to a Smart Prosthetic Leg*. Academic Press, 2020.
Reference Books	
1	Taktak, Azzam, et al., eds. *Clinical engineering: a handbook for clinical and biomedical engineers*. Academic Press, 2019.

Course Code	Course Name	L	T	P	X	C
216BME4181	ORTHOTIC SCIENCE	3	0	0	0	3

Prerequisite: Nil	**Syllabus revision:** NA
Course Category: Honor Elective	**Course Type:** Theory

Course description

This course aims at designing of various mobility aids for patient with disabilities and gait analysis.

Course outcomes:
On successful completion of the course the students will be able to

CO1	Understand the Anatomic and Biomechanical Principles Related to Orthotic Provision and Identify the tools, techniques and processes in design of orthotics.
CO2	Identify the components and fabrication process for prototyping the hand and upper extremity.
CO3	Understand the design principles of foot orthoses.
CO4	Identify the components required for the design of lower limb orthoses.
CO5	Discuss the components required to build special purpose orthoses.

CO	PO												PSO			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**	**4**
1	M	M											M			

2	M	M											M			
3	M	M											M			
4	M	M											M			
5	M	M											M			

H - High, M - Medium, L - Low

Unit 1	**Foundations of Orthotics**	**Hours: 12**

Foundations of Orthotics - Definition of Splint and Orthosis, Characteristics of an Ideal Orthosis, Occupation - Based Orthotic Intervention, **Materials and Technology for Orthotic Science** - Orthotic Processes, Tools and Techniques, Anatomic and Biomechanical Principles Related to Orthotic Provision, Clinical Examination and Implications for Orthotic Intervention, Clinical Reasoning for Orthotic Fabrication.

Unit 2	**Orthoses in the Management of Hand Dysfunction**	**Hours: 9**

Orthoses for the Wrist, Thumb Immobilization, Hand Immobilization, Elbow and Forearm Immobilization, Orthotics for the Fingers. Mobilization Orthoses - Types of Mobilization Orthoses, Biomechanical Principles, Common Features of Mobilization Orthoses, Technical Tips for Dynamic Orthotic Provision, Materials and Equipment for a Dynamic Orthosis, Precautions for a Mobilization (Dynamic) Orthosis, Clinical Considerations for Mobilization Orthoses.

Unit 3	**Foot Orthoses**	**Hours: 9**

History of the Functional Foot Orthosis, Triplanar Structure of the Foot, Function of the Foot in Gait, Biomechanical Examination, Non–Weight-Bearing Open Chain Examination, Static Weight-Bearing Closed Kinetic Chain Examination, Functional Foot Orthoses, Goals of Orthotic Intervention, Measurement and Fabrication, Managing Rearfoot Deformity, Managing Forefoot Deformity, Orthotic Checkout and Troubleshooting, Controversy With Root's Paradigm, Orthoses and Lower Extremity Function.

Unit 4	**Lower Extremity Orthoses**	**Hours: 12**

Biomechanics of the hip, knee, and ankle, Biomechanics of the foot, Shoes and shoe modifications, Ankle–foot orthoses, Knee–ankle–foot orthoses - controlling the knee, Knee orthoses, Hip orthoses, Hip–knee–ankle–foot orthoses, Compound orthoses.

Unit 5	**Special Purpose Orthoses**	**Hours: 12**

Orthoses for Spinal Dysfunction - Anatomy and Biomechanics, The Three-Column Concept, Scoliosis - Types of braces. Orthoses for the Pediatric Population. Lower limb orthoses for persons who have had a stroke.Knee orthoses for sports-related disorders.	
Total Lecture hours	**45**
Text Books	
1	Chui, Kevin C., et al. *Orthotics and Prosthetics in Rehabilitation E-Book*. Elsevier Health Sciences, 2019.
2	Coppard, Brenda M., and Helene Lohman. *Introduction to Orthotics E-Book: A Clinical Reasoning and Problem-Solving Approach*. Elsevier Health Sciences, 2019.
3	Hsu, John D., John Michael, and John Fisk. *AAOS Atlas of orthoses and assistive devices e-book*. Elsevier Health Sciences, 2008.
Reference Books	
1	Werd, Matthew B., E. Leslie Knight, and Paul R. Langer, eds. *Athletic footwear and orthoses in sports medicine*. New York: Springer, 2010.