P.S.R.ENGINEERING COLLEGE

(An Autonomous Institution, Affiliated to Anna University, Chennai)

Sevalpatti (P.O), Sivakasi–626140.

B.E-BIOMEDICAL ENGINEERING

CURRICULUM
AND
SYLLABI

U.G.Regulations 2023

Department of Biomedical Engineering

INSTITUTE VISION AND MISSION

VISION

To contribute to the society through excellence in technical education with societal values and thus available resource for industry and the humanity.

MISSION

- ➢ To create an ambience for quality learning experience by providing sustained care and facilities.
- ➢ To offer higher level training encompassing both theory and practices with human and social values.
- ➢ To provide knowledge based services and professional skills to adapt tomorrow's technology and embedded global changes.

DEPARTMENT VISION AND MISSION

VISION

The vision of the Biomedical Engineering department is to produce competent biomedical engineers to enhance healthcare and augment the wellbeing of society.

MISSION

- ➢ Provide a structured curriculum that bridges engineering with biological science.
- ➢ Offer required training that encourages the application of engineering techniques in the field of biomedical with societal context.
- ➢ Create an environment conducive to undertaking research and innovative projects, and foster collaborations with healthcare providers.

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

- ➢ **PEO1:** Attain the basic knowledge in biomedical engineering to lead a successful professional career.
- ➢ **PEO2:** Assess and resolve the issues related to social values relevant in the field of biomedical engineering.
- ➢ **PEO3:** Engage in lifelong learning by participating in professional activities and carrying out Biomedical research.
- ➢ **PEO4:** Acquire essential abilities and interpersonal skills to lead a team with ethics

for success.

PROGRAM SPECIFIC OUTCOMES (PSOs)

- **PSO1:** To acquire knowledge of the fundamentals of engineering and the basics of biological science.
- **PSO2:** To build diagnostic, therapeutic and life assist systems with ethical standards and ensure patient safety.
- **PSO3:** To apply software expertise to develop algorithms for solving health care related problems.

PROGRAMME OUTCOMES (POs)

- **PO1**: Engineering Knowledge: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization as specified in WK1 to WK4 respectively to develop to the solution of complex engineering problems.
- **PO2**: Problem Analysis: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development. (WK1 to WK4)
- **PO3:** Design/Development of Solutions: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required. (WK5)
- **PO4:** Conduct Investigations of Complex Problems: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions.(WK8).
- **PO5:** Engineering Tool Usage: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems. (WK2 and WK6)
- **PO6:** The Engineer and The World: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework,

culture and environment. (WK1, WK5, and WK7).

➢ **PO7:** Ethics: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)

➢ **PO8:** Individual and Collaborative Team work: Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.

➢ **PO9:** Communication: Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences

➢ **PO10:** Project Management and Finance: Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.

➢ **PO11:** Life-Long Learning: Recognize the need for, and have the preparation and ability for i) independent and life-long learning ii) adaptability to new and emerging technologies and iii) critical thinking in the broadest context of technological change. (WK8)

		SEMESTER– I			
S.No	Code	Course Title	L-T-P	C	Category
1.	SIP	Induction Programme	-	-	HS
2.	231HS11	Functional English	3-0-0	3	HS
3.	231BS11	Matrices and Calculus	2-1-0	3	BS
4.	231BS12	Engineering Physics	3-0-0	3	BS
5.	231BS13	Engineering Chemistry	3-0-0	3	BS
6.	231ES12	Basic Civil and Mechanical Engineering	3-0-0	3	ES
7.	231ESF2	Engineering Drawing	1-0-4	3	ES
8.	231HS12	Heritage of Tamils/தமிழர்மரபு	1-0-0	1	HS
9.	231BS17	Physics and Chemistry Laboratory	0-0-3	1.5	BS
10.	231ESF8	Engineering Practices Laboratory	0-0-3	1.5	ES
11.	231HS17	English Communication Laboratory-I	0-0-2	1	EEC
					Total No. of Credits:23

		SEMESTER–II			
S.No	Code	Course Title	L-T-P	C	Category
1.	231HS21	English for Engineers	3-0-0	3	HS
2.	231BS21	Partial Differential Equations and Numerical Methods	2-1-0	3	BS
3.	231BS22	Physics of Materials	3-0-0	3	BS
4.	231BS24	Environmental Science	3-0-0	3	BS
5.	231ESF1	Problem Solving and Python Programming	3-0-0	3	ES
6.	231BM21	Biosciences For Medical Engineering	3-0-0	3	PC
7.	231HS22	Tamils and Technology/தமிழரும் தொழில்நுட்பமும்	1-0-0	1	HS
8.	231ESF7	Python Programming Laboratory	0-0-3	1.5	ES
9.	231BM27	Biosciences Laboratory	0-0-3	1.5	PC
10.	231HS27	English Communication Laboratory-II	0-0-2	1	EEC
11.	NCC-L1	NCC Credit Course Level1#	-	2*	HS
					Total No. of Credits:23

| **SEMESTER–III** |
S.No	Code	Course Title	L-T-P	C	Category
1.	231BS31	Transforms and Complex Analysis	2-1-0	3	BS
2.	231EC31	Electronic Devices and Circuits(Common to ECE)	3-0-0	3	PC
3.	231BM31	Sensors and Measurements	3-0-0	3	PC
4.	231BM32	Electrical Circuit Analysis	2-1-0	3	PC
5.	231BM33	Biomaterials	3-0-0	3	PC
6.	231BM34	Anatomy and Human Physiology (Theory cum Practical)	3-0-2	4	PC
7.	231BM37	Electrical Circuits and Electronic Devices Laboratory	0-0-3	1.5	PC
8.	231BM38	Sensors and Measurements Laboratory	0-0-3	1.5	PC
9.	231HS37	Enhancing Communication Skills*	0-0-2	1*	EEC
10.	231MCXX	Mandatory Course-1*	1-0-0	1*	MC
			**Total No. of Credits:22**

| **SEMESTER–IV** |
S.No	Code	Course Title	L-T-P	C	Category
1.	231BS41	Probability and Random Processes	2-1-0	3	BS
2.	231BM41	Biomedical Instrumentation	3-0-0	3	PC
3.	231BM42	Analog and Digital Integrated Circuits	3-0-0	3	PC
4.	231BM43	Biomechanics	3-0-0	3	PC
5.	231BM44	Medical Imaging Systems	3-0-0	3	PC
6.	231EC35	Data structures with C and C++ (Theory cum Practical)	3-0-2	4	PC
7.	231BM47	Biomedical Instrumentation Laboratory	0-0-3	1.5	PC
8.	231BM48	Analog and Digital Integrated Circuits Laboratory	0-0-3	1.5	PC
9.	231HS47	Enhancing Aptitude and Reasoning Skills*	0-0-2	1*	HS
10.	VACEC0X	Value Added Course -1*	-	1*	EEC
11.	NCC-L2	NCC Course Level2#	-	-	HS
			**Total No. of Credits:22**

		SEMESTER– V			
S.No	Code	Course Title	L-T-P	C	Category
1.	231BM51	Embedded Systems and IoMT	3-0-0	3	PC
2.	231BM52	Diagnostic and Therapeutic Equipment	3-0-0	3	PC
3.	231BM53	Signal Processing Techniques (Theory cum Practical)	3-0-2	4	PC
4.	231BMVXX	Programme Elective I	3-0-0	3	PE
5.	231BMVXX	Programme Elective II	3-0-0	3	PE
6.	231OEXX	Open Elective I	3-0-0	3	OE
7.	231BM57	Embedded Systems and IoMT Laboratory	0-0-3	1.5	PC
8.	231BM58	Diagnostic and Therapeutic Equipment Laboratory	0-0-3	1.5	PC
9.	231MCXX	Mandatory Course-II*	1-0-0	1*	MC
				Total No. of Credits:22	

		SEMESTER– VI			
S.No	Code	Course Title	L-T-P	C	Category
1.	231BM61	Medical Image Processing	3-0-0	3	PC
2.	231BM62	Artificial Intelligence and Machine Learning for Healthcare	3-0-0	3	PC
3.	231BM63	Biocontrol Systems	3-0-0	3	PC
4.	231BMVXX	Programme Elective III	3-0-0	3	PE
5.	231BMVXX	Programme Elective IV	3-0-0	3	PE
6.	231OEXX	Open Elective–II	3-0-0	3	OE
7.	231BM67	Medical Image Processing Laboratory	0-0-3	1.5	PC
8.	231BM68	Machine Learning Practices Laboratory	0-0-3	1.5	PC
9.	231BM69	Mini project/Field project	0-0-3	1	EEC
10.	VACEC0X	Value Added Course – 2*	-	1*	EEC
11.	NCC-L3	NCC Credit Course Level 3#	-		HS
				Total No. of Credits:22	

SEMESTER–VII					
S.No	Code	Course Title	L-T-P	C	Category
1.	231BM71	Hospital Planning and Management	3-0-0	3	PC
2.	231BM72	Fundamentals of Healthcare Analytics (Theory Cum Practical)	3-0-2	4	PC
3.	231BAEX	Management Elective	3-0-0	3	HS
4.	231BMVXX	Program Elective V	3-0-0	3	PC
5.	231BMVXX	Program Elective VI	3-0-0	3	PC
6.	231OEXX	Open Elective III	3-0-0	3	OE
7.	231BM79	Project Phase-I	0-0-4	2	EEC
8.	231BMIN	Internship	0-0-2	1	EEC
				Total No. of Credits:22	

SEMESTER–VIII					
S.No	Code	Course Title	L-T-P	C	Category
1.	231BM89	Project Phase-II	0-0-16	8	EEC
				Total No. ofCredits:08	

Total No. of Credits: 164

#The NCC course is for the students enrolled for NCC only. The grade will not be considered for CGPA calculation.

VERTICAL COURSES

Vertical I Bioengineering	Vertical II Medical Device Innovation and Development	Vertical III Biological Mechanics	Vertical IV Signal and Image Processing	Vertical V Communication & Networking	Vertical VI Advanced Healthcare Devices
Cognitive Neuroscience	Medical Innovation and Entrepreneurship	Physiological Modeling	Computational tools in Bioengineering	Computer Networks	Advancements in Healthcare Technology
Principles of Tissue Engineering	Medical Device Regulations	Biofluids and Dynamics	Virtual Instrumentation for Biomedical Engineering	Communication systems	Wearable devices
Biomedical optics and Photonics	Product Design Engineering	Ergonomics	Biosignal Processing	Networking and Information system in medicine	3D Printing in Medicine
BioMEMS	Rapid Prototyping	Biomimetics	Speech and Audio Signal Processing	Big data analytics in Medical Applications	Advanced Medical Devices
Genetic Engineering	Patient safety, Standards and Ethics	Biomechatronics	Neural Network and Pattern Recognition	Data mining in Healthcare	Drug delivery Systems
Regenerative Medicine	Quality Control For Medical Devices	Rehabilitation Engineering	Bioelectromagnetism and Compatibility	Body Area Networks	Bioprosthetic Systems
Artificial Organs and Implants	Electrical Safety and Quality Assurance	Brain Computer Interface	Biometric Systems	Tele health Technology	Human Assist Devices
Neural Engineering	Testing and Troubleshooting of Medical Devices	Haptics in Healthcare	Forensic Science in Healthcare	Virtual reality and Augmented Reality in Healthcare	Robotics in Medicine

HONOR COURSES

S.No.	Course Code	Course Title
1	231BMH01	Biosensor Technology
2	231BMH02	Medical device Design
3	231BMH03	Medical Informatics
4	231BMH04	Clinical Trials
5	231BMH05	Critical Care Equipments
6	231BMH06	Nanotechnology and Applications

OPEN ELECTIVE COURSES

S.No.	Course Code	Course Title
1	231OE8A	E-health Systems
2	231OE8B	Nanotechnology in Medicine
3	231OE8C	Internet of Things in Medicine
4	231OE8D	Computers in Medicine
5	231OE8E	Medical Optics

MANAGEMENT–ELECTIVE

S.No.	Course Code	Course Title
1	231BAEA	Engineering Economics and Accounting
2	231BAEB	Entrepreneurship
3	231BAEC	Essentials of Management
4	231BAED	Intellectual Property Rights
5	231BAEE	Professional Ethics in Engineering
6	231BAEF	Women Studies and Women Empowerment

231HS11	FUNCTIONAL ENGLISH		L	T	P	C
			3	0	0	3
Programme:	**B.E./B.Tech. (Common to all branches)**		**Category:**			**HS**
AIM:	To acquire basic Language Skills (LSRW) in order to communicate confidently in academic, professional, and social contexts					
SDG:	04,10					

Course Outcomes:

The Students will be able to		BTL	SDG
CO1:	Explain the extensive vocabulary usage in formal English Learning.	UN	04
CO2:	Recall the content in general and professional contexts.	K1	04
CO3:	Use definitions, descriptions, narrations, and essays on various topics.	UN	04
CO4:	Show their opinions effectively in both oral and written communication.	UN	10
CO5:	Extend the listening skills and participate effectively in conversations.	UN	04
CO6:	Summarize the basics of Language &Grammar relating to English communication.	UN	04

UNIT – I GENERAL READING AND FREE WRITING	9

Listening– Listening to comprehension (story), native accents **Speaking**- Greetings, introducing one's self, one's family, asking for directions **Reading** – Casual reading, skimming & scanning, summarizing, note taking, reading comprehension. **Writing**- Paragraph writing, letter writing (formal & informal), **Grammar**- Parts of Speech. **Vocabulary**- Synonyms & Antonyms

UNIT – II DEVELOPING CONVERSATIONAL ABILITY	9

Listening- Listening to short and long conversations from different domains, telephonic conversations. **Speaking**-Narrating personal experiences/events; Interviewing celebrity, task based speeches, giving instructions. **Reading**- Detecting meaning from context, reading biographies, travelogues, newspaper reports, and technical blogs. **Writing**- e-mail writing, report writing. **Grammar**- Subject Verb Agreement; WH question, Yes or No type questions. **Vocabulary**- misplaced modifiers.

UNIT – III OPINION READING AND WRITING	9

Listening –Watching animated stories and documentaries & responding to questions, **Speaking**- Product description, stress, and intonates- pronunciation skills, discussing various current issues (GD). **Reading**–Critical reading, short stories, verbal reasoning, reading editorials & opinion blocks. **Writing**-Writing definitions; instructions and interpreting charts. **Grammar**-Degrees of comparison; relative pronoun. **Vocabulary**– Homonyms and Homophones,

UNIT – IV ACCENTS AND MEDIA WRITING	9

Listening – Listening to the talks of great personalities, news videos, and phonetic sounds**.** **Speaking** –summarizing documentaries, interviews, podcasts, and mini presentations. **Reading** – Newspaper articles; Journal reports –and Non Verbal Communication (tables, pie charts etc.) **Writing** – Note-making/Note taking (*studies skills to be taught, not tested) Writing recommendations; from nonverbal (chart, graph, etc, to verbal mode) **Grammar** –

Articles; simple tenses **Vocabulary**- Root words	

UNIT – V DESCRIPTIVES AND NARRATIVES	9
Listening–Listening to debates, discussions, scientific lectures & educational videos. **Speaking**– Picture descriptions, Debates, Role play. **Reading** – silent reading (newspapers, books, pamphlets), understanding captions. **Writing** – Essay Writing (Descriptive or narrative). **Grammar**– Continuous and Perfect tenses. **Vocabulary-**Idioms and Phrases.	

Total Periods:	45
Text Books:	
1. Dr.VeenaSelvam, Dr.Sujatha Priyadarshini – English for Engineering Students S. Chand Edition Jan-2005	
2. Jean Susan – English for Science and Technology, Cambridge University Press, 2021.	
References:	
1.TechnicalCommunication–PrinciplesandPractices by Meenakshi Raman & Sangeeta Sharma Oxford Univ. Press, 2016, New Delhi.	
2. Kumar Kul Bhushan - Effective Communication Skills, Khanna Book Publishing, 2016	
3. Viswamohan Aysha – English for Technical Communication, Mcgraw Hill Education, May 2008	
Extensive Reading	
1. Shiv Khera, *You Can Win*, Macmillan Books, New Delhi, 2003.	

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	-	-	-	-	-	1	-	2	3	1	2	1	-	-
CO2	-	-	-	-	-	1	-	2	3	1	2	1	-	-
CO3	-	-	-	-	-	1	-	2	3	1	2	1	-	-
CO4	-	-	-	-	-	1	-	2	3	1	2	1	-	-
CO5	-	-	-	-	-	1	-	2	3	1	2	1	-	-
CO6	-	-	-	-	-	1	-	2	3	1	2	1	-	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231BS11	MATRICES AND CALCULUS	L	T	P	C
		2	1	0	3

Programme:	B.E./B.Tech. (Common to all branches)	Category:	BS

AIM:	To acquire knowledge and skills in handling matrices and calculus in their field of specialization.

SDG:	04,09,11

Course Outcomes:

The Students will be able to		BTL	SDG
CO1:	Solve the problems using matrices.	AP	04
CO2:	Solve the ordinary differential equation.	AP	04
CO3:	Apply the concept of multi variable calculus to solve the problems.	AP	04
CO4:	Use double and triple integrals to compute areas and volumes.	AP	11
CO5:	Apply the concepts of Differentiation and Integration in Vectors.	AP	09
CO6:	Utilize areas and volumes by the application of vector calculus theorems.	AP	11

UNIT – I MATRICES	9

Review of Basic Matrices -Characteristic equation – Eigen values and Eigen vectors of a real matrix – Properties of Eigen values and Eigen vectors (without proof) – Cayley – Hamilton theorem (Statement and applications only) Orthogonal matrices – Orthogonal transformation of a symmetric matrix to diagonal form – Quadratic form – Nature of Quadratic forms – Reduction of quadratic form to canonical form by orthogonal transformation.

UNIT – II ORDINARY DIFFERENTIAL EQUATIONS	9

Higher order linear differential equations with constant coefficients – Method of variation of Parameters – Cauchy's and Legendre's linear equations.

UNIT – III MULTIVARIABLE CALCULUS	9

Partial Derivatives – Total Derivative – Differentiation of Implicit function – Jacobian – Taylor's Expansion - Maxima/Minima for function of two variables – Method of Lagrange's multipliers.

UNIT – IV IVMULTIPLE INTEGRALS	9

Double integration – Change the order of integration – Change of variables(Polar Co-ordinators) – Area as double integral – Triple integration – Volume as Triple Integral.

UNIT – V VECTOR CALCULUS	9

Gradient, Divergence and Curl – Directional derivative – Irrotational and Solenoidal vector fields – Vector integration – Green's and Gauss divergence theorems (without proof) – Verification of the above theorems and evaluation of integrals using them.

Total Periods:	45

Text Books:	

1. Grewal B.S., "Higher **Engineering Mathematics** ", 44[th]Edition, Khanna Publishers, New Delhi, 2018.
2. Kreyszig E, "**Advanced Engineering Mathematics** ", 10th Edition, John Wiley, New Delhi, India, 2018.

References:	

1. Veerarajan.T.,"**Engineering Mathematics for First Year**", Fourth Edition, Tata Mc-Graw – Hill, New Delhi, 2008.
2. G.B. Thomas and R.L. Finney, "**Calculus and Analytic Geometry**" 9th Edition, Pearson Reprint, 2002.
3. N.P. Bali and Manish Goyal, "**A Text Book of Engineering Mathematics**", Laxmi Publications, Reprint, 2008.
4. Ramana B V, "**Higher Engineering Mathematics**", 1st Edition, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2018.

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	1	1	1	-	-	-	-	2	2	-	-
CO2	2	3	2	1	1	1	-	-	-	-	2	2	-	-
CO3	3	3	2	1	1	1	-	-	-	-	2	2	-	-
CO4	3	3	2	1	1	1	-	-	-	-	2	2	-	-
CO5	3	3	2	1	1	1	-	-	-	-	2	2	-	-
CO6	3	3	2	1	1	1	-	-	-	-	2	2	-	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231BS12	ENGINEERING PHYSICS		L	T	P	C
			3	0	0	3
Programme:	**B.E./B.Tech. . (Common to all branches)**		**Category:**			**BS**
AIM:	To endow the students with the fundamentals of Physics for a better understanding of Engineering and Technology.					
SDG:	04,09					

Course Outcomes: The Students will be able to

		BTL	SDG
CO1:	Recall fundamental knowledge on elasticity and its applications relevant to the field of engineering.	RM	04
CO2:	Explain the basic concepts of Acoustics and Ultrasonic.	UN	04,09
CO3:	Outline the basic concepts of Laser, types of lasers and applications.	UN	09
CO4:	Infer the principles behind fiber optic communications and fiber optic sensors.	UN	09
CO5:	Apply the advanced physics concepts of quantum theory to characterize the matters.	AP	04
CO6:	Summarize the basics of crystals, structures, and crystal growth techniques.	UN	04

UNIT – I PROPERTIES OF MATTER	**9**

Elasticity-Stress-strain diagram and its uses-Poisson's ratio- Factors affecting elastic modulus and tensile strength - Twisting couple - shaft - Torsion pendulum: theory and experiment - Bending of beams – Bending moment - cantilever: theory and experiment- Uniform and non-uniform bending: theory and experiment- I-shaped girders

UNIT – II ACOUSTICS AND ULTRASONICS	**9**

ACOUSTICS: Classification of Sound-Loudness and Intensity-Weber-Fechner Law-standard intensity and intensity level- Decibel- Reverberation- Reverberation time-Jaeger's method-Absorption coefficient and its determination–Factors affecting acoustics of buildings focusing, interference, echo, Echelon effect, resonance-Noise and their remedies.
ULTRASONICS: Ultrasonic - Production –Magnetostriction and piezoelectric methods - Acoustical grating –Industrial applications-NDT.

UNIT – III LASERS AND FIBER OPTICS	**9**

LASERS: Population of energy levels, Einstein's A and B coefficients derivation-pumping methods-resonant cavity, optical amplification (qualitative)- three level and four level laser-CO_2 Laser-Semiconductor lasers:Homo junction and Hetero junction. Industrial Application-Cutting, welding, soldering, drilling.
FIBER OPTICS: Principle, Numerical aperture, and Acceptance angle - Types of optical fibers (material, refractive index, mode)-Fiber Optical Communication system (Block diagram) –Fiber optic sensors: pressure and displacement.

UNIT – IV QUANTUM PHYSICS	**9**

Black body radiation-Planck's theory(derivation)–Photo electric Effect-wave particle duality–DE Broglie wavelength - Concept of the wave function and its physical significance - Schrödinger's wave equation-Time independent and Time dependent equations-Particle in a box(one dimensional motion)	
UNIT – V CRYSTAL PHYSICS	**9**
Single crystalline, Polycrystalline and Amorphous materials - Unit cell, crystal systems, Braais lattices, directions and planes in a crystal -Miller indices – Interplanar distance – Calculation of number of atoms per unit cell-Atomic radius-Coordination number - Packing factor for SC, BCC, FCC and HCP structures – PolymorphismandallotropyCrystalgrowthtechniques-Solution,melt(BridgemanandCzochralski).	
Total Periods:	45
Text Books:	

1. M.N.Avadhanulu & P.G.Kshirshagar, "A Text Book of Engineering Physics", S. Chand& CoLtd.2021.
2. R.K.Gaur & S.L.Gupta, "Engineering Physics". Dhanpat Rai Publishers, 2012.

References:	

1. D. Halliday, Resnick & J.Walker, "Principles of Physics", Wiley, 2015.
2. R.A. Serway, & J.W.Jewett, "Physics for Scientists and Engineers", Cengage Learning, 2010.
3. N. K.Verma, "Physics for Engineers", PHI Learning Private Limited, 2014.
4. P.A.Tipler & G.Mosca, "Physics for Scientists and Engineers", W.H.Freeman, 2020.

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	1	-	-	-	-	-	-	-	-	1	2	-	-
CO2	3	3	3	-	-	2	-	1	-	-	1	2	-	-
CO3	3	2	3	3	-	1	-	1	-	-	1	2	-	-
CO4	3	3	3	3	-	1	-	1	-	-	1	2	-	-
CO5	3	2	2	1	-	1	-	-	-	-	1	2	-	-
CO6	3	1	2	1	-	1	-	1	-	-	1	2	-	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231BS13	ENGINEERING CHEMISTRY	L	T	P	C
		3	0	0	3
Programme:	**B.E./B.Tech. (Common to all branches)**	Category:			**BS**
AIM:	To impart a required knowledge on the principles of chemistry involving the different applications required for the engineering fields.				
SDG:	06,07,09,12				

Course Outcomes:

The Students will be able to		BTL	SDG
CO1:	Demonstrate the essential concept of water, its properties, and applications.	AP	06
CO2:	Explain the treatment of water for potable and industrial purposes.	UN	06
CO3:	Outline the concepts of electrochemistry, corrosion, and its control.	UN	12
CO4:	Interpret the basic principles, preparatory methods, and applications of nano materials.	UN	09
CO5:	Extend the different types of important polymers, techniques, and their uses.	UN	09
CO6:	Explain the concepts of batteries and lubricants.	UN	07

UNIT – I WATER AND ITS TREATMENT	**9**

Hardness –Types and Estimation by EDTA method – alkalinity – types of alkalinity and determination. Domestic water treatment – disinfection methods – Boiler feed water – internal conditioning – external conditioning – desalination and reverse osmosis.

UNIT – II ELECTROCHEMISTRY AND CORROSION	**9**

Electrode Potential – Nernst Equation– reference electrode – glass electrode – measurement of pH – electrochemical series – significance – Conductometric titrations (strong acid vs. strong base and weak acid vs. strong base). Corrosion: Types of corrosion – Factors influencing corrosion – Corrosion control – Sacrificial anode and impressed current cathodic methods – Corrosion inhibitors.

UNIT – III NANOCHEMISTRY	**9**

Basics: Distinction between molecules, nano materials, and bulk materials; Types of nano materials: Definition, properties, and uses of nano particle, nano cluster, nanorod, nano wire, and nano tube. Preparation of nano materials: sol-gel, solvo thermal, chemical vapour deposition, electrochemical deposition, and hydrothermal. Applications of nano materials in medicine, agriculture, energy, electronics, and catalysis.

UNIT – IV POLYMER CHEMISTRY	**9**

Introduction: Classification of polymers – Natural and synthetic; Thermoplastic and Thermosetting. Degree of polymerization. Types and mechanism of polymerization: Addition (Free Radical); condensation and copolymerization. Techniques of polymerization: Bulk, emulsion, solution, and suspension. Preparation, properties and uses of Nylon 6, 6, Bakelite, and Epoxy resin.

UNIT – V ENERGY STORAGE DEVICES AND LUBRICANTS	**9**

Batteries – Primary battery – Dry cell and Lithium battery – Secondary battery – Lead acid battery, Ni-Cd battery, and Lithium-ion battery – Fuel cells – H_2-O_2 fuel cells. Lubricants – mechanism of lubrication, liquid lubricants – properties (viscosity index, flash point, fire point, cloud point, pour point, and oiliness) – solid lubricants – graphite and molybdenum disulphide – semisolid lubricants and emulsions.

Total Periods:	45

Text Books:

1. A. Ravikrishnan, "Engineering Chemistry", Sri Krishna Hi-tech Publishing Company Pvt. Ltd. Chennai, 2023.
2. P.C.Jain and Monica Jain, "Engineering Chemistry" Dhanpat Rai Pub, Co., New Delhi, (2015)

References:

1. S.S. Dara, S.S. Umare, "Engineering Chemistry", S. Chand & Company Ltd., New Delhi 2013.
2. B.R. Puri, L.R. Sharma, M.S. Pathania, Vishal, Principles of Physical Chemistry, Vishal Publishing Co., Punjab, 47th Edition, 2017.
3. B. S. Murty, P. Shankar, Baldev Raj, B. B. Rath and James Murday, "Text book of Nanoscience and Nanotechnology", Universities Press-IIM Series in Metallurgy and Materials Science, 2018.
4. V.R.Gowariker, N.V.Viswanathan and Jayadev Sreedhar, "Polymer Science", New Age International P (Ltd.,), Chennai, 2021.

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	-	1	-	2	-	-	-	-	2	2	-	-
CO2	2	2	2	-	-	2	1	-	-	2	2	2	-	-
CO3	2	1	1	1	-	2	-	-	-	1	1	2	-	-
CO4	2	1	1	1	-	-	-	-	-	-	2	2	-	-
CO5	2	1	-	1	-	1	-	-	-	-	2	2	-	-
CO6	2	2	-	-	-	2	-	-	-	1	2	2	-	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231ES12	BASIC CIVIL AND MECHANICAL ENGINEERING	L	T	P	C
		3	0	0	3

Programme:	**B.E./B.Tech. Biomedical Engineering**	Category:	ES

AIM:	To provide the students with the significance of Civil and Mechanical Engineering concepts in general useful for their field of specialization.

SDG:	07,09,11

Course Outcomes:

The Students will be able to		BTL	SDG
CO1:	Explain the field of Civil Engineering and its importance.	UN	09,11
CO2:	Outline the field of Mechanical Engineering and its importance.	UN	09
CO3:	Summarize the basic knowledge in surveying, construction materials, and equipment.	UN	09,11
CO4:	Recall the concepts in building plans and types of constructions for society	RM	11
CO5:	Infer about IC engines and power plant mechanisms.	UN	07
CO6:	Explain the concept of refrigeration and air conditioning systems.	UN	07

UNIT – I OVERVIEW OF CIVIL AND MECHANICAL ENGINEERING	**9**

Civil Engineering Contributions to the Welfare of Society - Specialized Sub-disciplines in Civil Engineering – Structural, Construction, Geotechnical, Environmental, Transportation, and Water Resources Engineering – National building code – terminologists: Plinth area, Carpet area, Floor area, Buildup area, Floor space index - Types of buildings: Residential buildings, Industrial buildings.
Overview of **Mechanical Engineering** - Mechanical Engineering Contributions to the Welfare of Society –Specialized sub-disciplines in Mechanical Engineering – Manufacturing, Automation, Automobile and Energy Engineering - Interdisciplinary concepts in Mechanical Engineering.

UNIT – II SURVEYING AND CIVIL ENGINEERING MATERIALS	**9**

Objects – Classification – Principles – Measurements of Distances and Angles – Leveling – Determination of areas– Contours. Civil Engineering Materials: Bricks – Stones – Sand – Cement – Concrete – Steel - Timber – Modern Materials, Thermal and Acoustic Insulating Materials, Decorative Panels, Water Proofing Materials. Modern uses of Gypsum, Pre-fabricated Building components (brief discussion only)

UNIT – III BUILDING COMPONENTS AND INFRASTRUCTURE	**9**

Building plans – Setting out of a Building - Foundations: Types of foundations - Bearing capacity and settlement – Brick masonry – Stone Masonry – Beams – Columns – Lintels – Roofing – Flooring –Plastering. Types of Bridges and Dams – Water Supply Network - Rain Water Harvesting – Solid Waste Management - Introduction to Highways and Railways - Introduction to Green Buildings.

UNIT – IV INTERNAL COMBUSTION ENGINES AND POWER PLANTS	**9**

Classification of Power Plants- Working principle of steam, Gas, Diesel, Hydroelectric, and Nuclear Power plants- Internal combustion engines as an automobile power plant – Working principle of Petrol and Diesel Engines – Four-stroke and two-stroke cycles – Comparison of four-stroke and two-stroke engines. Working principle of Boilers-Turbines, Reciprocating Pumps (single acting and double acting) and Centrifugal Pumps, Concept of hybrid engines. Industrial safety practices and protective devices

UNIT – V REFRIGERATION AND AIR CONDITIONING SYSTEM	**9**

Terminology of Refrigeration and Air Conditioning. Principle of vapour compression and absorption system–Layout of typical domestic refrigerator–Window and Split type room Air conditioner .Properties of air - water mixture, concepts of psychometric and its process.

Total Periods:		45
Text Books:		
G Shanmugam, M S Palanichamy, Basic Civil and Mechanical Engineering, McGraw Hill Education; First edition, 2018		
References:		
1. Palanikumar, K. Basic Mechanical Engineering, ARS Publications, 2018.		
2. Ramamrutham S., "Basic Civil Engineering", Dhanpat Rai Publishing Co.(P) Ltd, 2013.		
3. Seetharaman S., "Basic Civil Engineering", Anuradha Agencies, 2005.		
Shantha Kumar SRJ., "Basic Mechanical Engineering", Hi-tech Publications, Mayiladuthurai, 2000.		

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	-	-	-	-	1	-	-	-	-	1	2	-	-
CO2	3	-	-	-	-	1	-	-	-	-	1	2	-	-
CO3	3	2	2	-	-	1	-	-	-	1	1	2	-	-
CO4	3	2	-	-	-	1	-	1	-	1	1	2	-	-
CO5	3	1	-	-	-	1	-	1	-	-	1	2	-	-
CO6	3	2	-	-	-	1	-	1	-	-	1	2	-	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231ESF2	ENGINEERING DRAWING	L	T	P	C
		1	0	4	3

Programme:	B.E./B.Tech. (Common to all branches) – In Sem-1: for ECE, CSE, AIDS & IT In Sem-II: for EEE, MECH, CIVIL, BT & BM	Category:	ES

AIM:	To develop basic graphic skills in students to understand the drawings in Engineering fields.

SDG:	09,11,12

Course Outcomes:

The Students will be able to		BTL	SDG
CO1:	Develop the plane curves and draw its tangent and normal.	AP	12
CO2:	Construct the orthographic projections of points, lines, and planes.	AP	09,11
CO3:	Examine the projections of simple solids.	AN	09
CO4:	Simplify the sectional views of solids.	AN	09
CO5:	Develop the surfaces of solids.	AP	09
CO6:	Inspect isometric and orthographic projections.	AN	09

UNIT – I PLANE CURVES	14

Conics – Construction of ellipse, Parabola, and hyperbola by eccentricity method – Construction of cycloid – Construction of involutes of square and circle – Drawing of tangents and normal to the above curves.

UNIT – II PROJECTION OF POINTS, LINES, AND PLANE SURFACES	14

Projection of Points in all four quadrants - Projection of straight lines located in the first quadrant – inclined to both planes – Determination of true lengths and true inclinations – Projection of regular polygonal and circular lamina inclined to both reference planes.

UNIT – III BUILDING COMPONENTS AND INFRASTRUCTURE	14

Projection of simple solids like Prisms, Pyramids, Cylinder, and Cone when the axis is inclined to one reference plane.

UNIT – IV SECTION OF SOLIDS AND DEVELOPMENT OF SURFACES	14

Sectioning of above solids in a simple vertical position by cutting planes inclined to HP and perpendicular to VP – Obtaining true shape of section; Development of lateral surfaces of truncated solids – Prisms, Pyramids, Cylinder, and Cone.

UNIT – V ISOMETRIC AND ORTHOGRAPHIC PROJECTIONS	14

Principles of isometric projection – isometric scale – isometric projections of truncated Prisms, Pyramids, cylinders, and cones; Conversion of Isometric Views to Orthographic Views and Vice-versa.

Total Periods:	75

Text Books:

1. Basant Agarwal and Agarwal C.M., **"Engineering Drawing",** Tata McGraw Hill Publishing Company Limited, New Delhi, (2022).

References:

1. Venugopal K. and Prabhu Raja V., **"Engineering Graphics",** New Age International (P)

Limited (2022).
2. Shah M.B. and Rana B.C., **"Engineering Drawing"**, Pearson Education (2022).
3. John K.C., **"Engineering Graphics for degree"** PHI Learning Pvt. Ltd., New Delhi, (2022).
4. Kumar M.S., **"Engineering Graphics"**, D.D. Publications, (2022).

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3			1	2	1	-	-	-	-	1	2	-	-
CO2	3	2	1		2	1	-	-	-	-	1	2	-	-
CO3	3			1	2	1	-	-	-	-	1	2	-	-
CO4	3	2		1	2	1	-	-	-	-	1	2	-	-
CO5	3		1		2	1	-	-	-	-	1	2	-	-
CO6	3	2	1		2	1	-	-	-	-	1	2	-	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231HS12	HERITAGE OF TAMILS/ *தமிழர்மரபு*	L-T-P	C
		1-0-0	1

Programme: B.E./B.Tech. (Common to all branches)   **Sem:** I   **Category:** HS
Prerequisites: Read and Write in English or Tamil
Objectives: தமிழ்மொழி மற்றும் தமிழர்களின் பாரம்பரியத்தை பற்றி தெரிந்து கொள்ளுதல்.

Course Outcomes:

Upon completion of the course, the students will be able to

CO1. தமிழ்மொழி மற்றும் தமிழ் இலக்கியத்தின் பாரம்பரியத்தை புரிந்து கொள்ளுதல்.

CO2. தமிழர் மரபுகள் மற்றும் பக்தி இலக்கியங்கள் பற்றி தெரிந்து கொள்ளுதல்.

CO3. தமிழர்களின் சிற்பக்கலை, இசைக் கருவிகள் மற்றும் கைவினைத் தொழில்களின் வளர்ச்சிகளைப் பற்றி அறிந்து கொள்ளுதல்

CO4. தமிழர்களின் நாட்டுப்புற கலைகள் மற்றும் தற்காப்பு கலைகளைப் பற்றி அறிந்து கொள்ளுதல்.

CO5. சங்ககாலத்தின் திணைவகைபாடுகள் (ஐவகைநிலங்கள்) பற்றி அறிந்து கொள்ளுதல்.

CO6: இந்திய விடுதலைப் போர், இந்திய கலாச்சாரம் மற்றும் மருத்துதுறையில் தமிழர்களின் பங்கினை அறிந்து கொள்ளுதல்.

மொழி மற்றும் இலக்கியம்   3
இந்தியமொழிக் குடும்பங்கள் - திராவிடமொழிகள் - தமிழ் ஒரு செம்மொழி - தமிழ் செவ்விலக்கியங்கள் - சங்க இலக்கியத்தின் சமயச் சார்பற்ற தன்மை - சங்க இலக்கியத்தில் பகிர்தல் அறம் - திருக்குறளில் மேலாண்மைக் கருத்துக்கள் - தமிழ்க் காப்பியங்கள்,தமிழகத்தில் சமணபௌத்த சமயங்களின் தாக்கம் - பக்தி இலக்கியம்,ஆழ்வார்கள் மற்றும் நாயன்மார்கள் - சிற்றிலக்கியங்கள் - தமிழில் நவீன இலக்கியத்தின் வளர்ச்சி - தமிழ் இலக்கியவளர்ச்சியில் பாரதியார் மற்றும் பாரதிதாசன் ஆகியோரின் பங்களிப்பு.

மரபு - பாறை ஓவியங்கள் முதல் நவீன ஓவியங்கள் வரை சிற்பக் கலை   3
நடுகல் முதல் நவீன சிற்பங்கள் வரை - ஐம்பொன் சிலைகள் - பழங்குடியினர் மற்றும் அவர்கள் தயாரிக்கும் கைவினைப் பொருட்கள், பொம்மைகள் - தேர் செய்யும் கலை - சுடுமண் சிற்பங்கள் - நாட்டுப்புறத் தெய்வங்கள் - குமரிமுனையில் திருவள்ளுவர் சிலை - இசைக் கருவிகள் - மிருதங்கம், பறை, வீணை, யாழ், நாதஸ்வரம் - தமிழர்களின் சமூக பொருளாதார வாழ்வில் கோவில்களின் பங்கு.

நாட்டுப்புறக் கலைகள் மற்றும் வீரவிளையாட்டுகள்   3
தெருக்கூத்து, கரகாட்டம், வில்லுப்பாட்டு, கணியான் கூத்து, ஒயிலாட்டம், தோல்பாவைக் கூத்து, சிலம்பாட்டம், வளரி, புலியாட்டம், தமிழர்களின் விளையாட்டுகள்.

தமிழர்களின் திணைக் கோட்பாடுகள்   3
தமிழகத்தின் தாவரங்களும்,விலங்குகளும் - தொல்காப்பியம் மற்றும் சங்க இலக்கியத்தில் அகம் மற்றும் புறக்கோட்பாடுகள் - தமிழர்கள் போற்றிய அறக்கோட்பாடு - சங்ககாலத்தில் தமிழகத்தில் எழுத்தறிவும், கல்வியும் - சங்ககால நகரங்களும் துறைமுகங்களும் - சங்ககாலத்தில் ஏற்றுமதி மற்றும் இறக்குமதி - கடல் கடந்த நாடுகளில் சோழர்களின் வெற்றி.

இந்திய தேசிய இயக்கம் மற்றும் இந்திய பண்பாட்டிற்குத் தமிழர்களின் பங்களிப்பு.   3
இந்திய விடுதலைகளின் பங்கு - இந்தியாவின் பிறப்பகுதிகளில் தமிழ்ப் பண்பாட்டின் தாக்கம் - சுயமரியாதை இயக்கம் - இந்திய மருத்துவத்தில் சித்த மருத்துவத்தின் பங்கு - கல்வெட்டுகள்,கையெழுத்துப்படிகள் - தமிழ்ப் புத்தகங்களின் அச்சுவரலாறு.

Total Periods: 15

Text – Cum – Reference Books

1. தமிழகவரலாறு—மக்களும் பண்பாடும் - கே.கே. பிள்ளை (வெளியீடு தமிழ்நாடு பாடநூல் மற்றும் கல்வியியல் பணிகள் கழகம்)

2. கணினித் தமிழ் - முனைவர் இல.சுந்தரம் (விகடன் பிரசுரம்)

3. கீழடி – வைகை நதிக்கரையில் சங்ககால நகர நாகரிகம் (தொல்லியல் துறை வெளியீடு)

4. பொருநை—ஆற்றங்கரை நாகரிகம் (தொல்லியல் துறை வெளியீடு)

5. Social Life of Tamils (Dr.K.K.Pillay) A joint publication of TNTB & ESC and RMRL – (in print)

6. Social Life of the Tamils - The Classical Period (Dr.S.Singaravelu) (Published by: International Institute of Tamil Studies.

7. Historical Heritage of the Tamils (Dr.S.V.Subatamanian, Dr.K.D. Thirunavukkarasu) (Published by: International Institute of Tamil Studies).

8. The Contributions of the Tamils to Indian Culture (Dr.M.Valarmathi) (Published by:International Institute of Tamil Studies)

9. Keeladi - 'Sangam City Civilization on the banks of river Vaigai' (Jointly Published by: Department of Archaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)

10. Studies in the History of India with Special Reference to Tamil Nadu (Dr.K.K.Pillay) (Published by: The Author)

11. Porunai Civilization (Jointly Published by: Department of Archaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)

12. Journey of Civilization Indus to Vaigai (R.Balakrishnan) (Published by: RMRL)

Course Outcomes	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1						3	1			2	2			
CO2						3	1			2	2			
CO3						3	1			2	2			
CO4						3	1			2	2			
CO5						3	1			2	2			
CO6						3	1			2	2			

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231BS17	PHYSICS AND CHEMISTRY LABORATORY	L	T	P	C

			0	0	3	1.5
Programme:	**B.E.- Common to all Branches**			**Category:**		**BS**
AIM:	To understand the basic concepts in Physics and Chemistry through experiments.					

Course Outcomes: The Students will be able to	
CO1:	Explain the basic concept of LASER application, Interference, and velocity of sound & Compressibility of liquid.
CO2:	Infer knowledge on elastic properties of beams& strings and the thermal conductivity of a bad conductor.
CO3:	Experiment with the fundamentals of the viscosity of a liquid, the wavelength of the mercury spectrum by diffraction, the band gap of the semiconductor, and the Photoelectric effect.
CO4:	Analyze the quality of water samples with respect to their alkalinity, hardness, and DO.
CO5:	Find the amount of metal ions through volumetric and gravimetric techniques.
CO6:	Demonstrate the amount of particles in an unknown solution.

LIST OF EXPERIMENTS - PHYSICS PART

1. Determination of wavelength of the LASER source Image Enhancement-Spatial filter
2. (a)Determination of Particle Size using Diode LASER.
   (b) Determination of Acceptance angle and Numerical aperture of an optical fiber.
3. Determination of thickness of thin wire–Air wedge method
4. DeterminationofVelocityofsoundandcompressibilityofliquid–UltrasonicInterferometer.
5. Determination of Young's modulus of the material-Non uniform bending.
6. Torsional pendulum – Determination of rigidity modulus.
7. Determination of viscosity of liquid – Poiseuille's method.
8. Determination of wavelength of mercury spectrum- Spectrometer Grating.
9. Determination of Band Gap of semiconductor material.
10. Determination of Planck's constant - Photoelectric effect

LIST OF EXPERIMENTS – CHEMISTRY PART

1. Estimation of Total Hardness of water by EDTA method.
2. Determination of types and amount of Alkalinity of a water sample.
3. Determination of DO content of water sample by Winkler's method.
4. Determination of Chloride content of water sample by Argentometric method.
5. Estimation of copper content of the given solution by Iodometry.
6. Estimation of TDS of a water sample by gravimetric.
7. Determination of strength of given hydrochloric acid using pH meter.
8. Determination of strength of acids in a mixture of acids using pH meter.
9. Conduct metric titration of barium chloride against sodium sulphate (Precipitation titration)
10. Estimation of Iron content of the given solution using a Potentiometer.

Total Periods:	**45**

References

1. "Experiments in Physics", Indian Academy of Sciences, India (2018)
2. Engineering Physics Laboratory Manual.
3. A. Ravikrishnan "Practical Engineering Chemistry", Sri Krishna Publications, Chennai (2002).
4. Engineering Chemistry Laboratory Manual.

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1		2	1		-	-	-	-	2	-	-
CO2	1	2	2			1		-	-	-	-	2	-	-
CO3	2	2	2			1		-	-	-	-	2	-	-
CO4	2	2	1		1	2		-	-	-	-	2	-	-
CO5	3	2	1	2	2	1		-	-	-	-	2	-	-
CO6	2	1	3		2	2		-	-	-	1	2	-	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231ESF8	ENGINEERING PRACTICES LABORATORY	L	T	P	C

				0	0	3	1.5
Programme:	B.E/B.TECH., (Common to all Branches) In Sem-1: for ECE, MECH, CIVIL, BT & BM In Sem-II: for EEE, CSE, AIDS & IT			**Category:**			**ES**
AIM:	To provide hands-on experience to the students in handling the basic Mechanical and Electrical tools and equipment.						

Course Outcomes: The Students will be able to	
CO1:	Develop simple wooden joints using woodworking tools.
CO2:	Build the concepts of plumping and handling the various components of plumbing.
CO3:	Construct simple welds of lap and butt joints and fabricate a few models.
CO4:	Demonstrate the concept of wiring circuits.
CO5:	Explain the measurement of Electrical quantities and the principles of diodes.
CO6:	Classify the functions of basic gates.

PART– A – MECHANICAL WORKSHOP (23 hrs)

CARPENTRY
Study of the joints in roofs, doors, windows, and furniture; Hands-on-exercise: Dismantling & Assembling of various wooden furniture; Preparation of T Joint, dovetail joint
PLUMBING
Study of pipeline joints, their location, and functions: valves, taps, couplings, unions, reducers, elbows in household fittings; Hands-on-exercise - basic pipe connections – Mixed pipe material connection – Connections with different joining components
WELDING AND SHEET METAL FORMING
Preparation of arc welding of butt joints and lap joints - Preparation of tray and funnel

PART – B – ELECTRICAL WORKSHOP (22 hrs)

NAME OF THE EXPERIMENT	
1. Practice on Simple wiring connections.	
2. Practice on wiring for Staircase setup.	
3. Practice on wiring Fluorescent lamp.	
4. Measurement of electrical quantities – current, voltage, power, and energy.	
5. Characteristics of semiconductor diode.	
6. Verifying the truth tables of Logic gates.	
Total Periods	**45**

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	1	1	-	1	1	-	3	-	2	2	1	-	-
CO2	2	1	1	-	1	1	-	3	-	2	2	1	-	-
CO3	2	1	1	-	1	1	-	3	-	2	2	1	-	-
CO4	2	1	1	-	1	1	-	3	-	2	2	1	-	-
CO5	2	1	1	-	1	1	-	3	-	2	2	1	-	-
CO6	2	1	1	-	1	1	-	3	-	2	2	1	-	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231HS17	ENGLISH COMMUNICATION LABORATORY - I	L	T	P	C
		0	0	2	1

Programme:	B.E./B.Tech. (Common to all branches)			Category:	EEC

AIM:	To acquire basic Language Skills (LSRW) in order to communicate confidently in academic, professional and social contexts.

Course Outcomes: The Students will be able to

CO1:	Show self and others confidently in English, discuss the events, and fill out forms.
CO2:	List the documentaries, narrate the events, experiences, places of visit, and interview others in English.
CO3:	Describe a product and picture and their uses, devise an advertisement of a product.
CO4:	Recall video lectures and make summaries and inferences.
CO5:	Name event and travel plans and describe arrangements.
CO6:	Relate debates, panel discussions, express views and opinions on the issues.

INTRODUCTION	6

Self-Introduction, Introducing Others, Conversation on the events, Listening and Filling forms.

NARRATION AND SUMMATION	6

Listen to the documentaries and event narration, Narrating personal experiences and events, Interviewing others, Describing the Places of Interest.

DESCRIPTION OF A PROCESS / PRODUCT	6

Listen to the description of a product, Advertisement of a product, Description of a Picture, and use of the products.

CLASSIFICATIONS AND RECOMMENDATIONS	6

Listen to lectures and educational videos, making and describing the plans, arrangements of an event, travel plans, etc.

EXPRESSIONS	6

Listen to debates, panel discussions, expressing the views on an issue, giving brief talk on a topic, giving opinions.

Total Periods:		30
Text Book		

Dr.P.Rathna and Jewelcy Jawahar, English Communication Laboratory .June 2023.

References:	

https://www.skillsyouneed.com/ips/conversational-skills.html

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	-	-	-	-	2	1	1	2	3	2	2	1	-	-
CO2	-	-	-	-	2	3	1	1	3	1	2	1	-	-
CO3	-	-	-	-	2	2	1	1	3	1	2	1	-	-
CO4	-	-	-	-	2	3	1	1	3	1	2	1	-	-
CO5	-	-	-	-	2	2	1	1	3	1	2	1	-	-
CO6	-	-	-	-	2	3	1	3	3	3	2	1	-	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231HS21	ENGLISH FOR ENGINEERS	L	T	P	C
		3	0	0	3

Programme:	B.E./B.Tech. (Common to all Branches)	Category:	HS
AIM:	To acquire basic Language Skills (LSRW)in order to communicate confidently in academic, professional and social contexts.		

Course Outcomes: The Students will be able to

CO1:	Explain the vocabulary development in English.
CO2:	Develop listening skills, and enhance the ability of comprehending.
CO3:	Identify cause and effects in events, industrial processes through technical texts.
CO4:	Recall the communicative competence of learners.
CO5:	Infer communicate confidently in varied real life situations.
CO6:	Extend the basic reading skills of the first year Engineering and Technology Students.

UNIT – I MAKING COMPARISONS	9

Listening - Introduction, Self-Awareness, Active Listening, becoming an Active Listener, Listening in Difficult Situations. **Speaking -**Formal Self-Introduction – Phrases to be used highlighting the strengths and Weaknesses. **Reading**- reading comprehension – brochure / Newspaper. **Writing** - Comprehension - Précis Writing / Common Everyday Situations: Conversations and Dialogues**. Language development**–Concord: **Vocabulary development** –single word substitutions.

UNIT – II EXPRESSING CAUSAL RELATIONS IN SPEAKING AND WRITING	9

Listening: - listening to basic technical concepts, short formal and informal conversations. **Speaking :** Submitted Video Recording/Presentation during class hours will be assessed for Language Style & Fluency. **Reading**: / poems – reading exercise, understanding sentences and fluency. **Writing**: Sentence Structures - Use of phrases and clauses in sentences - Importance of proper Punctuation. **Language development-**framing 'Who' Questions Yes; **Vocabulary development**- prefix and suffix.

UNIT – III PROBLEMS OLVING	9

Listening - listening to technical talks on emerging trends and filling in the blanks – cloze test; **Speaking** -asking for opinions about technical gadgets – presentation of reviews on electronic/electrical/mechanical devices; **Reading** - Reading Comprehension - Identify unfamiliar vocabulary, short narratives and news items from newspapers related to technology; **Writing** –Describing a process, Use of sequence words; **Language development** - Direct Speech and Indirect Speech - Articles; **Vocabulary development** – select Single Word Substitutes used in Engineering.

UNIT – IV REPORTING OF EVENTS AND RESEARCH	9

Listening- listening to talks relating to technology and noting down the merits and demerits; **Speaking -** stating a problem and expressing solutions giving more focus on pronunciation of words and sentence structure; **Reading -** understanding Articles from Magazines – Identify the problem statement and note down solution statements**; Writing –**Job application letter- cover letter- Resume Preparation: **Language development-** Tenses; **Vocabulary development** Synonyms, Antonyms, Phrasal Verbs.

UNIT – V THE ABILITY TO PUT IDEAS OR INFORMATION COGENTLY	9

Listening - Listening Types - Appreciative listening – Critical Listening – Relationship Listening; **Speaking** - presentation on the importance of Emotional Intelligence; **Reading**- Reading articles on Decision Making – Social Behaviour – Emotion – Language and Consciousness; **Writing** – Reports - Minutes of meeting; **Language development** - modal

verbs; Vocabulary development - Fixed and Semi-Fixed Expressions.	
Total Periods:	**45**
Text Books:	

1. Sanjay Kumar, Pushpalata, (2011), Communication skills,1st Edition Oxford Press.
2. Konarnira, (2011), Communication Skills forprofessionals,2nd Edition New arrivals.
3. John   Adair,   4th   Edition,   (2009),   Effective   communication, 1stEditionCengageLearning Indiapvt.ltd
4. Butter Field, (2011), Soft skill for everyone, Macmillan.
5. Stephen. P. Robbins, (2013).Communication skills, Oxford Press.

References:	

1. Kumar, Suresh. E. Engineering English. Orient Blackswan: Hyderabad,2015
2. Means, L. Thomas and Elaine Langlois, English & Communication for Colleges.
3. Cengage Learning, USA: 2007.

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	-	-	-	-	-	1	-	2	3	-	2	1	-	-
CO2	-	-	-	-	-	1	-	2	3	-	2	-	1	-
CO3	-	-	-	-	-	1	-	2	3	-	2	1	-	-
CO4	-	-	-	-	-	1	-	2	3	-	2	1	1	-
CO5	-	-	-	-	-	1	-	2	3	-	2	-	-	-
CO6	-	-	-	-	-	1	-	2	3	-	2	-	-	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231BS21	**PARTIAL DIFFERENTIAL EQUATIONS AND**	**L**	**T**	**P**	**C**

NUMERICAL METHODS	2	1	0	3
Programme: **B.E.- Biomedical Engineering**	**Category:**			**BS**

AIM:	To enable the students to understand the basic solving techniques in partial differential equations and to obtain numerical solutions of ordinary equations and differential equations.

Course Outcomes: The Students will be able to

CO1:	Solve the partial differential equations.
CO2:	Apply the techniques of solving the equations and eigen value problems.
CO3:	Apply the numerical techniques of interpolation in various intervals.
CO4:	Solve differentiation and integration by numerical methods.
CO5:	Explain the methods for solving ordinary differential equations.
CO6:	Compute the boundary value problems by numerical methods.

UNIT – I PARTIAL DIFFERENTIAL EQUATIONS	12

Formation of partial differential equations – Lagrange's linear equation – Solutions of standard types of first order partial differential equations (without reducing the standard type) –Linear homogenous partial differential equations of second and higher order with constant coefficients.

UNIT – II SOLUTION OF EQUATIONS AND EIGENVALUE PROBLEMS	12

Solution of algebraic and transcendental equations - Fixed point iteration method – Newton Raphson method- Solution of linear system of equations - Gauss elimination method – Iterative method of Gauss Seidel - Eigen values of a matrix by Power method.

UNIT – III NUMERICAL INTERPLATION , NUMERICAL DIFFERENTIATION AND INTEGRATION	12

Lagrange's and Newton's divided difference interpolations – Newton's forward and backward difference interpolation – Approximation of derivate using interpolation polynomials – Numerical integration using Trapezoidal and Simpson's 1/3 rules.

UNIT – IV NUMERICAL SOLUTION OF ORDINARY DIFFERENTIAL EQUATIONS	12

Taylor's series method – Euler's method – Modified Euler's method – Fourth order Runge-Kutta method – Milne's predictor – corrector methods for solving first order equations – Finite difference methods for solving second order equation.

UNIT – V BOUNDARY VALUE PROBLEMS OF PARTIAL DIFFERENTIAL EQUATIONS	12

 Finite differences solution of one dimensional heat equation by explicit and implicit methods – One dimensional wave equation and two dimensional Laplace and Poisson equations.

Total Periods:	60

The students may be practiced to solve the problems using Software packages.

Text Books:	

1. Veerarajan.T.,"**Engineering Mathematics for first year**", Fourth Edition, Tata Graw – Hill, New Delhi, 2008.
2. Grewal, B.S., and Grewal, J.S., "**Numerical Methods in Engineering and Scien** Khanna Publishers, 10th Edition, New Delhi, 2015.

References:	

1. Greenberg. *M.D*. "Advanced Engineering Mathematics", Second Edition, Pearson

Education Inc.(First Indian reprint), 2002

2. Kreyszig, E., "Advanced Engineering Mathematics", 8th edition, John Wiley Sons, 2001.
3. Chapra S.C. and Canale R.P., "Numerical Methods for Engineers", Tata Mc-Graw Hill, New Delhi, (2007).
4. Gerald C.F., and Wheatley P.O., "Applied Numerical Analysis", Pearson Education Asia, New Delhi, (2006).

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	-	-	-	-	-	-	-	-	1	3	2	-
CO2	3	2	-	-	-	-	-	-	-	-	-	3	2	-
CO3	2	3	2	-	-	-	-	-	-	-	-	2	3	2
CO4	3	2	-	-	-	-	-	-	-	-	1	3	2	-
CO5	2	2	1	-	-	-	-	-	-	-	1	2	2	1
CO6	3	3	2	-	-	-	-	-	-	-	2	3	3	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231BS22	PHYSICS OF MATERIALS	L	T	P	C

			3	0	0	3
Programme:	**B.E. - Biomedical Engineering**			**Category:**		**BS**
AIM:	To inculcate the students with fundamentals of materials and its properties for understanding the concepts of Engineering and Technology.					

Course Outcomes: The Students will be able to

CO1:	Explain the importance of electrical properties of materials.
CO2:	Infer knowledge in semiconductor physics.
CO3:	Extend the knowledge on magnetic properties of materials.
CO4:	Describe the knowledge on dielectric properties of materials.
CO5:	Summarize a sound grasp of knowledge on different optical properties of materials, optical displays and applications.
CO6:	Interpret idea of significance on Nanostructure, quantum confinement and applications of Nano devices.

UNIT – I ELECTRICAL PROPERTIES OF MATERIALS	9
Classical free electron theory - Expression for electrical conductivity – Thermal conductivity, Wiedemann -Franz law – Success and failures – Fermi Distribution function – Effect of temperature on Fermi function –Density of energy states–Electron in periodic potential–Energy bands in solids–tight binding approximation –Electron effective mass – concept of hole.	
UNIT – II SEMICONDUCTOR PHYSICS	**9**
Energy band diagram – Direct and indirect band gap semiconductors – Intrinsic Semiconductors – Carrier concentration in intrinsic semiconductors – Extrinsic semiconductors – Carrier concentration in n-type & p-typesemiconductors–Variationofcarrierconcentrationwithtemperature–Variation of Fermi level with temperature and impurity concentration–Hall effect-Determination of Hall Coefficient.	
UNIT – III MAGNETIC AND DIELECTRIC MATERIALS	**9**
Magnetic materials: Origin of magnetic moment–Bohrmagneton–Dia and Para magnetism–Ferromagnetism– Domain theory– Hysteresis–Soft and hard magnetic materials–Anti-ferromagnetic materials–Ferrites–applications**.** **Dielectric Materials:** Polarization-Electronic, Ionic, Orientation and Space charge polarization–Frequency and temperature dependence of polarization–Dielectric loss– Dielectric breakdown–uses of dielectric Materials (capacitor and transformer) –Ferro electricity and applications.	
UNIT – IV OPTICAL PROPERTIES OF MATERIALS	**9**
Classification of optical materials–Carrier generation and recombination processes– Absorption emission and scattering of light in metals, insulators and semiconductors (concepts only) – Photocurrent in a P-N diode –solar cell-LED– Organic LED–Laser diodes– Optical data storage techniques.	
UNIT – V NANODEVICES	**9**
Quantum confinement – Quantum structures – Density of states for quantum wells, wires and dots – Band gap of nano materials –Tunneling – Single electron phenomena – Single electron Transistor. Carbon nano tubes: Properties and applications.	
Total Periods:	45
Text Books:	

1. Jasprit Singh, "Semiconductor Devices: Basic Principles", Wiley (Indian Edition), 2007. 2. S.O. Kasap. Opto electronics and Photonics-Principles and practices, Dorling Kindersley Plt. (Indian Edition), 2009. 3. B. Rogers, J. Adams and S. Pennathur, Nanotechnology: Understanding Small Systems, CRC Press, 2014.	
References:	
1. Charles Kittel, Introduction to Solid State Physics, Wiley India Edition, 2019. 2. V.V. Mitin, V.A. Kochelap and M.A. Stroscio, Introduction to Nano electronics, Cambridge Univ. Press, 2008. 3. B. Rogers, J. Adams and S. Pennathur, Nanotechnology: Understanding Small Systems, CRC Press, 2014. 4. Y.B.Bandand Y. Avishai, Quantum Mechanics with Applications to Nano technology and Information Science, Academic Press, 2013.	

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	1	3	-	1	1	-	-	1	3	2	2
CO2	3	1	1	1	3	2	1	-	-	-	1	3	1	1
CO3	3	3	2	3	3	-	-	-	-	-	3	3	3	2
CO4	3	3	2	1	3	-	-	-	-	-	1	3	3	2
CO5	3	2	2	1	3	2	1	1	-	-	-	3	2	2
CO6	3	1	2	1	3	2	-	-	-	-	1	3	1	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231BS24	ENVIRONMENTAL SCIENCE	L	T	P	C
		3	0	0	3

Programme:	B.E.- Biomedical Engineering	Category:	BS

AIM:	To create and disseminate knowledge to the students about environmental problems at local, regional and global scale.

Course Outcomes: The Students will be able to

CO1:	Explain the basic concepts of environment and energy resources.
CO2:	Infer knowledge about the ecosystem.
CO3:	Describe the knowledge about biodiversity and its values.
CO4:	Identify and analyze causes, effects and control measures of various types of pollution.
CO5:	Outline the knowledge about types of disaster and mitigation measures.
CO6:	List the impact of social issues and climate change.

UNIT – I	ENVIRONMENTAL STUDIES AND ENERGY RESOURCES	9

Environment- definition, scope and importance – Need for public awareness – Forest resources-deforestation - dams and their effects on forests and tribal people –Energy resources: Growing energy needs, renewable (solar energy and wind energy) and non renewable energy sources- Nuclear energy – fission and fusion reactions and light water nuclear reactor for power generation (block diagram only), Petroleum processing and fractions.

UNIT – II	ECOSYSTEM AND BIODIVERSITY	9

ECOSYSTEM: Concept of an ecosystem – Structure and function of an ecosystem: Producers, Consumers and Decomposers-Nitrogen cycle, Food chains, food webs and ecological pyramids - Introduction, types, characteristic features, structure and function of the Forest ecosystem and Aquatic ecosystems (lake and rivers). **BIODIVERSITY:** Introduction to Biodiversity – Definition– Value of biodiversity.

UNIT – III	ENVIRONMENTAL POLLUTION	9

Definition – Causes, effects and control measures of: (a) Air pollution (b) Water pollution (c) Marine pollution (d) Noise pollution (e) Nuclear hazards (f) Fireworks: Current environmental issues - Solid waste Management: Causes, effects and control measures of urban and industrial wastes. Role of an individual in prevention of pollution – Pollution case studies.

UNIT – IV	DISASTER AND ITS IMPACTS	9

Definition of Disaster, Hazard, Vulnerability, Risk – Types – Natural disasters (earthquake, landslides, flood, cyclones, tsunami and drought) – Man-made disasters (Chemical, nuclear and biological) – Disaster impacts (environmental, physical, social, ecological and economical) – Case studies.

UNIT – V	SOCIAL ISSUES AND THE ENVIRONMENT	9

Population-variation among Nation-Unsustainable to Sustainable development – Urban problems related to energy – Water conservation, rainwater harvesting– climate change, global warming, acid rain, Ozone layer depletion-Goal of Green chemistry.

Total Periods:	45

Text Books:	

1. A. Ravikrishnan, "Environmental Science", Sri Krishna Hitech Publishing Company Private Limited, 2023.
2. Benny Joseph, "Environmental Science and Engineering", Tata McGraw-Hill, New

Delhi, 2017.

References:	

1. Anubha Kaushik, C.P. Kaushik, "Environmental Science and Engineering", New Age International Publishers, 2016.
2. Raman Sivakumar, Introduction to Environmental Science and Engineering, Tata McGraw Hill Education Private Limited, New Del, 2016.
3. Erach Bharucha, Textbook for Environmental Studies, New Delhi, 2019.
4. G.Tyler Miller and Scott E. Spoolman," Environmental Science", Cengage Learning India PVT, LTD, Delhi, 2014.

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	1	1	2	-	-	-	-	-	-	-	-	1	1	2
CO2	1	-	-	-	-	-	-	-	-	-	-	1	-	-
CO3	1	1	-	-	-	-	-	-	-	-	-	1	1	-
CO4	1	1	2	2	-	-	-	-	-	-	-	1	1	2
CO5	2	2	-	2	-	1	-	-	-	-	-	2	2	-
CO6	2	2	2	-	-	2	-	-	-	-	-	2	2	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231ESF1	PROBLEM SOLVING AND PYTHON PROGRAMMING		L	T	P	C
			3	0	0	3
Programme:	**B.E. - Biomedical Engineering**		**Category:**			**ES**
AIM:	To provide basic knowledge in problem solving and the use of python programming.					

Course Outcomes: The Students will be able to

CO1:	Develop algorithmic solutions to simple computational problems.
CO2:	Build and execute simple Python programs.
CO3:	Apply conditionals and loops concepts in python programming.
CO4:	Experiment with Python program into functions.
CO5:	Solve compound data using Python lists, tuples, dictionaries etc.
CO6:	Organize data from/to files in Python programs.

UNIT – I	COMPUTATIONAL THINKING AND PROBLEM SOLVING	9

Fundamentals of Computing – Identification of Computational Problems -Algorithms, building blocks of algorithms (statements, state, control flow, functions), notation (pseudo code, flow chart, programming language), algorithmic problem solving, simple strategies for developing algorithms (iteration, recursion). Illustrative problems: find minimum in a list, insert a card in a list of sorted cards, and guess an integer number in a range, Towers of Hanoi.

UNIT – II	DATA TYPES, EXPRESSIONS, STATEMENTS	9

Python interpreter and interactive mode, debugging; values and types: int, float, boolean, string, and list; variables, expressions, statements, tuple assignment, precedence of operators, comments; Illustrative programs: exchange the values of two variables, circulate the values of n variables, distance between two points.

UNIT – III	CONTROL FLOW, FUNCTIONS, STRINGS	9

Conditionals: Boolean values and operators, conditional (if), alternative (if-else), chained conditional (if-elif-else); Iteration: state, while, for, break, continue, pass; Fruitful functions: return values, parameters, local and global scope, function composition, recursion; Strings: string slices, immutability, string functions and methods, string module; Lists as arrays. Illustrative programs: square root, gcd, exponentiation, sum an array of numbers, linear search, binary search.

UNIT – IV	LISTS, TUPLES, DICTIONARIES	9

Lists: list operations, list slices, list methods, list loop, mutability, aliasing, cloning lists, list parameters; Tuples: tuple assignment, tuple as return value; Dictionaries: operations and methods; advanced list processing - list comprehension; Illustrative programs: simple sorting, histogram, Students marks statement, Retail bill preparation.

+UNIT – V	FILES, MODULES, PACKAGES	9

Files and exceptions: text files, reading and writing files, format operator; command line arguments, errors and exceptions, handling exceptions, modules, packages; Illustrative programs: word count, copy file, Voter's age validation, Marks range validation (0-100).

Total Periods:		45
Text Books:		

1. Paul Deitel and Harvey Deitel, "Python for Programmers", Pearson Education, 1/e, 2021.
2. Karl Beecher, "Computational Thinking: A Beginner's Guide to Problem Solving and Programming", 1/e, BCS Learning & Development Limited, 2017.

References:	
1. Allen B. Downey, *"Think Python: How to Think like a Computer Scientist"*, 2/e, O'Reilly Publishers, 2016. 2. G Venkatesh and Madhavan Mukund, "Computational Thinking: A Primer for Programmers and Data Scientists", 1/e, Notion Press, 2021. 3. John V Guttag, "Introduction to Computation and Programming Using Python: With Applications to Computational Modeling and Understanding Data", 3/e, MIT Press, 2021. 4. Eric Matthes, "Python Crash Course, A Hands – on Project Based Introduction to Programming", 2/e, No Starch Press, 2019. 5. https://www.python.org/ 6. Martin C. Brown, "Python: The Complete Reference", 4/e, Mc-Graw Hill, 2018.	

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	-	-	-	-	-	-	1	2	-	-	-
CO2	3	3	3	1	1	-	-	-	-	-	-	-	-	-
CO3	3	3	-	-	1	-	-	-	-	-	-	-	-	-
CO4	3	3	3	2	1	-	-	-	-	-	-	-	-	-
CO5	3	3	3	1	1	-	-	-	-	-	-	-	-	-
CO6	3	3	3	2	1	-	-	-	-	-	-	-	-	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231BM21	BIOSCIENCES FOR MEDICAL ENGINEERING	L	T	P	C
		3	0	0	3
Programme:	**B.E.-Biomedical Engineering**	**Category:**		**PC**	

AIM:	To integrate principles of biology, medicine, and engineering to advance healthcare, improve patient outcomes, and enhance our understanding of biological systems.

Course Outcomes: The Students will be able to

CO1:	Explain the clinical application of electrolytes.
CO2:	Analyze the aspects of structural and functional system in living organisms
CO3:	Explain the structure and function of various biological molecules.
CO4:	Describe the methods involved in treating the pathological disorder.
CO5:	Identify the Hematological disorders in human body.
CO6:	Analyze the Immunological techniques of immune diffusion and immune electrophoresis.

UNIT – I FUNDAMENTALS TO BIOCHEMISTRY	9

Introduction to Biochemistry, weak acid and bases, pH, buffers, Handerson - Hasselbalch equation, physiological buffers in living systems, Energy in living organism. Properties of water and their applications in biological systems., Biological membrane, Clinical application of Electrolytes and radioisotopes

UNIT – II CARBOHYDRATES, LIPIDS, PROTEIN	9

Introduction to Biomolecules, Classification of carbohydrates - mono, di, oligo and polysaccharides. Structure, physical and chemical properties of carbohydrates - Classification of lipids- simple, compound, and derived lipids. Nomenclature of fatty acid - Structure and properties of proteins, structural organization of proteins, classification and properties of amino acids. Nucleic acid: Structural aspects – Components of DNA and RNA, Nucleosides & Nucleotides (introduction, structure & bonding), Double helical structure of DNA (Watson-Crick model), various forms of DNA

UNIT – III CELL DEGENERATION, REPAIR AND NEOPLASIA	9

Cell injury - Reversible cell injury and Irreversible cell injury and Necrosis, Apoptosis, Intracellular accumulations, Pathological calcification- Dystrophic and Metastatic. cellular adaptations of growth and differentiation, Inflammation and Repair including fracture healing, Neoplasia, Classification, Benign and Malignant tumors, carcinogenesis, spread of tumors Autopsy and biopsy

UNIT – IV FLUID AND HEMODYNAMIC DERANGEMENTS	9

Edema, Hyperemia/Ischemia, normal hemostasis, thrombosis, disseminated intravascular coagulation, embolism, infarction, shock, Chronic venous congestion. Hematological disorders-Bleeding disorders, Leukemia's, Lymphomas Hemorrhage

UNIT – V FUNDAMENTALS OF MICROBIOLOGY AND IMMUNOPATHOLOGY	9

Structure of Bacteria and Virus - Morphological features and structural organization of bacteria and virus - List of common bacterial, fungal and viral diseases of human beings.- Basics of Microscopes : Light microscope, Electron microscope (TEM & SEM). - Natural and artificial immunity, types of Hypersensitivity, antibody and cell mediated tissue injury, Immunological techniques: immune diffusion, immunoelectrophoresis, RIA and ELISA, monoclonal antibodies

Total Periods:		45
Text Books:		

1. RAFI MD "Text book of biochemistry for Medical Student" Fourth Edition, Universities Press, Orient Blackswan Private Limited - New Delhi 2021. 2. Ramzi S Cotran, Vinay Kumar & Stanley L Robbins, "Pathologic Basis of Diseases", 10th edition: South Asia Edition Elsevier India, 2020. (Units III & IV). 3.Ananthanarayanan&Panicker, "Microbiology" Orient blackswan, 2017 10th edition	
References:	
1. Keith Wilson & John Walker, "Practical Biochemistry - Principles & Techniques", Oxford UniversityPress, 2009. 2. Underwood JCE: General and Systematic Pathology Churchill Livingstone, 3rd edition, 2000. 3. Dubey RC and Maheswari DK. "A Text Book of Microbiology" Chand & Company Ltd, 2007 4. Prescott, Harley and Klein, "Microbiology", 10th edition, McGraw Hill, 20	

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	-	-	-	2	-	-	-	-	2	2	1	-
CO2	3	2	-	-	-	2	-	-	-	-	2	3	-	-
CO3	3	2	1	-	-	2	-	-	-	-	2	3	-	-
CO4	3	1	-	-	-	2	-	-	-	-	2	2	-	-
CO5	3	1	1	-	-	2	-	-	-	-	2	2	1	-
CO6	3	1	-	-	-	2	-	-	-	-	2	2	-	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231HS22	**TAMILS AND TECHNOLOGY/** தமிழரும் தொழில்நுட்பமும்	L-T-P	C
		2-0-0	1

Programme:	B.E./B.Tech. (Common to all branches)	Sem:	II	Category:	HS

Prerequisites: Nil

Objectives : தமிழர்களின் பாரம்பரிய தொழில் நுட்பத்தை பற்றி தெரிந்து கொள்ளுதல்.

Course Outcomes:

Upon completion of the course, the students will be able to

CO1. சங்ககாலத்தின் நெசவு மற்றும் பானைத் தொழில் நுட்பம் பற்றி புரிந்து கொள்ளுதல்.

CO2. சங்ககாலத்தின் கட்டிடத் தொழில் நுட்பம் பற்றி புரிந்து கொள்ளுதல்.

CO3. உற்பத்தித் தொழில் நுட்பம் பற்றிஅறிந்து கொள்ளுதல்.

CO4. வேளாண்மை தொழில் நுட்பம் பற்றிஅறிந்து கொள்ளுதல்.

CO5. நீர்ப்பாசனத் தொழில் நுட்பம் பற்றி தெரிந்து கொள்ளுதல்.

CO6. அறிவியில் தமிழ் மற்றும் கணினித் தமிழ் வளர்ச்சி பற்றி தெரிந்து கொள்ளுதல்.

நெசவுமற்றும் பானைத் தொழில்நுட்பம்   3

சங்ககாலத்தில் நெசவுத் தொழில் - பானைத் தொழில்நுட்பம் - கருப்பு சிவப்பு பாண்டங்கள் - பாண்டங்களில் கீறல் குறியீடுகள்.

வடிவமைப்பு மற்றும் கட்டிடத் தொழில்நுட்பம்   3

சங்ககாலத்தில் வடிவமைப்பு மற்றும் கட்டுமானங்கள் ரூசங்ககாலத்தில் வீட்டுப் பொருட்களில் வடிவமைப்பு - சங்ககாலத்தில் கட்டுமான பொருட்களும் நடுகல்லும் - சிலப்பதிகாரத்தில் மேடை அமைப்பு பற்றிய விவரங்கள் - மாமல்லபுரச் சிற்பங்களும்,கோவில்களும் - சோழர் காலத்துப் பெருங்கோயில்கள் மற்றும் பிற வழிபாட்டுத் தலங்கள் - நாயக்கர் காலக் கோயில்கள் - மாதிரி கட்டமைப்புகள் பற்றி அறிதல்,மதுரை மீனாட்சிஅம்மன் ஆலயம் மற்றும் திருமலைநாயக்கர் மஹால் - செட்டிநாட்டு வீடுகள் - பிரிட்டிஷ் காலத்தில் சென்னையில் இந்தோசாரோசெனிக் கட்டிடக் கலை.

உற்பத்தித் தொழில் நுட்பம்   3

கப்பல் கட்டும் கலை ⬜ உலோகவியல் - இரும்புத் தொழிற்சாலை - இரும்பை உருக்குதல், எ.கு ⬜ வரலாற்றுச் சான்றுகளாக செம்பு மற்றும் தங்க நாணயங்கள் - நாணயங்கள் அச்சடித்தல் - மணி உருவாக்கும் தொழிற்சாலைகள் - கல்மணிகள், கண்ணாடி மணிகள் - சுடுமண் மணிகள் - சங்குமணிகள் - எலும்புத்துண்டுகள் - தொல்லியல் சான்றுகள் - சிலப்பதிகாரத்தில் மணிகளின் வகைகள்.

வேளாண்மை மற்றும் நீர்ப்பாசனத் தொழில் நுட்பம்   3

அணை, ஏரி, குளங்கள், மதகு ⬜ சோழர்காலக் குழுழித் தூம்பின் முக்கியத்துவம் - கால்நடை பராமரிப்பு ⬜ கால்நடைகளுக்காக வடிவமைக்கப்பட்ட கிணறுகள் - வேளாண்மை மற்றும் வேளாண்மைச் சார்ந்த செயல்பாடுகள் - கடல்சார் அறிவு ⬜ மீன்வளம் - முத்து மற்றும் முத்துக்குளித்தல் - பெருங்கடல் குறித்த பண்டைய அறிவு ⬜ அறிவுசார் சமூகம்.

அறிவியல் தமிழ் மற்றும் கணினித்தமிழ்   3

அறிவியல் தமிழின் வளர்ச்சி ⬜ கணினித்தமிழ் வளர்ச்சி ⬜ தமிழ் நூல்களை மின்பதிப்பு செய்தல் - தமிழ் மென்பொருட்கள் உருவாக்கம் - தமிழ் இணையக் கல்விக்கழகம் - தமிழ் மின் நூலகம் - இணையத்தில் தமிழ் அகராதிகள் - சொற்குவைத் திட்டம்.

                                                                       Total Periods: 15

Text – Cum – Reference Books

1. தமிழகவரலாறு ⬜ மக்களும் பண்பாடும் - கே.கே. பிள்ளை (வெளியீடு தமிழ்நாடு பாடநூல் மற்றும் கல்வியியல் பணிகள் கழகம்)

2. கணினித் தமிழ் - முனைவர் இல.சுந்தரம் (விகடன் பிரசுரம்)

3. கீழடி - வைகைநதிக்கரையில் சங்ககால நகர நாகரிகம் (தொல்லியல் துறை வெளியீடு)

4. பொருநை ⬜ ஆற்றங்கரை நாகரிகம் (தொல்லியல் துறை வெளியீடு)

5. Social Life of Tamils (Dr.K.K.Pillay) A joint publication of TNTB & ESC and RMRL – (in print)

6. Social Life of the Tamils - The Classical Period (Dr.S.Singaravelu) (Published by: International Institute of Tamil Studies.

7. Historical Heritage of the Tamils (Dr.S.V.Subatamanian, Dr.K.D. Thirunavukkarasu) (Published by: International Institute of Tamil Studies).

8. The Contributions of the Tamils to Indian Culture (Dr.M.Valarmathi) (Published by: International

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	-	-	-	-	3	1	-	-	2	-	1	1	-	-
CO2	-	-	-	-	3	1	-	-	2	-	1	1	-	-
CO3	-	-	-	-	3	1	-	-	2	-	1	1	-	-
CO4	-	-	-	-	3	1	-	-	2	-	1	1	-	-
CO5	-	-	-	-	3	1	-	-	2	-	1	1	-	-
CO6	-	-	-	-	3	1	-	-	2	-	1	1	-	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231ESF7	PYTHON PROGRAMMING LABORATORY	L	T	P	C
		0	0	3	1.5

Programme:	B.E. - Biomedical Engineering	Category:	ES

AIM:	To familiarize the use of Python for solving problems.

Course Outcomes: The Students will be able to

CO1:	Solve simple real life problems and use simple statements and expressions in programming.
CO2:	Apply conditional and iterative loops, Lists, Tuples, etc. in applications
CO3:	Utilize the programs using sets, dictionaries, and functions.
CO4:	Make use of strings and standard libraries like pandas, numpy, scipy and matplotlib.
CO5:	Develop programs using file handling like copy, word count, longest word, etc., and exceptional handling like divide by zero error, age validity, etc.
CO6:	Choose the Pygame tool and develop simple games application.

LIST OF EXPERIMENTS

Note: The examples suggested in each experiment are only indicative. The lab instructor is expected to design other problems on similar lines. The Examination shall not be restricted to the sample experiments listed here.

1. Identification and solving of simple real life or scientific or technical problems, and developing flow charts for the same. (Electricity Billing, Retail shop billing, Sin series, weight of a motorbike, Weight of a steel bar, compute Electrical Current in Three Phase AC Circuit, etc.)
2. Python programming using simple statements and expressions (exchange the values of two variables, circulate the values of n variables, distance between two points).
3. Scientific problems using Conditionals and Iterative loops. (Number series, Number Patterns, pyramid pattern)
4. Implementing real-time/technical applications using Lists, Tuples. (Items present in a library / Components of a car/Materials required for construction of a building – operations of list & tuples)
5. Implementing real-time/technical applications using Sets, Dictionaries. (Language, components of an automobile, Elements of a civil structure, etc.- operations of Sets & Dictionaries)
6. Implementing programs using Functions. (Factorial, largest number in a list, area of shape)
7. Implementing programs using Strings. (reverse, palindrome, character count, replacing characters)
8. Implementing programs using written modules and Python Standard Libraries (pandas, numpy. Matplotlib, scipy)
9. Implementing real-time/technical applications using File handling. (copy from one file to another, word count, longest word)
10. Implementing real-time/technical applications using Exception handling. (divide by zero error, voter's age validity, student mark range validation)
11. Exploring Pygame tool.
12. Developing a game activity using Pygame like bouncing ball, car race etc.

Total Periods:		**45**

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	-	-	-	-	-	-	-	2	1	-	-
CO2	3	3	3	1	1	-	-	-	-	-	2	1	-	-
CO3	3	3	-	-	1	-	-	-	-	-	2	1	-	-
CO4	3	3	3	2	1	-	-	-	-	-	2	1	-	-
CO5	3	3	3	1	1	-	-	-	-	-	2	1	-	-
CO6	3	3	3	2	1	-	-	-	-	-	2	1	-	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231BM27	BIOSCIENCES LABORATORY	L	T	P	C
		0	0	3	1.5

Programme:	**B.E. - Biomedical Engineering**	**Category:**	**PC**

AIM:	To advance our understanding of living organisms and biological processes, enabling breakthroughs in science, medicine, agriculture, and environmental sustainability.

Course Outcomes: The Students will be able to

CO1:	Experiment with absorption maxima of the given solution
CO2:	Examine carbohydrates, protein and lipids tests.
CO3:	Develop the preparation of serum and plasma from blood.
CO4:	Plan the estimation of hemoglobin and blood glucose
CO5:	Utilize the amino acids for separation
CO6:	Construct the staining processes

LIST OF EXPERIMENTS

1. Preparation of solutions:

    1) percentage solutions,

    2) molar solutions,

    3) normal solutions

2. Standardization of pH meter, preparation of buffers, emulsions.

3. Spectroscopy: Determination of absorption maxima (λmax) of a given solution

4. General tests for carbohydrates, proteins and lipids.

5. Identification of Blood Collection Tubes

6. Preparation of serum and plasma from blood

7. Estimation of Hemoglobin and blood glucose

8. Separation of amino acids by thin layer chromatography (Demo).

9. Urine physical and chemical examination (protein, reducing substances, ketones, bilirubin and blood)

10. Types of Staining : Simple stain, Gram stain

    Study of parts of compound microscopy

Total Periods:	**30**

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	1	-	-	2	2	-	-	-	2	3	2	-
CO2	3	3	1	-	-	2	2	-	-	-	2	3	2	-
CO3	3	3	1	-	-	2	2	-	-	-	2	3	2	-
CO4	3	3	1	-	-	2	2	-	-	-	2	3	2	-
CO5	3	3	1	-	-	2	2	-	-	-	2	3	2	-
CO6	3	3	1	-	-	2	2	-	-	-	2	3	2	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231HS27	ENGLISH COMMUNICATION LABORATORY -II	L	T	P	C
		0	0	2	1
Programme:	B.E./B.Tech. Biomedical Engineering	**Category:**			EEC
AIM:	To provide students with a digital learning platform to practice their language skills useful for their career.				

Course Outcomes: The Students will be able to

CO1:	Translate accurate pronunciation through stress on word accent, intonation and rhythm.
CO2:	Show technical language skills.
CO3:	Outline the participation in situational conversations like JAM sessions.
CO4:	Explain the importance of academic writing
CO5:	Extend necessary writing skills to face certification exams.
CO6:	Interpret to manage stress, emotion and time in order to be amicable in the workplace.

Phonology	**6**
Introduction to Phonetics : Speech Sounds -Vowels and Consonants- Transcriptions- Use of Dictionary **Basic Rules of Word Accent:** Structure of Syllables -Weak Forms and Strong Forms in Context-Minimal pairs **Indian Variants in Pronunciation:** Differences in British and American Pronunciation -Professional Etiquettes - Telephone Etiquette	
Technical Language Learning	**6**
Listening: Indian and Foreign Speakers – English News Channels - Listening Comprehension Tests-Speech/Audio and Video Recording for Self-Analysis **Creativity:** Out of Box Thinking - Lateral Thinking. **Attitude:** Factors Influencing Attitude, Challenges and Lessons from Attitude**.**	
Situational Conversation	**6**
Ice-Breaking: Activities- (Eg.Find the hidden words from the following figures, and write a paragraph.) **JAM Session:** Greetings – Taking Leave – Introducing One self and Others. **Expressions in Various Situations**: Making Requests and Seeking Permissions –Describing objects/Places/Persons/Situations – Story Telling- Narrating Incidents	
Mechanics of Writing and Guidance for TOEFL&IELTS	**6**
Goal Setting: Wish List - SMART Goals - Blue Print for Success - Short Term- Long Term - Life Time Goals **Techniques for Good Academic Writing:** Writing Planners, Journal Articles writing - Avoiding Plagiarism - Project Proposal - Statement of Purpose **Preparation for TOEFL and IELTS -** Guidance and Practice Sessions	
Self-Management Skills	**6**
Stress Management: Causes of Stress and Its Impact - How to Manage &Distress - Circle of Control - Stress Busters**.** **Emotional Intelligence:** What is Emotional Intelligence - Emotional Quotient - EmotionScales - Managing Emotions**.** **Time management:** Value of Time - Diagnosing Time Management	
Total Periods	**30**

TextBook

1.   Academic Writing: A Practical Guide for Students, Stephen Bailey London: Routledge Falmer
    2.   Technical Communication: Principles and Practice, Meenakshi Raman and Sangeeta Sharma, Oxford University Press, 2015
    3.   McCarthy, Michael and Felicity O'Dell. *English Vocabulary in Use*: advanced. Cambridge: CUP, 2002. South Asian Edition, 2008.

Reference
1. Pushpa Lata, Sanjay Kumar, English Language and Communication Skills for Engineers, 2018. 2. Sudarshana, N.P. and Savitha, C. (2018). English for Engineers. Cambridge University Press. 3. John Seely. The Oxford Guide to Effective Writing and Speaking. OUP, 2005. 4. Barron's TOEFL IBT 2016 Guide (with DVD) Pamela Sharpe, New Delhi: Galgotia,2013. 5. Professional Presentation, Malcolm Goodale, Cambridge University Press, 2005

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	-	-	-	2	-	-	2	3	-	2	2	1	2
CO2	3	-	-	-	2	-	-	2	3	-	2	-	1	-
CO3	3	-	-	-	2	-	-	2	3	-	2	2	-	2
CO4	3	-	-	-	2	-	-	2	3	-	2	-	-	-
CO5	3	-	-	-	2	-	-	2	3	-	2	2	1	2
CO6	3	-	-		2	-	-	2	3	-	2	-	-	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231BS31	TRANSFORMS AND COMPLEX ANALYSIS	L	T	P	C
		2	1	0	3
Programme:	B.E./B.Tech. (Common to all branches)	Category:			BS
AIM:	To study the techniques of complex variables and functions together with their derivatives, Contour integration and transformations				

Course Outcomes: The Students will be able to

CO1:	Explain the concept of Laplace transform and its application in solving ordinary differential Equations.
CO2:	Use the effective mathematical tools for the solutions of difference equations by using Z -transform techniques.
CO3:	Apply the Fourier transform in their domains.
CO4:	Analyse functions for their continuity, differentiation and Construct an analytic function, when its real or Imaginary part is known.
CO5:	Apply the techniques regarding conformal mappings to various fields.
CO6:	Apply complex integration in engineering problems.

UNIT – I LAPLACE TRANSFORM	9
Laplace Transform, Properties of Laplace Transform, Laplace transform of periodic functions. Finding inverse Laplace transform by different methods, convolution theorem - solving ODEs by Laplace Transform method.	
UNIT – II Z - TRANSFORM	9
Z-transform - Elementary properties - Inverse Z - transform - Convolution theorem – Formation of difference equations - Solution of difference equations using Z - transform.	
UNIT – III FOURIER TRANSFORM	9
Fourier integral theorem (without proof) – Fourier transform pair – Sine and Cosine transforms – Properties – Transforms of simple functions – Convolution theorem – Parseval's identity.	
UNIT – IV ANALYTIC FUNCTIONS	9
Functions of a complex variable – Analytic functions – Necessary and sufficient conditions (excluding proof) – Cauchy– Riemann equations (Statement only) – Properties of analytic function (Statement only) – Harmonic function – Construction of analytic function – Conformal mapping: $w = z + a$, az, $1/z$ – Bilinear transformation.	
UNIT – V COMPLEX INTEGRATION	9
Line integral – Cauchy's theorem and integral formula – Taylor's and Laurent's series – Singularities – Residues – Residue theorem – Application of residue theorem for evaluation of real integrals – Use of circular contour and semi-circular contour with no pole on real axis.	
Total Periods:	**45**

Text Books:	
1. Grewal B.S., "Higher **Engineering Mathematics** ", 44 th Edition, Khanna Publishers, New Delhi, 2018.	
2. Veerarajan,T., " **Engineering Mathematics**" (For Semester I and II), Tata McGraw-Hill publishing New Delhi, 2013.	

References:	
1. Kreyszig E, "**Advanced Engineering Mathematics** ", 10th Edition, John Wiley, New Delhi,	

India, 2018.
2. G.B. Thomas and R.L. Finney, "**Calculus and Analytic Geometry**" 9th Edition, Pearson, Reprint,2002.
3. N.P. Bali and Manish Goyal, "**A text book of Engineering Mathematics**", Laxmi Publications, Reprint, 2008.
4. Ramana B V, "**Higher Engineering Mathematics**", 1st Edition, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2018.

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	-	-	-	-	-	-	-	2	2	1	-
CO2	3	3	2	1	-	-	-	-	-	-	2	2	1	-
CO3	3	3	2	1	-	-	-	-	-	-	2	2	1	-
CO4	3	2	1	-	-	-	-	-	-	-	1	1	-	-
CO5	3	3	2	1	-	-	-	-	-	-	1	1	-	-
CO6	3	3	2	1	-	-	-	-	-	-	2	2	1	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231EC31	ELECTRONIC DEVICES AND CIRCUITS		L	T	P	C
			3	0	0	3
Programme:	**B.E-BME,ECE**		**Category:**		**PC**	
AIM:	To learn about the characteristics, working, and applications of semiconductor devices.					

Course Outcomes: The Students will be able to

CO1:	Explain the operation of semiconductor devices.
CO2:	Demonstrate the construction and operation of Transistors.
CO3:	Illustrate the characteristics of FETs.
CO4:	Classify the feedback amplifiers.
CO5:	Identify the performance of oscillators.
CO6:	Construct power amplifiers.

UNIT – I SEMICONDUCTOR DEVICES	9

Energy-Band Structure – Semiconductor and it's types- PN junction diode, Zener diode, Tunnel diode, PIN diode, Varactor diode, Schottky diode – Half wave and full wave rectifier – SCR, UJT, DIAC ,TRIAC LED and Photodiode.

UNIT – II BIPOLAR JUNCTION TRANSISTORS	9

NPN and PNP Transistor- Construction and Operations -Need for biasing-biasing methods - Fixed bias-Self bias- Bias Stability - Stability factor- – Configuration-I/O Characteristics of CE,CB and CC Configurations -h-Parameters for CE configuration - Comparison of CE,CB and CC configurations.

UNIT – III FIELD EFFECT TRANSISTORS	9

FET and MOSFET - Construction and Operations -Drain and Transfer Characteristics- Comparison of JFET and BJT- - Construction and Operation of MOSFET-Depletion Type and Enhancement Type -Comparison of MOSFET with JFET.

UNIT – IV FEEDBACK AMPLIFIERS AND OSCILLATORS	9

Feedback amplifier and its types – Voltage / Current, Series, Shunt feedback Amplifiers - characteristics of negative feedback – positive feedback –Condition for oscillations – General equations for an oscillator, phase shift – Wien bridge, Hartley, Colpitts and Crystal oscillators.

UNIT – V TUNED AMPLIFIERS AND LARGE SIGNAL AMPLIFIER	9

Single and double tuned voltage amplifiers and their frequency response - Difference between voltage and power amplifiers -Importance of impedance matching in amplifiers - Classification of large signal amplifiers - Class A,B,C and Class AB amplifiers - Push-pull class B amplifier and complementary symmetry push-pull amplifier.

Total Periods:	45

Text Books:	

1. Robert L. Boylestad and Louis Nasheresky, "Electronic Devices and Circuit Theory", 10th Edition, Pearson Education / PHI, 2018.
2. Joseph A. Edminister, Mahmood, Nahri, "Electric Circuits" – Shaum series,Tata Mc Graw Hill,7th Edition ,2017.

References:	

1. Donald.A. Neamen, "Electronic Circuit Analysis and Design", Tata McGraw Hill, 3rd Edition, 2014.
2. Muhammad H.Rashid, "Power Electronics", Pearson Education / PHI , 2014.
3. Salivahanan S, Sureshkumar N, "Electronic Devices and Circuits", Tata Mc Graw Hill, 7th

Edition, 2015
4. Adel .S. Sedra, Kenneth C. Smith, "Micro Electronic Circuits", Oxford University Press, 7th Edition, 2016.

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	-	-	-	-	-	-	-	1	3	2	-
CO2	3	2	1	-	-	-	-	-	-	-	1	3	2	-
CO3	3	2	1	-	-	-	-	-	-	-	1	3	2	-
CO4	3	2	1	-	-	-	-	-	-	-	1	3	2	-
CO5	3	3	2	1	-	-	-	-	-	-	1	3	3	-
CO6	3	3	2	1	-	-	-	-	-	-	1	3	3	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231BM31	SENSORS AND MEASUREMENTS	L	T	P	C
		3	0	0	3

Programme:	B.E. - Biomedical Engineering	Category:	PC

AIM:	To understand the purpose of measurement, the methods of measurements, errors associated with measurements.

Course Outcomes: The Students will be able to

CO1:	Classify various measuring parameters of accuracy, precision and resolution.
CO2:	Explain function of sensors used in measurement of strain, motion, position & temperature.
CO3:	Select appropriate photoelectric & Piezo electric for measurement of physical phenomenon.
CO4:	Find value of electrical elements using AC and DC bridges.
CO5:	Compare various measurement systems in multimeter, CRO and different types of recorders
CO6:	Explain the working principle and classification of Biosensors.

UNIT – I FUNDAMENTALS OF MEASUREMENTS	9

Measurement System – Instrumentation - Classification and Characteristics of Transducers – Static and Dynamic - Errors in Measurements and their statistical analysis- methods of erroranalysis,-uncertaintyanalysis-expressionofuncertainty:accuracyandprecisionindex, Propagation of errors–Calibration-Primary and secondary standards.

UNIT – II DISPLACEMENT, PRESSURE, TEMPERATURE SENSORS	9

Strain Gauge: Gauge factor, sensing elements, configuration, and unbounded strain gauge. Capacitive transducer - various arrangements, Inductive transducer, LVDT, Passive types: RTD materials & range, relative resistance vs. temperature characteristics, thermistor Characteristics, Active type: Thermo couple-characteristics, Biomedical applications of pressure and temperature sensors.

UNIT – III PHOTOELECTRIC AND PIEZOELECTRIC SENSOR	9

Phototube, scintillation counter, photo multiplier tube(PMT), photovoltaic, photoconductive cells, photo diodes, phototransistor, comparison of photoelectric transducers. Optical displacement sensors and optical encoders. Piezoelectric active transducer-Equivalent circuit and its characteristics. Biomedical applications of Spectro photometric.

UNIT – IV SIGNAL CONDITIONING CIRCUITS AND METERS	9

Functions of signal conditioning circuits, Preamplifiers, Concepts of passive filters, Impedance matching circuits, AC and DC Bridges - wheat stone bridge, Kelvin, Maxwell, Hay, Schering, Q-meter, PMMC, MI and dynamo meter type instruments-DC Potentio meter-Digital voltmeter–Multimeter.

UNIT – V RECORDING DEVICES AND ADVANCED SENSORS	9

CRO – block diagram, CRT – vertical & horizontal deflection system, DSO, LCD monitor, PMMC writing systems, servo recorders, photographic recorder, magnetic tape recorder, Inkjet recorder, thermal recorder. Biosensors: transduction mechanism in a biosensor and Classification-Electronicnose, Electrical Safety and Standards of Measuring Instruments.

Total Periods:	45
Text Books:	

1.	A.K.Sawhney,	―Electrical	&	Electronics	Measurement	and Instrumentation‖,10thedition, DhanpatRai& Co, New Delhi, 19th Revised edition 2011, Reprint 2014.

2. John G. Webster, ―Medical Instrumentation Application and Design‖, 4th edition, Wiley India PvtLtd, New Delhi, 2015. 3. Ernest O Doebelin and Dhanesh N Manik, "Measurement systems, Application and design",6thedition,McGraw-Hill,2012	
References:	

1. Khandpur R.S, ―Handbook of Biomedical Instrumentation‖, 3rd edition, Tata McGraw-Hill, New Delhi, 2014.
2. Leslie Cromwell, ―Biomedical Instrumentation and measurement‖, 2nd edition, Prentice hall of India, New Delhi, 2015.
3. Albert D.Helfrick and William D. Cooper. Modern Electronic Instrumentation and Measurement Techniques‖, Prentice Hall of India, 1stedition, 2016.

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	-	-	-	-	-	-	1	3	-	-
CO2	3	2	1	1	-	-	-	-	-	-	1	3	-	-
CO3	3	3	2	1	-	-	-	-	-	-	1	3	-	-
CO4	3	2	1	1	-	-	-	-	-	-	1	3	-	-
CO5	3	3	2	1	-	-	-	-	-	-	1	3	-	-
CO6	3	2	1	1	-	-	-	-	-	-	1	3	-	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231BM32	ELECTRICAL CIRCUIT ANALYSIS	L	T	P	C
		2	1	0	3
Programme:	B.E.-Biomedical Engineering	Category:			PC

AIM:	To Learning about the fundamental laws and elements of electrical circuits.

Course Outcomes: The Students will be able to

CO1:	Apply the knowledge of network analysis techniques in DC electric circuits.
CO2:	Apply suitable network theorems, duality in DC electric circuits
CO3:	Analyze steady state response of AC circuits for the sinusoidal inputs
CO4:	Examine the transient response for RC, RL and RLC circuits
CO5:	Inspect the frequency response of parallel and series resonance circuits.
CO6:	Analyze the magnetically coupled circuits and network topologies

UNIT – I DC CIRCUIT ANALYSIS	9

Basic Components of electric Circuits, Charge, current, Voltage and Power, Voltage and Current Sources, Ohms Law, Kirchhoff's Laws, the Single Loop circuit and Single Node – Pair Circuit, Series and Parallel Connected Independent Sources, Resistors in Series and Parallel, voltage and current division, Mesh current and Node Voltage analysis of DC circuit

UNIT – II NETWORK THEOREM AND DUALITY	9

Network reduction source transformation, star-delta and delta-star Conversions, Useful Circuit Analysis techniques: Linearity and superposition, Thevenin and Norton Equivalent Circuits, Maximum Power Transfer, Duality of Network, Application of Network theorems.

UNIT – III SINUSOIDAL STEADY STATE ANALYSIS	9

Characteristics of Sinusoids, The Complex Forcing Function, The Phasor, Phasor relationship for R, L, and C, impedance and Admittance, Nodal and Mesh Analysis, Phasor Diagrams, AC Circuit Power Analysis, Instantaneous Power, Average Power, apparent Power and Power Factor, Complex Power.

UNIT – IV TRANSIENTS AND RESONANCE IN RLC CIRCUITS	9

Basic RL and RC Circuits, the Source- Free RL and RC Circuit, the Unit-Step Function, Driven RL, RC and RLC Circuits, Frequency Response, Parallel Resonance, Series Resonance, Quality Factor.

UNIT – V COUPLED CIRCUITS AND TOPOLOGY	9

Magnetically Coupled Circuits, mutual Inductance, the Linear Transformer, the Ideal Transformer, An introduction to Network Topology, Trees and General Nodal analysis, Links and Loop analysis.

	Total Periods:	45

Text Books:	

1.Hayt Jack Kemmerly, Steven Durbin, "Engineering Circuit Analysis", Mc Graw Hill education, 9th Edition, 2018.

2. Joseph Ed minister and Mahmood Nahvi, "Electric Circuits", Schaum's Outline Series, Tata Mc Graw Hill Publishing Company, New Delhi, Fifth Edition Reprint2016.

References:	

1. Charles.K.Alexander, Mathew N.O.Sadiku,"Fundamentals of Electric Circuits", McGrawHill, 5th Edition, 2012.
2. John O Mallay, Schaum's Outlines "Basic Circuit Analysis", The Mc Graw Hill companies,2nd Edition, 2011

3. David Bell, "Fundamentals of Electric Circuits", Oxford University press, 7th Edition, 2009.
4. D.R.Cunningham, J.A. Stuller, "Basic Circuit Analysis", Jaico Publishing House, 2005.

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	1	-	-	-	-	-	-	1	3	-	-
CO2	3	2	1	1	-	-	-	-	-	-	1	2	-	-
CO3	3	3	2	1	-	-	-	-	-	-	1	3	-	-
CO4	3	3	2	1	-	-	-	-	-	-	2	3	-	-
CO5	3	3	2	1	-	-	-	-	-	-	2	3	-	-
CO6	3	3	2	1	-	-	-	-	-	-	1	3	-	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231BM33	BIOMATERIALS	L	T	P	C
		3	0	0	3

Programme:	B.E.-Biomedical Engineering	Category:	PC

AIM:	To gain knowledge about the scientific basis for understanding how biomaterials interact with biological molecules and cells

Course Outcomes: The Students will be able to

CO1:	Select bio compactable material for body implants.
CO2:	Compare metallic and ceramic biomaterials.
CO3:	Identify polymeric implant materials for tissue replacement.
CO4:	Contrast the material used for tissue therapeutics implants.
CO5:	Infer the quality of biomaterials.
CO6:	Illustrate the sterilization devices.

UNIT – I	**INTRODUCTION TO BIO-MATERIALS**	**9**

Definition and classification of bio-materials, mechanical properties, viscous elasticity, biomaterial performance, body response to implants, wound healing, blood compatibility, Nano scale phenomena.

UNIT – II	**METALLIC AND CERAMIC MATERIALS**	**9**

Metallic implants – Stain less steels, co – based alloys, Ti – based alloys, shape memory alloy, nano structured metallic implants, degradation and corrosion, ceramic implant – bioinert, bio degradable or bio resorbable, bioactive ceramics, nano structured bio ceramics.

UNIT – III	**POLYMERIC IMPLANT MATERIALS**	**9**

Polymerization, factors in fluencing the properties of polymers, polymers as biomaterials, biodegradable polymers, Bio polymers: Collagen, Elastin and chitin. Medical Textiles, Materials for ophthalmology: contact lens, Intraocular lens. Membranes for plasmas eparathion and Blood oxygenation, electro spinning: a new approach.

UNIT – IV	**TISSUE REPLACEMENT IMPLANTS**	**9**

Small intestinal sub mucosa and other decullarized matrix biomaterials for tissue repair: Extracellular Matrix. Soft tissue replacements, sutures, surgical tapes, adhesive, Percutaneous and skin implants, maxilla facial augmentation, Vascular grafts, hard tissue replacement Implants, joint replacements, tissues caffolding and engineering using Nano biomaterials.

UNIT – V	**TESTING OF BIOMATERIALS**	**9**

Bio compatibility, blood compatibility and tissue compatibility tests, Toxicity tests, sensitization, carcinogenicity, mutagen city and special tests, Invitro and Invivo testing; Sterilization of implants and devices: ETO, gamma radiation, auto claving. Effects of sterilization.

Total Periods:		**45**

Text Books:	

1. SujataV.Bhatt, "Biomaterials", Second Edition, Narosa PublishingHouse, 2005.
2. Joon B.Park Joseph D. Bronzino, "Biomaterials - Principles and Applications", CRC press,2003

References:	

3. Sreeram Ramakrishna, Murugan Ramalingam, T. S. Sampath Kumar, an Winston O.Soboyejo, "Biomaterials:A Nano Approach",CRC Press,2010.
4. Monika Saini, Yashpal Singh, Pooja Arora, Vipin Arora, and KratiJain. "Implant biomaterials :A comprehensive view", World Journal of Clinical Cases,2015.Biomaterials- Basic Theory with Engineering Applications C.Mauli Agarwal, JooL.Ong, Mark R.Apple ford,Gopinath Mani.Cambrige University Press, NewYork-2016.

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	1	-	2	-	-	-	-	1	3	1	-
CO2	3	3	2	1	-	2	-	-	-	-	1	3	1	-
CO3	3	3	2	1	-	2	-	-	-	-	1	3	1	-
CO4	3	3	2	1	-	2	-	-	-	-	1	3	1	-
CO5	3	3	2	1	-	2	-	-	-	-	1	3	1	-
CO6	3	3	2	1	-	2	-	-	-	-	1	3	1	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231BM34	ANATOMY AND HUMAN PHYSIOLOGY (THEORY CUM PRACTICAL)	L	T	P	C
		3	0	2	4
Programme:	**B.E.-Biomedical Engineering**		**Category:**		**PC**

AIM:	To teach the functions, processes and inter- relationship of the different organs and systems.

Course Outcomes: The Students will be able to

CO1:	Interpret the basic structure and functions of cell
CO2:	Illustrate the functions of skeletal and muscular system.
CO3:	Outline the structure, function of cardio vascular system and respiratory system
CO4:	Explain the structure of digestive and excretory system
CO5:	Infer the physiological process of Nervous system
CO6:	Illustrate the physiological process of sensory system.

UNIT – I BASIC ELEMENTS OF HUMAN BODY	9
Cell – Cell Structure and organelles - Functions of each component in the cell. Cell membrane –transport across membrane - Action potential (Nernst, Goldman equation), Homeostasis. Tissue: Types, functions.	
UNIT – II SKELETAL AND MUSCULAR SYSTEM	**9**
Skeletal: Types of Bone and function – Physiology of Bone formation – Division of Skeleton –Types of joints and function–Types of cartilage and function.–Types of muscles–Structure and Properties of Skeletal Muscle-Changes during muscle contraction-Neuro muscular junction.	
UNIT – III CARDIOVASCULAR AND RESPIRATORY SYSTEM	**9**
Cardiovascular System: Structure – Conduction System of heart – Cardiac Cycle – Cardiac output. Blood: Composition–Functions- Haemostasis–Blood groups and typing.Blood Vessels–Structure and types – Blood pressure Respiratory system: Parts of respiratory system– Respiratory physiology– Lung volumes and capacities– Gaseous exchange.	
UNIT – IV DIGESTIVE AND EXCRETORY SYSTEMS	**9**
Structure and functions of gastro intestinal system-secretory functions of the alimentary tract- Digestion and absorption in the gastro intestinal tract- structure of nephron-mechanism of urine formation- skin and sweat gland- temperature regulation.	
UNIT – V NERVOUS ANDSENSORY SYSTEM	**9**
Structure and function of nervous tissue– Brain and spinal cord – Functions of CNS – Nerve conduction and synapse – Reflex action – Somatic and Autonomic Nervous system. Physiology of Vision, Hearing, Integumentary, Olfactory systems. Taste buds.	
Total Periods:	**60**

Text Books:	
1. Elaine.N.Marieb, "Essential of Human Anatomy and Physiology", Ninth Edition, Pearson Education, NewDelhi, 2018.	
2. Gopal B. Saha "Physics and Radiobiology of Nuclear Medicine", Third edition Springer, 2006	
References:	
1. Guyton & Hall, "Text book of Medical Physiology",13th Edition, Saunders,2015.	

2. Ranganathan TS, "Textbook of Human Anatomy", S. Chand & Co. Ltd., New Delhi, 2012.
3. Sarada Subramanyam, K Madhavan Kutty ,Singh HD, "Text book of Human Physiology", S.Chand and Company Ltd, New Delhi, 2012.

S.No.	LIST OF EXPERIMENTS - 30Peroids
1.	Collection of Blood Samples
2.	Identification of Blood groups(Forward and Reverse)
3.	Bleeding and Clotting time
4.	Estimation of Hemoglobin
5.	Total RBC and WBC Count
6.	Differential count of Blood cells
7.	Estimation of ESR,PCV,MCH,MCV,MCHC
8.	Hearing test –Tuning fork
9.	Visual Activity– Snellen's Chart and Jaeger's Chart

LAB REQUIREMENT FOR A BATCH OF 30 STUDENTS:

1.	Microscope	2Nos
2.	Centrifuge Normal	1No
3.	Wintrobe's tube	2Nos.
4.	PCV tube	2Nos
5.	Neubaur's Chamber	2 Nos.
6.	Heparinized Syringe	1box
7.	Hemoglobino meter	1No
8.	Blood grouping kit	1No
9.	Capillary tubes	1box
10.	Ophthalmoscope	1No
11.	Tuning fork(256Hzto 512Hz)	5 Nos.
12.	Micro slides	2 packets
13.	Lancet	5 boxes

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	2	-	2	-	2	-	-	3	3	-	-
CO2	3	2	2	2	-	2	-	2	-	-	3	3	-	-
CO3	3	2	2	2	-	2	-	2	-	-	3	3	-	-
CO4	3	2	2	2	-	2	-	2	-	-	3	3	-	-
CO5	3	2	2	2	-	2	-	2	-	-	3	3	-	-
CO6	3	2	2	2	-	2	-	2	-	-	3	3	-	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231BM37	ELECTRICAL CIRCUITS AND ELECTRONIC DEVICES LABORATORY	L	T	P	C
		0	0	3	1.5
Programme:	B.E.-Biomedical Engineering	Category:			PC
AIM:	To study various electronic components and design of various electronic circuits				

Course Outcomes: The Students will be able to

CO1:	Experiment with the given electric circuit using Kirchhoff's laws and obtain the mesh current & node voltage and obtain the load current for the given circuit using Superposition, Thevenin's, and Norton's and Reciprocity theorem.
CO2:	Construct and test RLC series and parallel circuits to compute the resonant frequency and band width by plotting the frequency response.
CO3:	Experiment and determine the VI characteristics of given PN junction diode, Zener diode, Photo diode and Silicon Controlled Rectifier.
CO4:	Experiment and determine the Input & output characteristics of BJT.
CO5:	Experiment and test half wave and full wave rectifier circuit using PN Junction diode and obtain the ripple factor, rectifier efficiency.
CO6:	Experiment and test voltage regulation using Zener diode.

LIST OF EXPERIMENTS

1. Verification of KVL and KCL.
2. Verification of Thevenin's and Norton's Theorems.
3. Verification of superposition Theorem.
4. Verification of Maximum power transfer and reciprocity theorems.
5. Frequency response of RLC series and parallel resonance circuits.
6. Characteristics of PN and Zener diode.
7. Study of characteristics of photo diodes.
8. Study of characteristics of SCR
9. Characteristics of CE, CB configurations.
10. Half wave and Full wave rectifier with capacitor filter.
11. Voltage regulation using Zener diode.

LISTOFEQUIPMENTS:(30 STUDENTS PERBATCH)

1. DSO (50MHz)
2. DC Digital Ammeter DC Digital Voltmeter
3. Function Generator(3MHz)
4. Analog IC Tester, Digital IC Tester and Digital IC Trainer Kit
5. Dual Regulated Power supply (0-30)V/2A
6. Multiple Regulated Power supply (+5) V/2A,(015)V/2A.
7. Single Regulated Power supply (0-30)V/2A
8. Decade Inductance Box(6Dial) , Variable Resistance Box(6Dial)
9. Decade Capacitance Box(6Dial)
10. Analog Ammeter (0-1) mA and Analog Voltmeter
11. Digital Multimeter

Total Periods:	**30**

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	1	-	-	1	2	-	1	3	-	-
CO2	3	2	1	1	1	-	-	1	2	-	1	3	-	-
CO3	3	2	1	1	1	-	-	1	2	-	1	3	-	-
CO4	3	2	1	1	1	-	-	1	2	-	1	3	-	-
CO5	3	2	1	1	1	-	-	1	2	-	1	3	-	-
CO6	3	2	1	1	1	-	-	1	2	-	1	3	-	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231BM38	SENSORS AND MEASUREMENTS LABORATORY	L	T	P	C
		0	0	3	1.5
Programme:	B.E.-Biomedical Engineering	Category:		PC	
AIM:	To study measurement techniques, sensor applications, and error analysis in practical scenarios.				

Course Outcomes: The Students will be able to

CO1:	Conduct an experiment to study the characteristics of temperature sensor.
CO2:	Conduct an experiment to study the characteristics of light detection sensor.
CO3:	Conduct an experiment to measure the displacement using LVDT and hall effect transducer.
CO4:	Conduct an experiment to measure value of electrical elements using bridges.
CO5:	Conduct an experiment to study the characteristics of using strain gauge.
CO6:	Infer the electronic nose technology for sensory application.

LIST OF EXPERIMENTS

1. Characteristics of thermocouple, RTD, Thermistor
2. Characteristics of Photo Diode, Phototransistor, LDR
3. Characteristics of LVDT
4. Measurement of unknown Resistance using Kelvin Double Bridge and Wheatstone bridge
5. Measurement of unknown Capacitance using Schering Bridge
6. Measurement of unknown Inductance using Maxwell's & Hay's Bridge
7. Characteristics of Hall effect transducer
8. Characteristics of strain gauge
9. Study of Electronic nose
10. Characteristics of Piezoelectric Transducer

LAB REQUIREMENTS FOR 30 STUDENTS

1. Thermocouple--15 Nos
2. RTD--15Nos
3. Strain Gauge(bonded and unbounded type)-15each
4. Photo transistor, photo diode—15Noseach
5. Resistors-Range between1-0.0001ohm–30Nos/each
6. CRO-10
7. DSO-5LVDT–5
8. Hall effect transducer-15Nos
9. Piezoelectric Transducer-15Nos

Total Periods:		30

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	1	1	-	-	-	1	2	-	1	2	1	-
CO2	3	2	1	1	-	-	-	1	2	-	1	2	1	-
CO3	3	2	1	1	-	-	-	1	2	-	1	2	1	-
CO4	3	2	1	1	-	-	-	1	2	1	1	2	1	-
CO5	3	2	1	1	-	-	-	1	2	1	1	2	1	-
CO6	3	2	1	1	-	-	-	1	2	1	1	2	1	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231BS41	PROBABILITY AND RANDOM PROCESSES	L	T	P	C
		2	1	0	3
Programme:	B.E./B.Tech. (Common to all branches)	Category:		BS	
AIM:	To understand the concepts of basic probability and random variables.				

Course Outcomes: The Students will be able to

CO1:	Interpret the concept of random variables.
CO2:	Identify the type of statistical situation to which different distributions can be applied.
CO3:	Analyze statistical date using Two Dimensional Random Variables.
CO4:	Explain the concepts of correlation and regression and its applications.
CO5:	Solve real life problems using ergodic process, Markov process and sine wave process
CO6:	Find Auto correlation and Cross correlation functions

UNIT – I RANDOM VARIABLES	9

Introduction to Probability – Definition of random variable – Discrete and Continuous random variables – Probability Mass and Probability density functions – Mathematical expectation and Variance – Moments – Moment generating functions

UNIT – II STANDARD PROBABILITY DISTRIBUTIONS	9

Discrete Distributions: Binomial distribution – Poisson distribution – Geometric distribution – Continuous Distributions :Uniform distribution – Exponential distribution – Normal distribution

UNIT – III TWO DIMENSIONAL RANDOM VARIBLES	9

Joint distributions - Marginal and conditional distributions – Covariance - Correlation and Regression - Transformation of random variables - Central limit theorem (for 2-D random variables)

UNIT – IV CLASSIFICATION OF RANDOM PROCESSES	9

Definition and examples - first order, second order, strictly stationary, wide-sense stationary and ergodic processes - Markov process - Binomial, Poisson and Normal processes - Sine wave process – Random telegraph process.

UNIT – V CORRELATION AND SPECTRAL DENSITIES	9

Auto correlation - Cross correlation - Properties – Power spectral density – Cross spectral density - Properties – Wiener-Khintchine relation – Relationship between cross power spectrum and cross correlation function

Total Periods:	45
Text Books:	

1. Oliver C. Ibe, "Fundamentals of Applied probability and Random processes", Elsevier, First Indian Reprint (2007) (For units 1 and 2)

2. Peebles Jr. P.Z., "Probability Random Variables and Random Signal Principles", Tata McGraw-Hill Publishers, Fourth Edition, New Delhi, 2002. (For units 3, 4and 5).

References:	

1.Miller,S.L and Childers, S.L, "Probability and Random Processes with applications to Signal Processing and Communications", Elsevier Inc., First Indian Reprint 2007.
2. H. Stark and J.W. Woods, "Probability and Random Processes with Applications to Signal

Processing", Pearson Education (Asia), 3rd Edition, 2002.

3. Hwei Hsu, "Schaum's Outline of Theory and Problems of Probability, Random Variables and Random Processes", Tata McGraw-Hill edition, New Delhi, 2004.

4. Leon-Garcia,A, "Probability and Random Processes for Electrical Engineering", Pearson Education Asia, Second Edition, 2007.

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	-	-	-	-	-	-	-	1	1	-	-
CO2	3	3	2	1	-	-	-	-	-	-	1	2	1	-
CO3	3	3	2	1	-	-	-	-	-	-	1	2	1	-
CO4	3	2	1	-	-	-	-	-	-	-	1	1	-	-
CO5	3	3	2	1	-	-	-	-	-	-	1	2	1	-
CO6	3	3	2	1	-	-	-	-	-	-	1	2	1	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231BM41	BIOMEDICAL INSTRUMENTATION	L	T	P	C
		3	0	0	3

Programme:	B.E.- Biomedical Engineering	Category:	PC

AIM:	To design, develop, and implement devices and systems that measure, monitor, and treat various physiological and biological parameters of the human body.

Course Outcomes: The Students will be able to

CO1:	Classify the different types of electrodes in Biopotentials.
CO2:	Illustrate the recording and characteristics of bio signals using Bioamplifier.
CO3:	Identify the various techniques for measuring non-electrical bio-parameters.
CO4:	Interpret the Limitations, Risks, and Safety Protocols of Life-Supporting Instruments
CO5:	Explain the working and application of analytical Instruments.
CO6:	Infer the electrical hazards in healthcare environments.

UNIT-I BIOPOTENTIAL AND ELECTRODES	9

Components of Medical Instrumentation System- Origin of Biopotentials, Electrical Activity of Cells, Electrode Skin interface, Electrode-Electrolyte interface, motion artifact, half-cell Potential Polarization effects of electrode – Non polarizable electrodes. Types of electrodes - Surface; needle and micro electrodes – ECG – EMG - EEG Electrodes.

UNIT-II BIOELECTRIC SIGNALS RECORDING AND BIOAMPLIFIERS	9

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. Bio amplifiers- Carrier Amplifier, - Isolation Amplifier - Differential amplifier – Chopper Amplifier - Instrumentation Amplifier.

UNIT-III MEASUREMENT OF NON-ELECTRICAL PARAMETERS	9

Human body Temperature, Measurement of blood pressure – Measurement of Cardiac output Measurement of Heart rate, cardiac output, Measurement of Heart sound, Blood Gas analyzers, finger-tip oxymeter - ESR, GSR measurements.

UNIT IV LIFE SUPPORT INSTRUMENTS	9

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 V ANALYTICAL INSTRUMENTAION AND ELECTRICAL SAFETY	9

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 Periods:	45

Text Books:	

1. Leslie Cromwell, "Biomedical Instrumentation and measurement", 2nd edition, Prentice hall of India, New Delhi, 2015.
2. John G.Webster, "Medical Instrumentation Application and Design", 4th edition, Wiley India Pvt Ltd, NewDelhi,2015.
3. Khandpur R.S, "Handbook of Biomedical Instrumentation", Tata McGraw Hill,NewDelhi,2013.

References:	

4. John Enderle, Susan Blanchard, Joseph Bronzino, "Introduction to Biomedical Engineering" ,second edition, Academic Press, 2005.
5. 2.Joseph J. Carr and John M. Brown, "Introduction to Biomedical Equipment Technology", Pearson Education, 2004

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	-	-	-	-	-	-	1	2	3	-
CO2	3	2	1	1	-	-	-	-	-	-	1	2	3	-
CO3	3	2	1	1	-	-	-	-	-	-	1	2	3	-
CO4	3	2	1	1	-	2	-	-	-	-	1	2	3	-
CO5	3	2	1	1	-	-	-	-	-	-	1	2	3	-
CO6	3	1	1	1	-	2	-	-	-	-	1	2	3	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231BM42	ANALOG AND DIGITAL INTEGRATED CIRCUITS	L	T	P	C
		3	0	0	3
Programme:	**B.E.-Biomedical Engineering**	**Category:**		**PC**	
AIM:	To study circuit configurations and practical applications of linear integrated circuits while providing fundamental concepts for designing digital logic circuits.				

Course Outcomes: The Students will be able to	
CO1:	Design and develop Analog circuits using linear IC based Systems.
CO2:	Explain the functional blocks of the ADC, DAC and Phase Locked Loop with applications
CO3:	Apply number systems, digital codes and Boolean minimization techniques to design digital logic circuits.
CO4:	Explain the function of various digital logic families.
CO5:	Design various combinational digital circuits using logic gates.
CO6:	Design the sequential circuits using Flip Flops.

UNIT – I	INTRODUCTION TO OPERATIONAL AMPLIFIER AND ITS APPLICATIONS	9

Operational amplifier –ideal characteristics, Performance Parameters, Linear and Nonlinear Circuits and their analysis- Adder, Subtractor, buffer , voltage follower, Inverting amplifier, Non-inverting Amplifiers, Differentiator, Integrator, Voltage to Current converter, Instrumentation amplifier, Active filters Comparator, Multivibrator and Schmitt trigger, Triangular wave generator.

UNIT – II	DIGITAL TO ANALOG AND ANALOG TO DIGITAL CONVERTERS AND PLL	9

High speed sample and hold circuit and IC 's, Types of D/A converter –Weighted resistor, R-2R ladder DAC.A/D converter- Flash, Dual slope, Successive approximation. Voltage controlled oscillator, Voltage to Frequency converters. PLL-Closed loop analysis of PLL, Frequency multiplication/division ,FSK demodulator**.**

UNIT – III	THE BASIC GATES AND LOGIC FAMILIES	9

Number Systems – Decimal, Binary, Octal, Hexadecimal, 1's and 2's complements, Codes – Binary, BCD, Excess 3, Biquinary, Gray, Alphanumeric codes, Boolean theorems, Logic gates, Universal gates, Sum of products and product of sums, Min terms and Max terms, Karnaugh map and Tabulation methods. Logic families-TTL, MOS, CMOS, BiCMOS-Comparison of Logic families.

UNIT – IV	COMBINATIONAL LOGIC CIRCUITS	9

Problem formulation and design of combinational circuits - Code-Converters, Half and Full Adders, Binary Parallel Adder – Carry look ahead Adder, BCD Adder, Magnitude Comparator, Decoder, Encoder, Priority Encoder, Mux/ Demux.

UNIT – V	SEQUENTIAL LOGIC CIRCUITS	9

Flip flops – SR, JK, T, D, Master/Slave FF, Triggering of FF, Realization of FF, Analysis and design of clocked sequential circuits – State Diagram, State minimization, State assignment, circuit implementation. Counters, Ripple Counters, Ring Counters. Types of Registers, Serial In- Serial Out, Serial In - Parallel out, Parallel In-Serial Out, Parallel In-Parallel Out, Universal Shift Register.

Total Periods:		**45**
Text Books:		

1. Sergio Franco, "Design with operational amplifiers and analog integrated circuits", McGrawHillEducation,3rd Edition,2017.
2. John.F.Wakerly,"Digitaldesignprinciplesandpractices",PearsonEducation,5thEdition,2018.

References:	

1. Tauband Schilling,"Digital Integrated Electronics",McGrawHill,2017.

2. CharlesH.Roth,Jr,"Fundamentals of Logic Design",Jaico Books,7thEdition,2013.

3. M.Morris Mano and MichaelD.Ciletti,"Digital Design",Pearson,5thEdition,2013.

4. SSalivahanan and VSKanchana Bhaaskaran,Linear Integrated Circuits,McGrawHill Education,3rd Edition,2018.

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	1	-	-	-	-	-	-	1	3	-	-
CO2	3	2	1	-	-	-	-	-	-	-	1	2	-	-
CO3	3	3	2	1	-	-	-	-	-	-	1	3	-	-
CO4	3	2	1	-	-	-	-	-	-	-	1	2	-	-
CO5	3	3	2	1	1	-	-	-	-	-	1	3	-	-
CO6	3	3	2	1	1	-	-	-	-	-	1	3	-	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231BM43	BIOMECHANICS	L	T	P	C
		3	0	0	3
Programme:	**B.E. - Biomedical Engineering**	**Category:**		**PC**	
AIM:	To understand and apply mechanical principles to biological systems, including analyzing material properties, biological tissues, and fluid dynamics, as well as exploring joint biomechanics and ergonomics to design safe and effective work environments.				

Course Outcomes: The Students will be able to

CO1:	Analysis the materials using the principles of mechanics.
CO2:	Apply the principles of mechanics in the context of blood circulation system.
CO3:	Analysis the biological tissues by muscular skeletal models.
CO4:	Apply biomechanical analysis for various joint in a human body.
CO5:	Outline the biological tissue model using finite element analysis.
CO6:	Design a good work place using Ergonomic principles.

UNIT – I	INTRODUCTION TO MECHANICS	9

Introduction–Scalars and vectors, Statics–Resolution and composition of forces, Moments, couple, Resultant, equilibrium of coplanar forces, Dynamics – Linear motion, Newton's laws of motion, Velocity and acceleration, Kinematics – Models, Transducers Constitutive equations –Non-viscous fluid, Newtonian Viscous fluid and Hookean Elastic solid.

UNIT – II	BIOFLUID MECHANICS	9

Intrinsic fluid properties, Rheological properties of blood ,Pressure-flow relationship for Non-Newtonian Fluids, Fluid mechanics in straight tube, Structure of blood vessels, Material properties and modelling of Blood vessels, Heart – Cardiac muscle characterization, Native heart valves, Prosthetic heart valve fluid dynamics.

UNIT – III	MUSCULOSKELETAL MECHANICS	9

Constitutive equation of visco elasticity – Maxwell, Voight and Kelvin models, anisotropy, Hard Tissues–Structure, viscoelastic properties, functional adaptation, Soft Tissues–Structure, functions, material properties and modelling of Soft Tissues – Cartilage, Tendons and Ligaments Skeletal Muscle, Bone fracture mechanics, Implants for bone fractures.

UNIT – IV	BIOMECHANICS OF JOINTS	9

Skeletal joints, forces and stresses in human joints, Analysis of rigid bodies in equilibrium, Free body diagrams, Structure of joints, Types of joints, Biomechanical analysis of elbow, shoulder, spinal column, hip, knee and ankle, Lubrication of synovial joints, Gait analysis, Motion analysis using video.

UNIT – V	MODELLING AND ERGONOMICS	9

Introduction to Finite Element Analysis, finite element analysis of lumbar spine; models for voice biomechanics, Ergonomics –Musculoskeletal disorders, Ergonomic principles contributing to good workplace design, Design of a Computer work station, Whole body vibrations, Hand transmitted and whole-body vibrations.

Total Periods:	45

Text Books:

1. Y.C. Fung, Bio-Mechanics- Mechanical Properties of Tissues, Springer-Verlag, 1998.
2. Subrata Pal, Textbook of Biomechanics, Viva Books Private Limited,2009.
3. Krishna B.Chandran, AjitP.Yoganathan and Stanley E.Rittgers, Biofluid Mechanics:TheHumanCirculation,TaylorandFrancis,2007.

4. Duane Knudson, "Fundamentals of Biomechanics", Second Edition Springer Science+Business Media, 2007.
5. Özkaya, Nihat, DawnLeger, David Goldsheyder, and Margareta Nordin. Fundamentals of biomechanics: equilibrium, motion, and deformation.Springer,2016.

References:	

1. Sheraz S.Malik and Shahbaz S.Malik, Orthopaedic Biomechanics Made Easy, Cambridge University Press, 2015.
2. Jay D.Humphrey, Sherry DeLange, An Introduction to Biomechanics: Solids and Fluids, Analysis and Design, Springer Science Business Media, 2004.
3. Shrawan Kumar, Biomechanics in Ergonomics, Second Edition, CRC Press 2007.
4. NeilJ. Mansfeild, Human Response toVibration,CRCPress,2005.
5. CarlJ.Payton, Biomechanical Evaluation of movement in sports and Exercise, 2008.

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	1	1	-	-	-	-	3	3	1	-
CO2	3	2	1	1	-	-	-	-	-	-	3	3	1	-
CO3	3	2	1	-	-	-	-	-	-	-	3	2	1	-
CO4	3	2	2	1	1	2	-	-	-	-	3	3	2	1
CO5	3	2	1	1	2	1	-	-	-	-	3	3	-	-
CO6	3	2	1	1	1	1	-	-	-	-	3	3	1	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231BM44	MEDICAL IMAGING SYSTEMS	L	T	P	C
		3	0	0	3

Programme:	B.E.- Biomedical Engineering	Category:	PC

AIM:	To provide students with a knowledge of recording images of the internal structure of the body to assess the presence or absence of disease, foreign objects, and structural damage or anomaly.

Course Outcomes: The Students will be able to

CO1:	Outline the core principles, design, and functionality of essential radiographic equipment.
CO2:	Analyze the tomography concept and image reconstruction techniques.
CO3:	Interpret the concept of nuclear imaging techniques and radiation detectors.
CO4:	Summarize the basic principle involved in Ultrasound Imaging technique.
CO5:	Interpret the basic principle of NMR and MRI
CO6:	Explain MRI equipment,artifacts, and its applications.

UNIT – I PRINCIPLES OF RADIOGRAPHIC EQUIPMENT	9

X-Ray tubes, cooling systems, removal of scatters, Fluoroscopy-construction of image Intensifier tubes, angiographic setup, mammography, digital radiography, DSA.

UNIT – II COMPUTED TOMOGRAPHY	9

Need for sectional images, Principles of sectional scanning, Generation in CT,CT detectors, Methods of Reconstruction-Iterative, Back projection, convolution and Back-Projection and central slice theorem. Artifacts ,Principle of 3D imaging, Spiral CT.

UNIT – III RADIO ISOTOPIC IMAGING	9

Alpha, Beta and Gamma radiation, Radiation detectors, Radio iso topic imaging equipment, Radio nuclides for imaging, Gamma camera, scanners, Positron Emission Tomography, SPECT,PET/CT.

UNIT – IV ULTRASOUND IMAGING SYSTEMS	9

Wave propagation and interaction in Biological tissues, Acoustic radiation fields, continuous and pulsed excitation, Transducers and imaging systems, Scanning methods, Imaging Modes, Principle and theory of image generation, Applications. Doppler Ultrasound, Ultrasound Image Quality and Artifacts.

UNIT – V MAGNETIC RESONANCE IMAGING	9

NMR, Principle of MRI, Relaxation processes and their measurements, Pulse Sequencing and MRI image acquisition, MRI Instrumentation, MRI Artifacts, Magnetic Resonance Spectroscopy, Functional MRI. Case Study.

Total Periods:	45

Text Books:

3. Sergio Franco, "Design with operational amplifiers and analog integrated circuits", McGrawHillEducation,3rd Edition,2017.
4. John.F.Wakerly,"Digitaldesignprinciplesandpractices",PearsonEducation,5thEdition,2018.

References:

5. Tauband Schilling,"Digital Integrated Electronics",McGrawHill,2017.

6. CharlesH.Roth,Jr,"Fundamentals of Logic Design",Jaico Books,7thEdition,2013.

7. M.MorrisMano and MichaelD.Ciletti,"Digital Design",Pearson,5thEdition,2013.

8. SSalivahanan and VSKanchana Bhaaskaran,Linear Integrated Circuits,McGrawHill

Education,3rd Edition,2018.

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	-	-	-	-	2	1	-	-	-	1	2	1	-
CO2	3	2	1	1	-	2	1	-	-	-	1	2	1	1
CO3	3	-	-	-	-	2	1	-	-	-	1	2	1	-
CO4	3	-	-	-	-	2	1	-	-	-	1	2	1	-
CO5	3	-	-	-	-	2	1	-	-	-	1	2	1	-
CO6	3	-	-	-	-	2	1	-	-	-	1	2	1	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231EC35	DATA STRUCTURES WITH C AND C++	L	T	P	C

		(Theory cum Practical)	3	0	2	4
Programme:		**B.E.- BME,ECE**	**Category:**			**PC**
AIM:		To develop foundational skills in C and C++ programming, object-oriented principles, and data structures, equipping students with essential techniques for problem-solving and efficient data management in computer science.				

Course Outcomes: The Students will be able to

CO1:	Interpret the fundamentals of constructing a C program.
CO2:	Develop C programs for complex problems, making good use of the features of the language such as functions, Pointer, Structure and union.
CO3:	Illustrate the object-oriented paradigm, and create class hierarchies using the object-oriented design process.
CO4:	Illustrate the importance of data structures in context of writing efficient programs.
CO5:	Outline the concepts of basic data structures such as linked lists, stacks and queues.
CO6:	Apply algorithms for solving problems in sorting and searching.

UNIT – I C PROGRAMMING BASICS	**9**

Introduction to ' C' programming - fundamentals - structure of a 'C' program - compilation and linking processes - Constants, Variables - Data Types - Expressions using operators in 'C' - Manag Input and Output operations - Decision Making and Branching - Looping statements - Arrays - Initialization - Declaration - One dimensional and Two dimensional arrays. String- String operation String Arrays.

UNIT – II FUNCTIONS AND POINTERS	**9**

Function - Definition of function - Declaration of function - Pass by value - Pass by reference - Recursion - Pointers - Definition - Initialization - Pointers arithmetic - Pointers and arrays- Example Problems - Structure -Union.

UNIT – III OBJECT ORIENTED PROGRAMMING FUNDAMENTALS	**9**

Procedure Oriented Programming Vs. Object Oriented Programming (OOP). Object oriented programming concepts – Classes, reusability, encapsulation, inheritance, polymorphism, dynamic binding, and message passing. C++ Programming features -– member functions – pointers – references - Role of this pointer – Storage classes – function as arguments.

UNIT – IV LINEAR DATA STRUCTURES	**9**

Abstract Data Types (ADTs) - List ADT – array based implementation - linked list implementation - singly linked lists - circularly linked lists – doubly linked lists - applications of lists. Stack ADT - Evaluating arithmetic expressions-Queue ADT - circular queue implementation - Double ended Queues - applications of queues..

UNIT – V SORTING, SEARCHING AND HASH TECHNIQUES	**9**

Sorting algorithms: Insertion sort - Selection sort - Bubble Sort - Shell sort - Quick sort - Merge sort - Searching: Linear search - Binary Search. Hashing: Hash Functions - Separate Chaining - Open Addressing - Rehashing - Extendible Hashing-Trees: Binary Tree-Insertion and Deletion-Graphs: Breadth-first search - Depth-first search.

Total Periods:		**60**
Text Books:		

1. Anita Goel and Ajay Mittal, "Computer Fundamentals and Programming in C", Dorling Kindersley (India) Pvt. Ltd., Pearson Education in South Asia, 2017.
2. Mark Allen Weiss, Data Structures and Algorithm Analysis in C++, Pearson Education, 4/e, 2014.

References:	

1. Kernighan B.W, Ritchie,D.M, "The C Programming language", Pearson Education, 2/e, 2006.
    2. Herbert Schildt, "The Complete Reference C++", Fifth Edition, TMH, 2012.
    3. E. Balagurusamy, "Object Oriented Programming with C++", McGraw Hill Company Ltd., 7/e, 2017.
4. ReemaThareja, "Data Structures Using C", Oxford University Press, 2/e, 2011

LIST OF EXPERIMENTS:
Implementation in the following topics:
1. Scientific problem solving using decision making and looping.
2. Simple programming for one dimensional and two dimensional arrays.
3. Solving problems using String functions.
4. Programs with user defined functions - Includes Parameter Passing.
5. Program using Recursive Function and conversion from given program to flow chart.
6. Programs using pointers
7. Program using structures and unions.
8. Implement Matrix class with dynamic memory allocation and necessary methods. Give proper constructor, destructor, copy constructor, and overloading of assignment operator.
9. Develop with suitable hierarchy, classes for Point, Shape, Rectangle, Square, Circle, Ellipse, Triangle, Polygon, etc. Design a simple test application to demonstrate dynamic polymorphism using C++.
10. Operations on a Stack and Queue
        a. Infix to postfix
        b. Simple expression evaluation using stacks
        c. Linked Stack Implementation
        d. Linked Queue Implementation.
11. Implementation of Sorting algorithm.
12. Implementation of Linear search and Binary Search.
13. Implementation of Binary Search Tree.

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	1	2	3	-	-	-	-	-	2	1	-	1
CO2	3	3	2	2	3	-	-	-	-	-	2	1	-	1
CO3	3	2	2	3	2	-	-	-	-	-	2	1	-	1
CO4	3	2	2	3	3	-	-	-	-	-	2	1	-	1
CO5	3	3	2	2	3	-	-	-	-	-	2	1	-	1
CO6	3	3	3	1	3	-	-	-	-	-	2	1	-	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231BM47	BIOMEDICAL INSTRUMENTATION	L	T	P	C

		LABORATORY	0	0	3	1.5
Programme:		**B.E.-Biomedical Engineering**	**Category:**			**PC**
AIM:		To design, operate, and troubleshoot biomedical instruments used in medical diagnosis, treatment, and patient monitoring.				

Course Outcomes: The Students will be able to

CO1:	Design and test the amplifier for Bio signal measurements.
CO2:	Demonstrate the measurement of vital parameters of heart
CO3:	Demonstrate the measurement of blood pressure and blood flow.
CO4:	Demonstrate the measurement of PH and conductivity of the given solution.
CO5:	Design PCB layout using software tool.

LIST OF EXPERIMENTS

1. Design of pre amplifiers to acquire bio signals along with impedance matching circuit using suitable IC's
2. Design of ECG Amplifiers with appropriate filter to remove power line and other artifacts.
3. Design of EMG amplifier
4. Design a suitable circuit to detect QRS complex and measure heart rate
5. Design of frontal EEG amplifier
6. Design of EOG amplifier to detect eye blink
7. Design a right leg driven ECG amplifier.
8. Design and study the characteristics of optical Isolation amplifier
9. Design a Multiplexer and De multiplexer for any two bio signals.
10. Measurement of pulse –rate using Photo transducer.
11. Measurement of pH and conductivity.
12. Measurement of blood pressure using sphygmomanometer.
13. Measurement and recording of peripheral blood flow
14. Design a PCB layout for any bio amplifier using suitable software to

List of Equipment: (30 Students per Batch)

1. pH meter and conductivity meter   :1No.
2. Photo transducer for pulse measurement : 1No.
3. Sphygmomanometer and Stethoscope   : 1No.
4. Blood flow measurement system   : 1No.
5. Multi parameter (ECG, EMG and EEG) Simulator: 2No.
6. Function generator, DSO, Regulated Power supplies, Bread boards–8 each
7. ICLM 324, AD 620, INA series(126,128etc.),555Timer :20each
8. Opto Isolator IC: MCT2E–1No.
9. Soft ware tool for PCB design:1

Total Periods:	**30**

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	-	2	-	2		-	1	3	3	-
CO2	3	2	1	1	-	2	-	2		-	1	3	3	-
CO3	3	2	1	1	-	2	-	2		-	1	3	3	-
CO4	3	2	1	1	-	2	-	2		-	1	3	3	-
CO5	3	2	1	1	3	2	-	2		-	1	3	3	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231BM48	**ANALOG AND DIGITAL INTEGRATED**	L	T	P	C

			0	0	3	1.5
Programme:	**B.E.-Biomedical Engineering**			**Category:**		**PC**
AIM:	To acquire skills in designing and implementation of Op – Amp applications and to design combinational, sequential logic circuits.					

Course Outcomes: The Students will be able to	
CO1:	Design and implement arithmetic circuits for different applications using opamp
CO2:	Design wave form generators and analyse their characteristics
CO3:	Design active filters and instrumentation amplifier using operational amplifiers.
CO4:	Design Combinational Circuits using logic gates.
CO5:	Design Sequential Circuits using logic gates.
CO6:	Design and simulate the circuit using simulation software.

LIST OF EXPERIMENTS

1. Inverting, non-inverting amplifier and comparator
2. Integrator and Differentiator
3. Design and analysis of active filters using op-amp
4. Schmitt trigger using operational amplifier
5. Instrumentation amplifier using operational amplifier
6. RC and LC oscillators
7. Multivibrators using IC555Timer
8. Study of logic gates, Half adder and Full adder
9. Encoder and BCD to7 segment decoder
10. Multiplexer and de-multiplexer using digital ICs
11. Universal shift register using flip flops
12. Design of counter
13. Simulation and analysis of circuits using software

LIST OF EQUIPMENT:(30 Students per Batch)

1. CRO/DSO (30MHz)– 15Nos.
2. Signal Generator /Function Generators(3MHz)–15Nos
3. Dual Regulated Power Supplies (0–30V)–15Nos.
4. Standalone desktop PC switch SPICE software– 15Nos.
5. Components and Accessories: Resistors, Capacitors, diodes, Bread Boards, Op Amp, Digital Trainer kit Digital IC's, Transformers.
6. Circuit Simulation Software:(any public domain or commercial software)

Total Periods:	**30**

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	1	-	-	-	2	1	-	1	3	-	-
CO2	3	3	2	1	-	-	-	2	1	-	1	3	-	-
CO3	3	3	2	1	-	-	-	2	1	-	1	3	-	-
CO4	3	3	2	1	-	-	-	2	1	-	1	3	-	-
CO5	3	3	2	1	-	-	-	2	1	-	1	3	-	-
CO6	3	3	2	1	1	-	-	2	1	-	1	3	-	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231BM51	EMBEDDED SYSTEMS AND IoMT	L	T	P	C

				3	0	0	3
Programme:	**B.E. - Biomedical Engineering**			**Category:**			**PC**
AIM:	To equip students with skills in designing secure, real-time embedded and IoMT systems for healthcare applications.						

Course Outcomes: The Students will be able to

CO1:	Explain fundamental embedded systems design paradigms, architectures, challenges.
CO2:	Outline the hardware architecture, features of embedded microcontrollers with Peripherals.
CO3:	Explain the embedded system design using software tools.
CO4:	Analyze the various components of IoT Architecture.
CO5:	Design IoT Systems for real time applications.
CO6:	Develop the IoMT infrastructure for healthcare applications.

UNIT I-INTRODUCTION TO EMBEDDED SYSTEM DESIGN	9
Introduction to embedded processors- Application Areas- Categories of embedded processors-Challenges in Embedded System Design, Design Process- Requirements-Specifications-Hardware architecture- Software architecture-Introduction to Harvard & Von Neumann architectures-CISC & RISC Architectures. CPU Bus- Bus Protocols- Bus Organization, Memory Devices, and their Characteristics- RAM, EEPROM-Flash Memory-DRAM.	

UNIT II-PERIPHERAL INTERFACING	9
I/O Devices-Timers and Counters- Watchdog Timers, Interrupt Controllers- A/D and D/A, Interfacing- Memory interfacing with a case study- I/O Device Interfacing with case Study-Programmed IO-Memory Mapped IO, Interfacing Protocols-SPI, I2C, USB, CAN, Ethernet/Wi-Fi, Bluetooth.	

UNIT III-EMBEDDED SYSTEM SOFTWARE DESIGN	9
Application Software, System Software, Design techniques – State diagrams, sequence diagrams, flowcharts, Model-based system engineering (MBSE), embedded C Programming, Integrated Development Environment tools- Assembler.- Compiler-Linker- Debugger-Emulator, Factors affecting embedded software design.	

UNIT IV- DESIGN AND DEVELOPMENT OF IOT	9
Definition and characteristics of IoT, Technical Building blocks of IoT, Communication Technologies, Physical design of IoT - system building blocks - sensors and sensor Node and interfacing using any Embedded target boards (Raspberry Pi / Intel Galileo/ARM Cortex/ Arduino),Benefits and impact of IoMT. Cyber security – vulnerability, penetration & encryption technologies.	

UNIT V- INTERNET OF MEDICAL THINGS	9
Case studies – Novel Symmetrical Uncertainty Measure (NSUM) for Diabetes Patients, Healthcare Monitoring through Cyber-Physical Systems ,AdaBoost, Feature Selection and IoT for Cancer Mutation Analysis, Fuzzy-Based Expert System for Alzheimer's Disease Diagnosis.	

Total Periods:		45
Text Books:		
1. Embedded Systems – A Contemporary Design Tool, James K Peckol, John Weily, 2008, ISBN: 0- 444-51616-6.		
2. David Hanes, Gonzalo Saguaro, Patrick Grossetete, Rob Barton and Jerome Henry, "IoT		

Fundamentals: Networking Technologies, Protocols and Use Cases for internet of Things, Cisco Press, 2017.

3. VenkataKrishna, Sasikumar Gurumoorthy, Mohammad S.Obaidat, "lnternet of Things and Personalized Healthcare Systems", Springer Briefs in Applied Sciences, and Technology, Forensic and Medical Bioinformatics, 2019.

References:	

1. Introduction to Embedded Systems, Shibu K V, Tata McGraw Hill Education Private Limited, 2009, ISBN: 10: 00706787903.
2. Embedded Software Primer, David E.Simon, Addison Wesley, ISBN-13: 978-0201615692.
3. The Intel Microprocessors, Architecture, Programming and Interfacing" Barry B.Brey, 6th Edition, Pearson Education.
4. Arshdeep Bahga, Vijay Madisetti, "lnternet of Things – A hands-on approach", Universities Press, 2015.
5. Olivier Hersent, David Boswarthick, Omar Elloumi,"The Internet of Things – Key applications and Protocols", Wiley, 2012.
6. Jan Holler, Vlasios Tsiatsis, Catherine Mulligan, Stamatis, Karnouskos, Stefan Avesand. David Boyle, "From Machine-to-Machine to the Internet of Things – Introduction to a New Age of Intelligence", Elsevier, 2014.
7. Dieter Uckelmann, Mark Harrison, Michahelles, Florian (Eds), "Architecting the Internet of Things", Springer, 2011
8. Michael Margolis, Arduino Cookbook, "Recipes to Begin, Expand, and Enhance Your Projects", OReilly Media, 2nd Edition

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	-	2	-	2	1	1	1	3	-	-
CO2	3	2	1	1	2	2	-	2	1	1	1	3	-	2
CO3	3	2	1	1	2	2	1	2	1	1	1	3	-	2
CO4	3	2	1	1	2	2	1	2	1	1	1	3	-	2
CO5	3	2	1	1	2	2	1	2	1	1	1	3	-	2
CO6	3	2	1	1	2	2	1	2	1	1	1	3	-	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231BM52	DIAGNOSTIC AND THERAPEUTIC EQUIPMENT	L	T	P	C

				3	0	0	3
Programme:		**B.E.- Biomedical Engineering**			**Category:**		**PC**
AIM:		To Enhance healthcare delivery by providing tools that diagnose, monitor, and treat medical conditions with accuracy, efficiency, and safety.					

Course Outcomes: The Students will be able to

CO1:	Infer cardiac and neurological equipment to the patient.
CO2:	Outline the types of diathermy and its applications.
CO3:	Explain the concept of various extracorporeal devices in hospitals.
CO4:	Interpret the assistive system related to pulmonary functions.
CO5:	Explain the important functions of ultrasound and sensory equipments.
CO6:	Identify the importance of patient safety against electrical hazard.

UNIT I CARDIAC AND NEUROLOGICAL EQUIPMENT	9

ECG, Normal and Abnormal Waves, Heart rate monitor, PMS, Holter Monitor, Phonocardiography, ECG machine, Visual, Auditory and Somatosensory, MEG, Biotelemetry.

UNIT II DIATHERMY AND EXTRA CORPOREAL DEVICES	9

Diathermy-ESU, ultrasound, Microwave and short wave. Need for heart lung machine, functioning of bubble, disc type and membrane type oxygenators, finger pump, roller pump, electronic monitoring of functional parameters. Hemo Dialyser unit, Lithotripsy, Principles of Cryogenic technique and application, Endoscopy, Laparoscopy, Otoscopes, Oncology Thermography – Recording and clinical application.

UNIT III PULMONARY EQUIPMENTS	9

Spiro meter –Lungs Volume and vital capacity, measurements of residual volume, Pneumo tachometer–Airway resistance measurement, Whole body Plethysmograph, Intra-Alveolar and Thoracic pressure measurements, Apnoea Monitor. Types of Ventilators– pressure, Volume and Time controlled. Flow, Patient Cycle Ventilators, Humidifiers, Nebulizers, Inhalators.

UNIT IV ULTRASONIC EQUIPMENTS AND SENSORY EQUIPMENT	9

Diagnosis: Tissue Reaction, Basic principles of Echo technique, probes, display techniques A, B and M mode, B Scan, Application of ultrasound as diagnostic tools, Sensory responses-Audiometer-Puretone, Speech, Eye Tonometer, Applanation Tonometer, slit lamp, auto refractometer

UNIT V PATIENT SAFETY	9

Physiological effects of electricity – important susceptibility parameters – Macro shock – Microshock hazards – Patient's electrical environment – Isolated Power system – Conductive surfaces –Electrical safety codes and standards – IEC 60601-1 2005 standard, Basic Approaches to Protection against shock, Protection equipment design, Electrical safety analyser – Testing the Electric system

Total Periods:	45
Text Books:	

1. John G. Webster, "Medical Instrumentation Application and Design", 4th edition, Wiley IndiaPvtLtd,NewDelhi,2015

2. Joseph J. Carr and John M. Brown, "Introduction to Biomedical Equipment Technology",Pearsoneducation,2012

References:	

3. L.AGeddes and L.E.Baker,"Principles of Applied Biomedical Instrumentation",3rdEdition,2008

4. Khandpur. R.S., "Handbook of Biomedical Instrumentation". Second Edition Tata McGraw Hill Pub.Co., Ltd.2003.

5. AntonyY.K.Chan,"BiomedicalDeviceTechnology, Principles and design", Charles Thomas Publisher Ltd, Illinois, USA, 2008.

6. Leslie Cromwell, "Biomedical Instrumentation and Measurement", Pearson Education,NewDelhi,2007

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	-	-	-	-	2	-	-	-	-	2	3	3	-
CO2	3	-	-	-	-	2	-	-	-	-	2	3	3	-
CO3	3	-	-	-	-	2	-	-	-	-	2	3	3	-
CO4	3	-	-	-	-	2	-	-	-	-	2	3	3	-
CO5	3	-	-	-	-	2	-	-	-	-	2	3	3	-
CO6	3	-	-	-	-	2	3	-	-	-	2	3	3	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

		L	T	P	C
231BM53	**SIGNAL PROCESSING TECHNIQUES** **(Theory Cum Practical)**	**3**	**0**	**2**	**4**

Programme:	B.E- Biomedical Engineering	Category:	PC
AIM:	To study and analyze the characteristics of Continuous and Discrete signals, systems and Filters.		

Course Outcomes: The Students will be able to

CO1:	Explain the principles & properties of Signals and Systems.
CO2:	Analysis the discrete signals using Z and Discrete Time Fourier Transforms.
CO3:	Construct IIR filters for given specifications.
CO4:	Build FIR filters for given specifications.
CO5:	Interpret finite word length effects.
CO6:	Illustrate the architecture of various digital signal processors.

UNIT – I FUNDAMENTALS OF SIGNALS AND SYSTEMS	9
Basic signals, Classification of signals: continuous and Discrete signals - Periodic and Aperiodic signals, Deterministic and Random signals, Energy and power signals- Classification of Systems: Continuous and discrete systems, Linear, causal, stability, dynamic, time variance.	

UNIT – II ANALYSIS OF DISCRETE LTI SYSTEMS	9
Review of Fourier Transforms,- DTFT Analysis of Discrete Time LTI Systems - Z Transform - Properties of ROC– Inverse Z Transform .DFT and its properties, magnitude and phase representation-Linear Convolution -Circular Convolution-Correlation. FFT - Decimation in Time Algorithm, Decimation in Frequency Algorithm. Use of FFT in Linear Filtering.	

UNIT – III INFINITE IMPULSE RESPONSE FILTERS	9
Characteristics of practical frequency selective filters. characteristics of commonly used analog filters - Butterworth filters, Chebyshev filters. Design of IIR filters from analog filters (LPF, HPF, BPF, BRF) - Approximation of derivatives, Impulse invariance method, Bilinear transformation. Frequency transformation in the analog domain. Structure of IIR filter - direct form I, direct form II, Cascade, parallel realizations.	

UNIT – IV FIR FILTER DESIGN	9
Symmetric and Anti symmetric FIR filters - Linear phase FIR filter - Filter design using windowing techniques (Rectangular Window, Hamming Window, Hanning Window and Blackmann Windows), Frequency sampling techniques - Realization of FIR filters.	

UNIT – V FINITE WORD LENGTH EFFECTS AND DIGITAL SIGNAL PROCESSORS	9
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. Architecture of DSP chip TMS320C54x.	

Total Periods	**45**
LIST OF EXPERIMENTS	**15**
1. Simulate various signals with different Frequencies.	
2. Analyze the stability of a DT System with various inputs	
3. Analyze the stability of a CT System with various inputs.	
4. Reconstruct a signal from samples and study the effect of Aliasing.	
5. Linear and Circular convolution.	
6. Spectrum analysis using FFT.	
7. Design of IIR Filter.	
8. Design of FIR Filter.	

9.   Study the architecture of DSP chips – TMS 320C 5X/6X Instructions and its addressing modes

10.   Generation of sine, square and triangular waveforms

11.   Implementation of linear and circular convolution

	Total Period	**60**

Equipment required for 30 students	
1. Computers with MATLAB / Equivalent software- 15 Numbers	
2. TMS320C5416 Processors – 5 Numbers	
Text Books:	1. Allan V.Oppenheim, S.Wilsky and S.H.Nawab, "Signals and Systems", Pearson, Indian Reprint, 2nd EEdition, 2015. 2. John G Proakis and Manolakis, "Digital Signal Processing Principles, Algorithms and Applications", Pearson, 4th Edition, 2014.
References:	1. S.Haykin and B.Van Veen, "Signals and systems ", Wiley, 2nd Edition, 2009. 2. M.H.Hayes, "Digital Signal Processing, Schaum's outlines", Tata McGraw Hill, 2nd Edition, 2011.

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	3	2	2	-	-	2	-	-	2	1	-	-
CO2	3	3	3	2	2	-	-	2	-	-	2	1	-	-
CO3	3	3	3	2	2	-	-	2	-	-	2	1	-	-
CO4	3	3	3	2	2	-	-	2	-	-	2	1	-	-
CO5	3	3	2	2	2	-	-	2	-	-	2	1	-	-
CO6	3	3	2	2	2	-	-	2	-	-	2	1	-	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

		L	T	P	C
231BM57	**EMBEDDED SYSTEMS AND IOMT LABORATORY**	0	0	3	1.5
Programme:	**B.E – Biomedical Engineering**	**Category:**		**PC**	
AIM:	To study embedded processor architecture, biomedical I/O interfacing, and IoT				

	evolution in healthcare.	
Course Outcomes: The Students will be able to		
CO1:	Develop the application and implement in embedded target boards for real time applications	
CO2:	Develop basic embedded programs in IoT Platform using sensors and actuators.	
CO3:	Develop real time IoMT system for healthcare applications	
LIST OF EXPERIMENTS		

1. Explore AVR/ARM based controllers using Embedded C.

2. Write Basic and arithmetic Programs Using Embedded C.

3. Write Embedded C program to test interrupt and timers.

4. Develop Real time applications – clock generation, waveform generation, counter using embedded C.

5. Explore different communication methods with IoT devices.

6. To interface LED/Buzzer with platform/ Arduino /Raspberry Pi. and write an embedded C program to turn on / off LED/Buzzer with specified delay.

7. To interface DC/stepper motor using relay with open platform/ Arduino /Raspberry Pi. write an embedded C program to turn on motor if push button is pressed.

8. Develop simple application – testing infrared sensor – IoT Applications – using open Platform / Raspberry Pi.

9. Develop simple application to interface DHT11 sensor with and write a program to display temperature humidity readings in LCD.

10. Develop IoMT Application using open platform/ Arduino /Raspberry Pi. and sensors such as temperature, ECG, Pulse rate, ultrasound, Gas sensors etc.,

11. Deploy IoMT applications using platforms.

12. Mini Project.

	Total Periods : 30

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	1	3	-	-	-	3	3	1	1	2	-	3
CO2	3	2	1	1	3	-	-	-	3	3	1	1	2	-	3
CO3	3	2	1	1	3	-	-	-	3	3	1	1	2	-	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231BM58	**DIAGNOSTIC AND THERAPEUTIC EQUIPMENT LABORATORY**	**L**	**T**	**P**	**C**
		0	**0**	**3**	**1.5**
Programme:	**B.E.- Biomedical Engineering**	**Category:**			**PC**

AIM:	To provide hands-on experience and practical knowledge in the operation, maintenance, and application of medical devices used for diagnosis, treatment, and monitoring in healthcare.

Course Outcomes: The Students will be able to

CO1:	Measure the physiological signals using biomedical instruments.
CO2:	Record and interpret sensory and functional responses using specialized biomedical diagnostic devices.
CO3:	Analyze the working of Electosurgical, ultrasound and shortwave diathermy.
CO4:	Demonstrate the operation of life-support and imaging equipment.
CO5:	Perform essential safety checks and verify the proper functioning of critical biomedical equipment.

LIST OF EXPERIMENTS

1. Measure and identify the label of P,QRS and T waves by using ECG
2. Measurement of various physiological signals using biotelemetry.
3. Measurement of Oxygen Saturation and Heart Rate using Pulse-oximeter.
4. Measurement of visually evoked potential.
5. Analyze the working of ESU–cutting and coagulation modes.
6. Shortwave and Ultrasonic diathermy.
7. Measure the lung volume by using spirometer.
8. Study of ventilators and Ultrasound Scanners.
9. Recording of Audiogram.
10. Galvanic skin resistance (GSR) measurement.
11. Electrical safety measurements.
12. Study of hemodialysis model.
13. Study the working of Defibrillator and pacemakers.

Total Periods:	30

List of Equipments:
1. Galvanic skin resistance (GSR) Measurement-1 nos.
2. Shortwave and ultrasound diathermy-1 nos
3. EEG-1 NOS
4. Electrical Safety analyzer.
5. PMS-1
6. ESU-1
7. SPO2-1
8. Spirometer-1
9. ECG-1
10. Ultrasound scanner-1
11. Defibrillator
12. Audiometer

CO's- PO's & PSO's MAPPING

Course	Program Outcomes (POs)	Program Specific Outcomes (PSOs)

Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	1	1	-	2	-	-	1	1	3	-
CO2	3	2	1	1	1	1	-	2	-	-	1	1	3	-
CO3	3	2	1	1	1	1	-	2	-	-	1	1	3	-
CO4	3	2	1	1	1	1	-	2	-	-	1	1	3	-
CO5	3	2	1	1	1	1	-	2	-	-	1	1	3	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231BM61	MEDICAL IMAGE PROCESSING	L	T	P	C
		3	0	0	3
Programme:	**B.E. - Biomedical Engineering**	**Category:**		**PC**	

	AIM:	To provide students with the essential knowledge and skills to apply image processing techniques for analyzing and interpreting medical images in diagnostic and clinical settings.	
Course Outcomes: The Students will be able to			
CO1:		Apply image processing techniques for medical images.	
CO2:		Interpret the Medical image file formats	
CO3:		Apply frequency and time domain filters for medical images.	
CO4:		Analyze various segment and restoration techniques for medical application.	
CO5:		Apply the concept of registration, visualization for medical image analysis.	
CO6:		Apply the image compression techniques for medical applications.	

UNIT – I FUNDAMENTALS OF MEDICAL IMAGE PROCESSING AND TRANSFORMS	9
Overview of Image Processing system and human Visual system- Image representation – pixel and voxels, Gray scale and color models- Medical image file formats- DICOM, ANALYZE 7.5, NIFTI and INTERFILE- Discrete sampling model and Quantization- Relationship between the pixels, Image Transforms- 2D DFT, DCT.	
UNIT – II ENHANCEMENT TECHNIQUES	9
Gray level transformation- Log transformation, Power law transformation, Piecewise linear transformation. Histogram processing- Histogram equalization, Histogram Matching. Spatial domain Filtering-Smoothing filters, sharpening filters. Frequency domain filtering-Smoothing filters, Sharpening filters- Homomorphic filtering -Medical image enhancement using Hybrid filters- Performance measures for enhancement techniques.	
UNIT – III SEGMENTATION AND RESTORATION TECHNIQUES	9
ROI definition -Detection of discontinuities–Edge linking and boundary detection – Region based segmentation- Morphological processing, Active contour models. Image Restoration-Noise models– Restoration in the presence of Noise – spatial filtering, Periodic noise reduction by frequency domain filtering- linear position- Invariant degradation- Estimation of degradation function, Inverse filter, Weiner filtering.	
UNIT – IV REGISTRATION AND VISUALISATION	9
Registration–Rigid body transformation, principal axes registration, and feature based. Visualisation-Orthogonal and perspective projection in medicine, Surface based rendering, Volume visualization in medical image.	
UNIT – V APPLICATIONS OF MEDICAL IMAGE ANALYSIS	9
Medical Image compression- DCT and Wavelet transform based image compression, Pre-processing of medical images -Retinal images, Ultrasound –liver, kidney, Mammogram. Segmentation of ROI -blood vessels, lesions, tumour, lung nodules, feature extraction- shape and texture, Computer aided diagnosis system – performance measures (confusion matrix, ROC, AUC).	
Total Periods:	**45**
Text Books:	

1. Rafael C. Gonzalez and Richard E. Woods, Digital Image Processing, Pearson Education, 3rd edition, 2016.
2. Isaac N. Bankman, Handbook of Medical Image Processing and Analysis, 2nd Edition, Elsevier, 2009.
3. Wolfgang Birkfellner, Applied medical Image Processing: A Basic course, CRC Press, 2011.

References:	
1. AtamP.Dhawan, Medical Image Analysis, Wiley-Inter science Publication, NJ, USA 2003.
2. Rangaraj M. "Rangayyan, Biomedical Image Analysis", 1st Edition, CRC Press, Published December 30, 2004.
3. Joseph V.Hajnal, Derek L.G.Hill, David J Hawkes, "Medical image registration", Biomedical Engineering series, CRC press,2001
4. Milan Sonka, Image Processing, Analysis And Machine Vision, Brookes/Cole, Vikas Publishing House, 2nd edition, 1999.
5. Anil Jain K, Fundamentals of Digital Image Processing, PHI Learning Pvt. Ltd., 2011.

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	1	2	-	-	-	-	1	3	-	2
CO2	3	2	1	1	1	2	-	-	-	-	1	3	-	2
CO3	3	2	1	1	1	2	-	-	-	-	1	3	-	2
CO4	3	2	1	1	1	2	-	-	-	-	1	3	-	2
CO5	3	2	1	1	1	2	-	-	-	-	1	3	-	2
CO6	3	2	1	1	1	2	-	-	-	-	1	3	-	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231BM62	ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING FOR HEALTHCARE		L	T	P	C
			3	0	0	3

Programme:	B.E. - Biomedical Engineering	Category:	PC

AIM:	To provide knowledge and skills to develop AI and ML models and apply them to solve healthcare problems, improving diagnostics, treatment, and healthcare management.

Course Outcomes: The Students will be able to

CO1:	Outline the intelligent agents and problem solving in the artificial intelligence
CO2:	Construct the different kinds of models in probabilistic reasoning over time
CO3:	Analyze the various algorithms of supervised learning
CO4:	Analyze the statistics of datasets and select appropriate model to fit the data
CO5:	Apply AI techniques for system monitoring, fault detection, optimization, and intelligent human–machine interaction.
CO6:	Analyze advanced ML models to classify and predict medical conditions for clinical decision support.

UNIT – I INTRODUCTION TO ARTIFICIAL INTELLIGENCE	9

Definition –Artificial Intelligence – Characteristic of Intelligent Agents -Typical Intelligent Agents –Console based agents-Problem Solving Approach to Typical AI problems. Problem solving by Searching: Uninformed and informed strategies and implementation; Path planning; Constraint Satisfaction Problems (CSP).

UNIT – II PROBABILISTIC REASONING	9

Probabilistic Reasoning **-** The Semantics of Bayesian Network - Exact Inference in Bayesian Networks - Representing Knowledge in an Uncertain Domain - Inference in Temporal Models –Hidden Markov Models - Kalman Filters - Dynamic Bayesian Networks

UNIT – III SUPERVISED LEARNING	9

Introduction to machine learning – Linear Regression Models: Least squares, single & multiple variables, Bayesian linear regression, gradient descent, Linear Classification Models: Discriminant function – Probabilistic discriminative model - Logistic regression, Probabilistic generative model – Naive Bayes, Maximum margin classifier – Support vector machine, Decision Tree, Random forests.

UNIT – IV DEVELOPMENT OF ML MODEL	9

Steps in ML modeling, Data Collection, Data pre-processing, Model Selection, Model training (Training, Testing, K-fold Cross Validation), error backpropagation, Model evaluation (understanding and interpretation of confusion matrix, Accuracy, Precision, Recall, True positive, false positive etc.), Hyper parameter Tuning, Predictions. Characteristics of Deep Learning, Artificial Neural Network, Convolution Neural Network. Application of Reinforced and Deep Learning in Biomedical Engineering.

UNIT – V APPLICATIONS OF AI & ML IN HEALTHCARE	9

Human Machine Interaction, Predictive Maintenance and Health Management, Fault Detection, Dynamic System Order Reduction, Image based part classification, Process Optimization, Material Inspection, Tuning of control algorithms. Classifying cancer sub types using Clustering, Predicting Cardiovascular using Regression, Predicting diabetic Retinopathy using Decision Trees, Diagnosing breast cancer from biopsy images using Transfer Learning.

Total Periods:	45
Text Books:	

1. Stuart Russell and Peter Norvig, "Artificial Intelligence – A Modern Approach", Fourth Edition, Pearson Education, 2021.
2. Ethem Alpaydin, "Introduction to Machine Learning", MIT Press, Fourth Edition, 2020.

References:

1. Dan W. Patterson, "Introduction to Artificial Intelligence and Expert Systems", Pearson Education,2007
2. Kevin Night, Elaine Rich, and Nair B., "Artificial Intelligence", McGraw Hill, 2008
3. Patrick H. Winston, "Artificial Intelligence", Third Edition, Pearson Education, 2006
4. Deepak Khemani, "Artificial Intelligence", Tata McGraw Hill Education, 2013 (http://nptel.ac.in/)
5. Christopher M. Bishop, "Pattern Recognition and Machine Learning", Springer, 2006.
6. Tom Mitchell, "Machine Learning", McGraw Hill, 3rd Edition,1997.
7. Charu C. Aggarwal, "Data Classification Algorithms and Applications", CRC Press, 2014
8. MehryarMohri, AfshinRostamizadeh, AmeetTalwalkar, "Foundations of Machine Learning", MIT Press, 2012. Ian Goodfellow, YoshuaBengio, Aaron Courville, "Deep Learning", MIT Press, 2016

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	1	1	-	2	-	-	-	-	2	3	-	2
CO2	3	3	2	1	-	2	-	-	-	-	2	3	-	2
CO3	3	3	2	2	1	2	-	-	-	-	2	3	-	2
CO4	2	2	1	1	1	2	-	-	-	-	2	3	-	2
CO5	3	3	1	3	1	2	-	-	-	-	2	3	-	2
CO6	3	2	2	2	2	2	-	-	-	-	2	3	-	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231BM63		BIOCONTROL SYSTEMS	L	T	P	C
			3	0	0	3
Programme:		**B.E. - Biomedical Engineering**	**Category:**			**PC**
AIM:		To impart profound knowledge in understanding, analyzing, and applying system concepts to physiological systems.				

Course Outcomes: The Students will be able to

CO1:	Apply control-system concepts to find transfer functions and simplify physiological system models.
CO2:	Analyze physiological systems using open- and closed-loop control models.
CO3:	Analyze physiological models in transient response concepts.
CO4:	Apply time-domain analysis in first- and second-order systems.
CO5:	Analyze physiological systems using frequency-domain response methods.
CO6:	Apply stability analysis methods in physiological models.

UNIT I MODELLING & SYSTEM REPRESENTATION	**9**

Terminology and the basic structure of control system- Examples of open loop and closed-loop system - Transfer function - Reduction of block diagram and signal flow graph representation - Linear models of physiological systems.

UNIT II STATIC ANALYSIS	**9**

Open-loop versus closed-loops system - Block diagram representation of muscle stretch reflex model - Regulation of cardiac output- Cardiac output curve and venous return curve- Closed-loop analysis - Regulation of glucose-insulin - Chemical regulation of ventilation.

UNIT III TIME DOMAIN ANALYSIS	**9**

Electrical analogy of lung mechanics model- Transient response analysis of neuromuscular reflex model action-Time domain specifications-Transient response of first order model: impulse and step response-Transient response of second-order model: impulse and step response, Steady state error constants

UNIT IV FREQUENCY DOMAIN ANALYSIS	**9**

Frequency domain specifications, Bode plot, Polar plot, Constant M and N circles, Frequency response of circulatory control model

UNIT V STABILITY ANALYSIS	**9**

Stability analysis of Pupillary light reflex, Root locus method, Routh-Hurwitz stability criterion, Nyquist plot

Total Periods:	**45**

Text Books:	

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.
3. J. Nagarath and M. Gopal, Control Systems Engineering, New Age International Publishers, 1st September, 2018.

References:	

1. Kuo, B. C. (1995). Automatic control systems. India: Prentice Hall.
2. 1.Salivahanan S. Rengaraj R. and Venkatakrishnan G.R., Control Systems Engineering, Pearson Education India ,2015.
3. Dukkipati, R. V. (2006). Analysis and design of control systems using MATLAB.

India: New Age International.
4. Bishop, R. H. (1993). Modern control systems analysis and design using MATLAB. United Kingdom: Addison-Wesley.

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	3	3	-	2	-	-	-	-	1	3	2	-
CO2	3	3	3	3	-	2	-	-	-	-	1	2	1	-
CO3	3	3	3	3	-	2	-	-	-	-	1	3	2	-
CO4	3	3	3	3	-	2	-	-	-	-	1	3	2	-
CO5	3	3	3	3	-	2	-	-	-	-	1	3	2	-
CO6	3	3	3	3	-	2	-	-	-	-	1	2	1	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231BM67	MEDICAL IMAGE PROCESSING LABORATORY	L	T	P	C
		0	0	3	1.5
Programme:	**B.E. - Biomedical Engineering**	**Category:**			**PC**
AIM:	To enable students to apply and experiment with image processing techniques to design and implement applications for medical imaging analysis.				

Course Outcomes: The Students will be able to

CO1:	Apply basic image enhancement techniques in spatial and frequency domains.
CO2:	Implement segmentation, edge detection, and morphological operations.
CO3:	Design and demonstrate the medical image processing applications using image processing tool.

LIST OF EXPERIMENTS

   Simulation using MATLAB
1. Image Enhancement-Frequency domain filter
2. Image Enhancement-Spatial filter
3. Image Segmentation
4. Edge Detection
5. Continuity based Segmentation
6. Morphological operation
7. Image coloring
8. Image Registration
9. Image Reconstruction
10. Image Deblurring
11. DICOM Files

Total Periods:	**30**

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	2	-	-	-	3	1	1	1	2	2	3
CO2	2	2	2	2	2	1	-	3	1	1	1	2	-	3
CO3	2	2	2	2	2	1	-	3	1	1	1	2	-	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231BM68	MACHINE LEARNING PRACTICES LABORATORY	L	T	P	C
		0	0	3	1.5

Programme:	B.E-Biomedical Engineering	Category:		PC

AIM:	To be able to apply AI and machine learning algorithms to solve real world problems

Course Outcomes: The Students will be able to

CO1:	Apply various AI search algorithms
CO2:	Apply predictive and regression models for data-driven analysis.
CO3:	Develop classification models using Naïve Bayes, Decision Trees, KNN, and Random Forest.
CO4:	Build and train neural networks for pattern recognition tasks.
CO5:	Perform clustering using K-Means and Hierarchical methods for data segmentation.
CO6:	Apply machine learning techniques to develop disease prediction systems.

LIST OF EXPERIMENTS

1. Implementation of Uninformed (BFS, DFS) and informed search (A*, memory-bounded A*).
2. Implement model predictive.
3. Implement Naïve Bayes Classification in Python
4. Develop Decision Tree Classification model for a given dataset and use it to classify a new sample.
5. Build Artificial Neural Network model with backpropagation on a given dataset.
6. Build KNN Classification model for a given dataset.
7. Implement K means Segmentation Algorithm
8. Implement Random Forest Classifier
9. Implement Linear Discriminant Analysis
10. Implement Regression models and Regression tree.
11. Implement K-Means clustering Algorithm and Hierarchical Clustering.
12. Build SVM models in logistic Discrimination
13. Implement Machine learning algorithm to predict Heart disease

Total Periods:	30

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	3	3	3	-	-	3	2	-	2	2	-	3
CO2	3	3	3	3	3	-	-	3	2	-	2	2	-	3
CO3	3	3	3	3	3	-	-	3	2	-	2	2	-	3
CO4	3	3	3	3	3	-	-	3	2	-	2	2	-	3
CO5	3	3	3	3	3	-	-	3	2	-	2	2	-	3
CO6	3	3	3	3	3	-	-	3	2	-	2	2	-	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231BM69	MINI PROJECT/FIELD PROJECT		L	T	P	C
			0	0	3	1
Programme:	**B.E. - Biomedical Engineering**		**Category:**			EEC

Course Outcomes: The Students will be able to	
CO1:	Identify suitable problem in Biomedical Engineering field
CO2:	Design and develop a suitable solution for the problem.
CO3:	Prepare documentation of observed results and maintain team work.

Syllabus Content	
The students are required to search / gather the material / information on a specific a topic Comprehend it and present / discuss in the class. They can take up small problems in the field of design engineering as mini project. It can be related to solution to an engineering problem, verification and analysis of experimental data available, conducting experiments on various engineering subjects, studying a software tool for the solution of an engineering problem.	
Total Periods:	**45**

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	1	1	1	2	1	2	3	2	2	3	3	3
CO2	3	3	3	2	3	2	1	2	3	2	2	3	3	3
CO3	3	3	2	1	3	2	1	2	3	2	2	3	3	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231BM71	HOSPITAL PLANNING AND MANAGEMENT	L	T	P	C
		3	0	0	3
Programme:	B.E – Biomedical Engineering	Category:	PC		

Course Outcomes : The Students will be able to

CO1:	Explain the planning , management and challenges in hospital.
CO2:	Summarize the principles and functions of human resource management in hospital.
CO3:	Interpret the marketing systems and buyer behavior in the medical sector.
CO4:	Illustrate the hospital information systems and their role in support services.
CO5:	Infer quality systems, standards, and accreditation processes in healthcare.
CO6:	Outline the hospital safety, security, and health insurance management practices.

UNIT I OVERVIEW OF HOSPITAL ADMINISTRATION	9

Distinction between Hospital and Industry, Challenges in Hospital Administration –Hospital Planning – Equipment Planning- AMC – Functional Planning – Current Issues in Hospital Management – Telemedicine – Bio-Medical Waste Management

UNIT II HUMAN RESOURCE MANAGEMENT IN HOSPITAL	9

Principles of HRM – Functions of HRM – Profile of HRD Manager – Tools of HRD –Human Resource Inventory – Manpower Planning. Different Departments of Hospital, Recruitment, Selection, Training Guidelines –Methods of Training – Evaluation of Training – Leadership grooming and Training, Promotion – Transfer.

UNIT III MARKETING RESEARCH & CONSUMER BEHAVIOUR	9

Marketing information systems – assessing information needs, developing & disseminating information – Market Research process – Other market research considerations – Consumer Markets & Consumer Buyer behavior – Model of consumer behavior – Types of buying decision behavior – The buyer decision process – Model of business buyer behavior – Major types of buying situations – global marketing in the medical sector – WTO and its implications.

UNIT IV HOSPITAL INFORMATION SYSTEMS & SUPPORTIVE SERVICES	9

Management Decisions and Related Information Requirement - Clinical Information Systems - Administrative Information Systems - Support Service Technical Information Systems – Medical Transcription, Medical Records Department – Central Sterilization and Supply Department – Pharmacy– Food Services - Laundry Services.

UNIT V QUALITY AND SAFETY ASPECTS IN HOSPITAL	9

Quality system – Elements, implementation of quality system, Documentation, Quality auditing, International Standards ISO 9000 – 9004 – Features of ISO 9001 – ISO 14000 – ISO 13485, Environment Management Systems. NABA, JCI, NABL, NABH. Security – Loss Prevention – Fire Safety – Alarm System – Safety Rules. Health Insurance & Managing Health Care - Medical Audit – Hazard and Safety in a hospital Setup

Total Periods:	45
Text Books:	

1. G. D. Kunders, *Hospitals: Facilities Planning and Management*, McGraw Hill Education (India) Pvt. Ltd., New Delhi – 2019.
2. R. C. Goyal, "Hospital Administration and Human Resource Management",

PHI–4th Edition,2017.

3. Caceres, Cesar A. & Zara, Albert. *The Practice of Clinical Engineering*, Academic Press, New York — 2012 edition.

References:

4. Shortell & Kaluzny's Health Care Management: Organization, Design and Behavior — 7th Edition, edited by Lawton Burns, Elizabeth Bradley & Bryan Weiner. Publication date: 2019

5. Peter Berman,"Health Sector Reforming Developing Countries",Harvard University Press, 1995.

6. Norman Metzger,"Hand book of HealthCare Human Resources Management",Aspen Publication Inc. Rockville, Maryland, USA, 2nd Edition 1990.

7. Blane, David, Brunner, Eric , "Health and Social organization: Towards a health policy for the 21st century", Calrendon Press, 1994

CO's-PO's&PSO's MAPPING

Course Outcomes	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	-	-	-	1	-	-	-	-	-	1	1	-	-
CO2	3	-	-	-	1	-	-	-	-	-	1	1	-	-
CO3	3	-	-	-	1	-	-	-	-	-	1	1	-	-
CO4	3	-	-	-	1	-	-	-	-	-	1	1	-	-
CO5	3	-	-	-	1	-	-	-	-	-	1	1	-	-
CO6	3	-	-	-	-	-	1	-	-	-	1	1	-	-

1 -low,2-medium, 3-high,'-'-nocorrelation

231BM72	FUNDAMENTALS OF HEALTHCARE ANALYTICS	L	T	P	C
		3	0	2	4
Programme:	B.E – Biomedical Engineering	Category:		PC	

Course Outcomes : The Students will be able to

CO1:	Interpret the statistical distribution using appropriate software tool.
CO2:	Examine the statistical parameters using R/Python software.
CO3:	Solve the regression and correlation methods by using software.
CO4:	Explain the META analysis for research activities
CO5:	Analyze the experimental designs and META-analysis using variance testing in R/Python.
CO6:	Analyze epidemiological studies and biomedical case data for health interpretation

UNIT I INTRODUCTION	9

Computers and bio statistical analysis, Introduction to probability, likelihood & odds, distribution variability. Finding the statistical distribution using appropriate software tool like R/Python.

UNIT II STATISTICAL PARAMETERS	9

Statistical parameters p-values, computation, level chi square test and distribution and hypothesis testing-single population proportion, difference between two population proportions, single population variance, tests of homogeneity. Testing of statistical parameters using appropriate software R/Python.

UNIT III REGRESSION AND CORRELATION ANALYSIS	9

Regression model, evaluating the regression equation, correlation model, correlation coefficient. Finding regression, correlation for the data using appropriate software like R /Python

UNIT IV ANALYSIS OF VARIANCE	9

META analysis for research activities, purpose and reading of META analysis, kind of data used for META analysis, completely randomized design, randomized complete block design, repeated measures design, factorial experiment. Testing the variance using appropriate software tool like R /Python.

UNIT V CASESTUDIES	9

Epidemical reading and interpreting of epidemical studies, application in community health, Case study on Medical Imaging like MRI, CT. Case study on respiratory data, Case study on ECG data.

Total Periods:	45
Text Books:	

1. Wayne W. Daniel, Biostatistics-A Foundation for Analysis in the Health Sciences, John Wiley &Sons Publication,10th Edition,2013.
2. Peter Armotage, Geoffrey Berry and J.N.S.Mathews, Statistical methods in Medical Research,Wiley-Blackwell,4thEdition,2001.
3. Bernard Rosner. Fundamentals of biostatistics. Nelson Education, 8th Edition 2015 ISBN:978-1-305-26892-0

References:	

4. Marcello Pagano and Kimberlee Gauvreu, Principles of Biostatistics,Chapman and Hall/CRC,2ndEdition,2018.

5.	RonaldN	For	thofer	and	Eun	SulLee,Introduction
	toBiostatistics,AcademicPress,1stEdition,2014.					
6.	Animesh					K.Dutta,Basic
	BiostatisticsanditsApplications,NewCentralBookAgency,1stEdition,2006					

LIST OF EXPERIMENTS:

1. Analysis of Descriptive Statistics and Distribution of Biomedical Data using Python

2. **Probability, Likelihood, and Odds Computation for Diagnostic Data using Python**

3. **Statistical Distribution Fitting of Physiological Data using Python**

4. **Chi-Square Test for Categorical Biomedical Data using Python**

5. **Linear Regression Analysis for Physiological Parameter Prediction using Python**

6. **Correlation Analysis of Multi-Parameter Biomedical Data using Python**

7. **Meta-Analysis of Research Study Data with Effect Size Estimation using Python**

8. **Experimental Design Analysis (CRD/RCBD/Factorial Design) using Python**

Requirements:

Python, NumPy, Pandas, SciPy, Matplotlib

CO's-PO's&PSO's MAPPING

Course Outcomes	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	3	3	3	2	-	-	-	-	1	3	-	3
CO2	3	3	3	3	3	2	-	-	-	-	1	3	-	3
CO3	3	3	3	3	3	2	-	-	-	-	1	3	-	3
CO4	3	3	3	3	3	2	-	-	-	-	1	3	-	3
CO5	3	3	3	3	3	2	-	-	-	-	1	3	-	3
CO6	3	3	3	3	3	2	-	-	-	-	1	3	-	3

1 -low,2-medium, 3-high,'-'-nocorrelation

231BM79	PROJECT PHASE-I		L	T	P	C
			0	0	4	2
Programme:	**B.E – Biomedical Engineering**	**Category:**		EEC		

Course Outcomes: The students will be able to

CO1:	Analyze the societal/Industrial/Hospital problems either from rigorous literature survey or from the requirements raised from need analysis.
CO2:	Develop the prototype and simulation model using advanced technology tools.
CO3:	Paraphrase comprehensive report and present about the project work.

Syllabus Contents:

The project topic should be selected to ensure the satisfaction of the vital need to establish a direct link between education, national development and productivity and thus reduce the gap between the world of work and the world of study. The project should have the following

- Relevance to social needs of society
- Relevance to value addition to existing facilities in the institute
- Relevance to industry need
- Problems of national importance
- Research and development in various domain

The student should complete the following:
- Motivation for study and objectives
- Literature survey problem definition
- Preliminary design / feasibility / modular approaches
- Implementation and validation
- Presentation and Report preparation.

COURSE REQUIREMENTS:

In this course, students will work in groups of up to three members to identify a research problem and develop solutions by applying the knowledge gained up to the 6th semester. Each project team will be guided by an assigned faculty member, who will support and refine the project report. Throughout the semester, three project reviews will be conducted by a review committee consisting of the project guide and a senior faculty member nominated by the Head of the Department in the relevant project area. During these reviews, students must present their progress to the committee. At the end of the semester, students are required to submit the project report, and the final product must be demonstrated during the examination. The same review committee will award marks for the report and the viva-voce.

CO's-PO's&PSO's MAPPING

Course Outcomes	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	1	2	2	1	2	3	2	2	3	3	3
CO2	3	3	3	2	3	2	1	2	3	2	2	3	3	3
CO3	3	3	2	1	3	2	1	2	3	2	2	3	3	3

1 -low,2-medium, 3-high,'-'-nocorrelation

.

231BMIN	INTERNSHIP		L	T	P	C
			0	0	2	1
Programme:	**B.E – Biomedical Engineering**	**Category:**	**EEC**			

Course Outcomes: The students will be able to

CO1:	Demonstrate the organizational activity of the industry/organization
CO2:	Report the work and communicate effectively through technical presentation

1. Student shall undergo internship/implant training to an industry supervised by an expert.
2. A report should be submitted after the successful completion of internship / in-plant training.

Mode of Evaluation: Internship Report, Presentation and Project Review

CO's-PO's&PSO's MAPPING

Course Outcomes	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	1	2	2	1	2	3	2	2	3	3	3
CO2	3	3	3	2	3	2	1	2	3	2	2	3	3	3

1 -low,2-medium, 3-high,'-'-nocorrelation

231BM89	PROJECT PHASE-II		L	T	P	C
			0	0	16	8
Programme:	**B.E – Biomedical Engineering**	**Category:**	**EEC**			

Course Outcomes: The students will be able to

CO1:	Analyze the societal/Industrial/Hospital problems either from rigorous literature survey or from the requirements raised from need analysis.
CO2:	Develop the prototype and simulation model using advanced technology tools.
CO3:	Paraphrase comprehensive report and present about the project work.

Syllabus Contents:

The Project work II is based on

- Design, fabrication and analyzing of proposed research work.
- Experimental verification / Proof of concept.
- The viva-voce examination will be based on the above report and work

The students in a group of 3 to 4 works on a topic approved by the head of the department under the guidance of a faculty member and prepares a comprehensive project report after completing the work to the satisfaction of the supervisor. The progress of the project is evaluated based on a minimum of three reviews. The review committee may be constituted by the Head of the Department.

A project report is required at the end of the semester. The project work is evaluated based on oral presentation and the project report jointly by external and internal examiners constituted by the Head of the Department.

Total Periods:240

CO's-PO's&PSO's MAPPING

Course Outcomes	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	1	2	2	1	2	3	2	2	3	3	3
CO2	3	3	3	2	3	2	1	2	3	2	2	3	3	3
CO3	3	3	2	1	3	2	1	2	3	2	2	3	3	3

1 -low,2-medium, 3-high,'-'-nocorrelation

.

VERTICAL - I

231BMV11	COGNITIVE NEUROSCIENCE	L	T	P	C
		3	0	0	3
Programme:	**B.E. - Biomedical Engineering**	**Category:**			**PE**

AIM:	To gain the knowledge of neural and cognitive processes by using neuroanatomy.

Course Outcomes: The Students will be able to

CO1:	Explain the functional pathways of Neuroanatomy.
CO2:	Illustrate the mechanism of learning, control and loss of memory.
CO3:	Outline the process of sound, speech and music perception.
CO4:	Explain the levels of sleeping disorders.
CO5:	Illustrate the exceptional states of mind.
CO6:	Classify the various types of brain disorders.

UNIT – I A FRAMEWORK FOR MIND AND BRAIN	**9**

Consciousness, Cortical Core, Connectivity, and Consistency. Brain Function-Functional Neuroanatomy, Brain Pathways- Neuro connectivity, Brain Dynamics-Brain Rhythms and Oscillations.

UNIT – II LEARNING AND REMEMBERING	**9**

Episodic Learning and Memory, Memory Trace Formation and Consolidation, Memory Traces and Models, Control of Memory, Loss of memory.

UNIT – III SOUND, SPEECH, AND MUSIC PERCEPTION	**9**

Introduction, A Model for Sound Processing, Sound and Hearing Basics, Pathways to Auditory Cortex, Cortical Auditory Functions and Pathways, Speech and Music Perception.

UNIT – IV SLEEP AND LEVELS OF CONSCIOUSNESS	**9**

Introduction, Daily Rhythms for Sleep, Architecture of Sleep, Memory and Sleep, Dreaming, Sleep Disorders.

UNIT – V ATTENTION, CONSCIOUSNESS AND BRAIN DISORDERS	**9**

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 Periods:	45
Text Books:	

1. Marie T. Banich and Rebecca J. Compton "Cognitive Neuroscience" by (5th Edition) Published in 2023.
2. Baars B, Gage NM. "Fundamentals of cognitive neuroscience: a beginner's guide". Academic Press; 2018.
3. Michael S. Gazzaniga, "Cognitive Neuroscience" The MIT Press Cambridge, Massachusetts 4th Edition, 2009.

References:	

1. Eagleman D, Downar J. Brain and behavior: a cognitive neuroscience perspective. New York: Oxford University Press; 2016.
2. Passingham R. Cognitive neuroscience: a very short introduction. Oxford University Press; 2016

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	-	-	-	-	2	-	-	-	-	2	3	-	-
CO2	3	-	-	-	-	2	-	-	-	-	2	3	-	-
CO3	3	-	-	-	-	2	-	-	-	-	2	3	-	-
CO4	3	-	-	-	-	2	-	-	-	-	2	3	-	-
CO5	3	-	-	-	-	2	-	-	-	-	2	3	-	-
CO6	3	-	-	-	-	2	-	-	-	-	2	3	-	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231BMV12	PRINCIPLES OF TISSUE ENGINEERING	L	T	P	C
		3	0	0	3

Programme:	B.E. - Biomedical Engineering	Category:	PE

AIM:	To help students understand the basic principles of tissue engineering and how it can be applied in healthcare

Course Outcomes: The students will be able to

CO1:	Explain the mechanisms involved in interaction of cells.
CO2:	Outline the importance and fundamentals of tissue engineering.
CO3:	Classify the types of stem cells and its application.
CO4:	Compare the different tissue Engineering methods in biomaterials.
CO5:	Infer the various applications of replacement engineering.
CO6:	Classify the regenerative applications in tissue engineering.

UNIT – I INTRODUCTION TO CELL BIOLOGY	9

Cell types - Progenitor cells - Cell growth and differentiation - Cell culture: Expansion – Transfer-Storage and Characterization – Cell signaling molecules – Growth factors –Cell attachment: Differential cell adhesion, Receptor-ligand binding –Cell surface markers

UNIT – II FUNDAMENTALS OF TISSUE ENGINEERING	9

History and scope of tissue engineering – Tissue organization –Tissue types: Epithelial, Connective – Vascularity and angiogenesis – Extra Cellular Matrix: Matrix molecules and their ligands – Tissue culture– Materials in tissue engineering.

UNIT – III STEMCELLS	9

Definition of stem cells–Types of stem cells–Differentiation, de differentiation maturation, proliferation, pleuripotency and immortalization - Sources of stem cells: Hematopoietic – Fetal -cord blood – Placenta - Bone marrow - Primordial germ cells - Cancer stem cells – Induced pleuripotent stem cells.

UNIT – IV ENGINEERING METHODS AND DESIGN	9

Soft lithography -Self-assembled monolayer, Micro contact printing, Micro fluidic patterning-Laminar flow patterning - Cell interaction with Polymer scaffolds and gels - Polymer scaffolds fabrications: Electro spinning - Solvent casting and particulate leaching - Micro fabrication of cell seeded scaffolds.

UNIT – V APPLICATION OF TISSUE ENGINEERING	9

Replacement Engineering: Bone, cartilage, skin, blood, pancreas, kidney, heart valve and liver -Regenerative engineering: Peripheral Nerve regeneration, Cardiac tissue regeneration, Muscle regeneration – Regulation, Commercialization and Patenting.

	Total Periods:	45

Text Books:	

1. Robert P lanza, Robert Langer, Joseph Vacanti, "Principles of Tissue Engineering", Academic Press, UnitedStates, 2020.
2. Bernhard Palsson, Jeffrey A. Hubbell, Robert Plonsey, Joseph D. Bronzino , "Tissue Engineering", CRC Press, 2019.
3. Donglu Shi, Qing Liu, "Tissue Engineering and Nanotheranostics", World Scientific Publications, Singapore, 2018.

References:	

1. Bernhard O. Palsson and Sangeeta Bhatia, "Tissue Engineering" Prentice Hall, 2004.
2. Tissue Engineering: Engineering Principles for the Design of Replacement Organs

and Tissues, W.Mark Saltzman, Oxford University Press, 2004.

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	-	-	-	-	2	-	-	-	-	2	3	-	-
CO2	3	-	-	-	-	2	-	-	-	-	2	3	-	-
CO3	3	-	-	-	-	2	-	-	-	-	2	3	-	-
CO4	3	-	-	-	-	2	2	-	-	-	2	3	-	-
CO5	3	2	2	2	-	3	2	-	-	-	2	3	2	-
CO6	3	2	2	2	-	3	2	-	-	-	2	3	2	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231BMV13	BIOMEDICAL OPTICS AND PHOTONICS	L	T	P	C
		3	0	0	3

Programme:	B.E.-Biomedical Engineering	Category:	PE
AIM:	To provide an in-depth knowledge of optical instrumentation and biosensing techniques, the principles of light and its interaction with tissues, and the biomedical applications of lasers in diagnosis and therapy..		

Course Outcomes: The Students will be able to

CO1:	Apply basic light properties and optical tissue characteristics in biomedical applications.
CO2:	Interpret the working principles of light sources, optical detectors, and components
CO3:	Explain the principles, types and applications of optical biosensors.
CO4:	Outline the principles and biomedical applications of optical diagnostic techniques
CO5:	Summarize the principles and applications of lasers in medical fields
CO6:	Illustrate the laser-tissue interaction in photodynamic therapy and low-level laser therapy.

UNIT – I OPTICAL PROPERTIES	9

Basic principles of light - Reflection - Refraction - Absorption - Polarization - Interference - Coherence, Basic laws of light - Beer Lambert law - Snell's law, Optical properties of tissues -Absorption - Scattering - Anisotropy.

UNIT – II OPTICAL INSTRUMENTATION	9

Working principle of light sources - Lasers - LEDs, Working principle of optical detectors - Photodiode - Spectrometer - CMOS and CCD cameras - Lens - Optical filters - Optical fibers.

UNIT – III OPTICAL BIOSENSORS	9

Principles of Optical biosensing - Immobilization of bio-recognition elements, Types of optical biosensor - Fiber optic - Planar waveguide - Evanescent - Interferometric - Surface Plasmon resonance – Advantages and disadvantages - Applications.

UNIT – IV APPLICATIONS OF LASERS	9

Diagnostic - Optical coherence tomography, Fluorescence, Raman, Photoacoustic tomography,Laser induced breakdown spectroscopy (LIBS), Hyperspectral imaging. Surgical - Lasers in dentistry, Dermatology, Ophthalmology.

UNIT – V LASER TISSUE INTERACTION	9

Laser tissue interactions via photochemical, Photothermal, Photomechanical techniques, Photodynamic therapy (PDT) - Oncological and non-oncological applications, Low level laser therapy (LLLT) - Biostimulation applications.

	Total Periods:	45

Text Books:

1. Tuan Vo Dinh, "Biomedical Photonics –Handbook, CRC Press, Bocaraton, 2014.
2. Jurgen Popp, Valery V. Tuchin, Arthur Chiou and Stefen Heinemann, Handbook of Biophotonics, Vol 2: Photonics for Healthcare, John Wiley and Sons, 1st Edition, 2011.

References:	

1. Markolf H. Niemz, "Laser-Tissue Interaction Fundamentals and Applications" Springer, 2007.
2. Splinter R and Hooper B. A., "An Introduction to Biomedical Optics", Taylor and Francis, 2006.
3. Mark E. Brezinski, "Optical Coherence Tomography: Principles and Applications", Academic Press, 2006.
4. Paras N. Prasad, "Introduction to Biophotonics", A. John Wiley and sons, Inc. Publications, 2003

CO's- PO's & PSO's MAPPING

Course Outcomes	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO 1	3	-	-	-	-	-	-	-	-	-	2	2	-	-
CO 2	3	-	-	-	-	-	-	-	-	-	2	2	-	-
CO 3	3	-	-	-	-	-	-	-	-	-	2	2	-	-
CO 4	3	-	-	-	-	2	2	-	-	-	2	2	2	-
CO 5	3	-	-	-	-	2	2	-	-	-	2	2	2	-
CO 6	3	-	-	-	-	2	2	-	-	-	2	2	2	-

1: Slight (Low)   2: Moderate (Medium) 3: Substantial (High)

231BMV14		BIOMEMS		L	T	P	C
				3	0	0	3
Programme:	**B.E.- Biomedical Engineering**			**Category:**			**PE**
AIM:	To integrate biological and medical processes with microelectronics and micro fabrication technologies.						

Course Outcomes: The Students will be able to

CO1:	Interpret the various MEMS fabrication techniques.
CO2:	Explain the principles of various mechanical ,thermal sensors and actuators.
CO3:	Illustrate the various types of electrostatic, piezoelectric sensors and actuators.
CO4:	Relate the specified micro fluidic systems for respective operations
CO5:	Apply MEMS in different field of medicine
CO6:	Experiment with the bioelectronic systems using simulation tool.

UNIT – I MEMS MATERIALS AND FABRICATION	9

Semiconductor materials; photo lithography; doping; thin film growth and deposition; CVD and Ion Implantation, metallization; wet and dry etching; silicon micromachining; metal MEMS processes; submicron optical lithography; electron beam lithography; soft lithography and printing.

UNIT – II MECHANICAL AND THERMAL SENSORS AND ACTUATORS	9

Mechanical sensors and actuators – beam and cantilever –microplates, strain, pressure and flow measurements, Thermal sensors and actuators- actuator based on thermal expansion, thermo couples, thermistor, Shape memory alloys.

UNIT – III ELECTROSTATIC AND PIEZOELECTRIC SENSORS AND ACTUATOR	9

Electrostatic sensors and actuators- Inertia sensor, Pressure sensor, flow sensor, tactile sensor, comb drive. Piezoelectric sensor and actuator – inchworm motor, inertia sensor, flow sensor.

UNIT – IV MICROFLUIDIC SYSTEMS	9

Laminar flow in circular conduits, fluid flow in micro conduits, in sub micrometer and nanoscale. microfluidic components (filters, mixers, valves, and pumps).

UNIT – V APPLICATIONS OF BIOMEMS	9

CAD for MEMS, DNA sensor, MEMS based drug delivery, Biosensors- sensors for glucose, uric acid, and urea and triglyceride sensor. Introduction to the MATLAB/Simulink/ CAD tool for modeling/simulations of bioelectronic systems.

	Total Periods:	**45**

Text Books:	

1. TaiRanHsu, MEMS and Microsystems Design and Manufacture, Tata McGrawHill Publishing Company, New Delhi, 2017.
2. Wanjun Wang and Stephen A.Soper, BioMEMS:Technologies and Applications, CRC Press, NewYork, 2007.
3. Chang Liu, Foundations of MEMS, Pearson Education International, New Jersey, USA, 2011.
4. EllisMeng, Biomedical Microsystems, CRC Press, Boca Raton, FL, 2011.

References:	

1. P. Tabeling, S .Chen, Introduction to microfluidics, Oxford University Press, 2010.
2.AlokPandya ,Vijai Singh, Micro/Nanofluidics and Lab-on-Chip Based Emerging Technologies for Biomedical and Translational Research Applications - Part B, Academic

Press, 2022.

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	-	-	-	-	-	-	-	2	2	-	-
CO2	3	3	2	-	-	-	-	-	-	-	2	2	-	-
CO3	3	3	2	-	-	-	-	-	-	-	2	2	-	-
CO4	3	3	2	-	-	-	2	-	-	-	2	2	-	-
CO5	3	3	2	-	-	-	2	-	-	-	2	2	-	-
CO6	3	3	2	2	3	-	-	-	-	-	2	2	-	3

1: Slight (Low)   2: Moderate (Medium) 3: Substantial (High)

231BMV15		GENETIC ENGINEERING	L	T	P	C
			3	0	0	3
Programme:		**B.E. Biomedical Engineering**	**Category:**			**PE**
AIM:		To provide the fundamental knowledge on genetics, its laws, genes and chromosomes, inheritance, heredity, causes of genetic disorders and the methods of gene transfer.				

Course Outcomes: The Students will be able to

CO1:	Explain the principles and techniques of recombinant DNA manipulation.
CO2:	Illustrate the artificial chromosomes and DNA libraries.
CO3:	Outline the sequence and amplifications of DNA.
CO4:	Infer the sequencing techniques of genome.
CO5:	Identify the Gene expression and proteomics.
CO6:	Analyze genomic and proteogenomic data using functional and comparative genomics tools.

UNIT-I BASICS OF RECOMBINANT DNA TECHNOLOGY	9

Manipulation of DNA – Restriction and Modification enzymes - Design of linkers and adaptors -Characteristics of cloning and expression vectors - Introduction of recombinant DNA in to host cells and selection methods.

UNIT-II DNA LIBRARIES	9

Construction of genomic and c DNA libraries, Artificial chromosomes– Bacteria, Yeast-Chromosomal walking.

UNIT- III SEQUENCING AND AMPLIFICATION OF DNA	9

Maxam Gilbert's and Sanger's methods of DNA sequencing – PCR: Inverse PCR, Nested PCR, Allele specific PCR, Hot start PCR, Colony PCR, single cell PCR, Real-time PCR/qPCR – SYBR green assay, Taqman assay, Molecular beacons. Site directed mutagenesis.

UNIT- IV ORGANIZATION AND STRUCTURE OF GENOMES	9

Organization and structure of genomes - Genome sequencing methods: Conventional and shotgun genome sequencing methods, Next generation sequencing technologies - Ordering the genome sequence - Genetic maps and Physical maps, STS content based mapping, Hybridization mapping, Optical mapping.

UNIT-V CURRENT STATUS OF GENOME SEQUENCING PROJECTS	9

Introduction to Functional genomics – Microarrays - Serial Analysis of Gene expression (SAGE), Subtractive hybridization, Comparative Genomics, Proteogenomics, Web resources for Genomics, Applications of genome analysis and genomic.

	Total Periods:	45

Text Books:

1. S.B. Primrose and R.M. Twyman,Principles of Genome Analysis and Genomics, 3rd Edition, 2014.
2. Brown, T. A. (2021). Genomes 4 (4th ed.). Garland Science, an imprint of the Taylor & Francis Group.4th Edition, 2021.

References:

1. IsilAksanKurnaz, "Techniques in Genetic Engineering", CRCPress, 2015.
2. Oksana Ableitner, "Introduction to Molecular Biology: Working with DNA and RNA (essentials)", Springer International, 2022.

3. ArunK.Shukla, "Proteomics in Biology", Academic Press, 2017.

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	-	-	-	-	2	-	-	-	-	2	3	-	-
CO2	3	-	-	-	-	2	-	-	-	-	2	3	-	-
CO3	3	-	-	-	-	2	-	-	-	-	2	3	-	-
CO4	3	-	-	-	-	2	-	-	-	-	2	3	-	-
CO5	3	2	2	-	-	2	-	-	-	-	2	3	-	-
CO6	3	2	2	-	-	2	-	-	-	-	2	3	-	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231BMV16	REGENERATIVE MEDICINE	L	T	P	C
		3	0	0	3

Programme:	B.E.- Biomedical Engineering	Category:	PE

AIM:	To provide basics of regenerative medicine, including regeneration works, 3D bioprinting methods and the rules and challenges in this field.

Course Outcomes : The Students will be able to

CO1:	Illustrate the principles of regeneration and their types.
CO2:	Classify the different types of bioprinting used for regeneration.
CO3:	Outline the biomaterials used for different applications of regenerative medicine.
CO4:	Interpret the working principles of bioartificial organs in Therapeutic Applications.
CO5:	Explain the FDA regulatory process for biologics and regenerative medicine therapies.
CO6:	Summarize the key challenges in the standardization and regulation.

UNIT – I INTRODUCTION TO REGENERATION	9

An over view, Evolutionary perspective and origin of regeneration, Wound healing process, Repair Vs Regeneration, Tissue specificity, Types of regeneration - Regeneration by instrument, Regeneration by drug, Regeneration by materials, Regeneration by Bio printing, Regeneration and aging, Developmental clues in regeneration.

UNIT – II 3D BIOPRINTING TECHNIQUES	9

Definition and Principle, Technologies, Types of Bio printing - Pressure Assisted, Laser Assisted, AI-integrated, In Situ, Volumetric bioprinting, , Solenoid valve, Acousting, Applications - Cell Printing, Microvasculature Printing, Muscle Printing, Cartilage and Bone printing

UNIT – III BIOMATERIALS FOR REGENERATIVE MEDICINE	9

Design principles in biomaterials and scaffolds, Naturally occurring scaffolds materials - Collagen, Chitosan, synthetic polymers - Biodegradable, non-biodegradable, Surface modifications of biomaterials, Biocompatibility and bio response, Essential elements for wound for wound healing.

UNIT – IV THERAPEUTIC APPLICATIONS	9

Biomineralisation and Bone regeneration - scaffolds; Blood substitutes - biomaterials, cardiovascular biomechanics, Bioartificial liver - bioreactors, modelling, Tissue engineered vascular graft, Bioartificial kidney – Ultrafiltration membrane.

UNIT – V REGULATIONS AND STANDARDISATION	9

Overview of FDA Regulatory Process, The development and licensure process for biologics, Advancements in regenerative medicine, Challenges and Policy Options for Regenerative Medicine Technologies and Therapies - Challenges related to standardization, Challenges related to regulation, Challenges related to manufacturing.

Total Periods:	45

Text Books:	

1. Nishant Chakravorty, Praphulla Chandra Shukla, "Regenerative Medicine: Emerging Techniques to Translation", Springer Verlag, Singapore, 2023.
2. Birru Bhaskar, Naresh Kasoju, Parcha Sreenivasa Rao, "Biomaterials in Tissue Engineering and Regenerative Medicine: From Basic Concepts to State of the Art Approaches", Springer Verlag, Singapore, 2021.

References:	

1. Anthony Atala, Robert Lanza, James A. Thomson, Robert M. Nerem, "Principles of Regenerative Medicine", Elsevier, 3rd Edition - August 9, 2018.

2. Elisa Lottor, "The Miracles of Regenerative Medicine", Healing Arts Press, 2017.
3. Ancreas Lendlein, Antonios Mikos, LinShu Liu , Samir Mitragotri, "Advances in Material Design for Regenerative Medicine, Drug Delivery and Targeting/Imaging", Cambridge University Press; 1st edition, 2014.

CO's- PO's & PSO's MAPPING

Course Outcomes	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO 1	3	-	-	-	-	2	-	-	-	-	2	3	-	-
CO 2	3	-	-	-	-	2	-	-	-	-	2	3	-	-
CO 3	3	-	-	-	-	2	-	-	-	-	2	3	-	-
CO 4	3	-	-	-	-	2	-	-	-	-	2	3	2	-
CO 5	3	-	-	-	-	-	3	-	-	-	2	3	-	-
CO 6	3	-	-	-	-	-	3	-	-	-	2	3	-	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231BMV17	ARTIFICIAL ORGANS AND IMPLANTS	L	T	P	C
		3	0	0	3
Programme:	**B.E. - Biomedical Engineering**	**Category:**			**PE**
AIM:	To understand the principles and design of Implants and artificial organs.				

Course Outcomes: The Students will be able to

CO1:	Infer the knowledge about artificial organs & transplants.
CO2:	Illustrate the basic principles of implant design with a case study.
CO3:	Explain the implant design and its parameters and solution.
CO4:	Classify the various blood interfacing implants.
CO5:	Interpret the hard tissue and soft tissue replacements.
CO6:	Classify the technologies of bio printing in biomedical and regenerative medicine.

UNIT – I ARTIFICIAL ORGANS & TRANSPLANTS	9

Introduction, outlook for organ replacements, design consideration, evaluation process. TRANSPLANTS: - Overview, Immunological considerations, Blood transfusions, individual organs –kidney, liver, heart and lung, bone marrow, cornea.

UNIT – II PRINCIPLES OF IMPLANT DESIGN	9

Principles of implant design, Clinical problems requiring implants for solution, Permanent versus absorbable devices, the missing organ and its replacement, Tissue engineering, scaffolds, cells and regulator criteria for materials selection, Case study of organ regeneration.

UNIT – III IMPLANT DESIGN PARAMETERS AND ITS SOLUTION	9

Biocompatibility, local and systemic effects of implants, Design specifications for tissue bonding And modulus matching, Degradation of devices, natural and synthetic polymers, corrosion, wear and tear, Implants for Bone, Devices for nerve regeneration.

UNIT – IV BLOOD INTERFACING IMPLANTS, IMPLANT ABLE MEDICAL DEVICES AND ORGANS	9

Neural and neuro muscular implants, heart valve implants, heart and lung assist devices, artificial heart, cardiac pacemakers, artificial kidney-dialysis membrane and artificial blood. Gastro intestinal system, cranio facial replacement, recent advancement and future directions.

UNIT – V BIO-PRINTING	9

Definition, principle and component of bio-printing, Techniques- Extrusion-based, droplet based, Laser-based bio-printing, and 3D modeling software, Study of Bio-inks and properties, Applications and trends of bio-printing in tissue and organ.

	Total Periods:	**45**

Text Books:

1. Buddy D. Ratner, Allan S. Hoffman, et al.**"Biomaterials Science: An Introduction to Materials in Medicine"** (4th edition, 2020)
2. Dr. Yang Wu , Dr. Jerry Fuh Dr. Ibrahim T. Ozbolat, 3D Bio-printing in Tissue and Organ Regeneration, 2022.
3. Park J.B., "Biomaterials Science and Engineering", Plenum Press, 1984
4. Kopff W.J, Artificial Organs, John Wiley and sons, New York, 1st edition, 1976

References:	

1. Subrata Pal, Design Of Artificial Human Joints & Organs,Springer New York, NY-ISBN978-1-4614-6255-2(2014)
2. Biomedical Implants Materials, Design, and Manufacturing, Edited By Ravi K. Dwivedi, Premanand S. Chauhan, Avadesh K. Sharma, Madhavi Singh, Anupma AgarwalCopyright 2024
3. JDBronzino,   Biomedical   Engineering   handbook   VolumeII, (CRCPress/IEEEPress), 2000.
4. RSKhandpur, Hand book of Biomedical Instrumentation,TataMcGrawHill, 2003

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	-	-	-	-	1	1	-	-	-	2	2	2	-
CO2	3	2	2	2	-	1	1	-	-	-	2	2	2	-
CO3	3	2	2	2	-	1	1	-	-	-	2	2	2	-
CO4	3	-	-	-	-	1	1	-	-	-	2	2	2	-
CO5	3	-	-	-	-	1	1	-	-	-	2	2	2	-
CO6	3	2	2		-	1	1	-	-	-	2	2	2	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231BMV18	NEURAL ENGINEERING		L	T	P	C
			3	0	0	3

Programme:	B.E. - Biomedical Engineering	Category:	PE

AIM:	To understand the structure, function, and disorders of the nervous system, including neuronal diseases, nerve reconstruction, and rehabilitation strategies.

Course Outcomes: The Students will be able to

CO1:	Illustrate the neuron development, structure, communication, and supporting components.
CO2:	Explain the brain, brainstem, spinal cord structures and pathways.
CO3:	Identify the neuronal disorders, degeneration processes, and neural plasticity.
CO4:	Interpret the nerve conduction, brain activity, and neuroimaging techniques.
CO5:	Outline neural plasticity, neural regeneration, and tissue-engineering approaches.
CO6:	Apply advanced rehabilitation techniques including robotics, VR, and TMS.

UNIT – I BASICS OF NEURON	9

Nervous system development. Trophic factors, extra cellular matrix components in nervous system development. Neuron: structure – function – classification. Glial cells – myelination. Neurotransmitter – types and functions. Synapses - Transport of materials and impulse in neurons.

UNIT – II BRAIN, BRAIN STEM AND SPINAL CORD	9

Brain: structures – lobes – functional areas. Brain stem: structures – functional areas. Spinal cord: structure – functions. Concepts of nuclei – sensory and motor Tracts - Reticular formation. Blood supply to Brain and spinal cord.

UNIT – III NEURONAL DISEASES AND DISORDERS	9

Neuro degeneration: Degenerative, Demyelinated and injury related disorders associated with nervous system. Wallerian Degeneration. Neuronal plasticity – CNS acting drugs and their pharmacokinetics. Alzheimers, Parkinsons and Prion diseases

UNIT – IV NEUROPHYSIOLOGY & NEURORADIOLOGY	9

Physiology of nerve conduction. Peripheral nerves – structure & Functions. Synaptic transmission and cellular signaling of Neurons. Electrical activity of the Brain and recording of brain waves. Evoked potentials. Visualization of nervous system. Neuromotor-machine interface: human voluntary motor control system.

UNIT – V NERVE RECONSTRUCTION AND REHABILITATION	9

Neural plasticity; Neurological dysfunctions - Regeneration of the peripheral nervous system. Neural tissue engineering; Nerve graft; Drug delivery system in CNS. Rehabilitation: Mechanisms for Neuromotor rehabilitation; Robotics and virtual reality in physical therapy; Transcranial magnetic stimulation.

	Total Periods:	45

Text Books:

1. Mathews G.G., "Neurobiology", 2nd edition, Blackwell Science, UK, 2001.
2. Malcom Carpenter, "Textbooks of Neuroanatomy", Mc. Graw hill Edition, 1996

References:

1. W. Mark Saltzman, ―Tissue Engineering – Engineering principles for design of replacement organs and tissue‖, Oxford University Press Inc New York, 2004.
2. Park J.B., ―ACS Biomaterials Science and Engineering‖, Plenum Press, 2014. Saunders, 2006.

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	-	-	-	-	2	2	-	-	-	2	3	2	-
CO2	3	-	-	-	-	2	2	-	-	-	2	3	2	-
CO3	3	-	-	-	-	2	2	-	-	-	2	3	2	-
CO4	3	-	-	-	-	2	2	-	-	-	2	3	2	-
CO5	3	-	-	-	-	2	2	-	-	-	2	3	2	-
CO6	3	2	2	2	2	2	2	-	-	-	2	3	2	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

VERTICAL - II

231BMV21	MEDICAL INNOVATION AND ENTREPRENEURSHIP	L	T	P	C
		3	0	0	3

Programme:	B.E. - Biomedical Engineering	Category:	PE

AIM:	To create value through innovative products or services that meet specific market needs.

Course Outcomes: The Students will be able to

CO1:	Explain creativity and innovation in entrepreneurship with IPR and ethical responsibilities.
CO2:	Outline the scope for biomedical engineering entrepreneurship.
CO3:	Develop the business models, venture development, and forms of business organization.
CO4:	Interpret the funding needs and incentives in medical device entrepreneurship.
CO5:	Summarize the globalization's impact on medical product development and quality.
CO6:	Apply marketing research and industry analysis to develop venture strategies.

UNIT – I CREATIVITY, INNOVATION AND IPR	9

The role of creativity – The innovation Process – Sources of New Ideas – Methods of Generating Ideas – Creative Problem Solving – Entrepreneurial Process. Patents – Copyright - Trademark-Geographical indications– Ethical and social responsibility and challenges.

UNIT – II SCOPE FOR BIOMEDICAL ENGINEERING ENTREPRENEURSHIP	9

Definition–Characteristics and Functions of Entrepreneur–Common myths about entrepreneurs. Fundamentals and models, Advancements in biomedical field, medical Equipment system clearance, Supporting societies and professional activities. Impact of innovation in medical devices.

UNIT – III NEW VENTURE	9

Developing an Effective Business Model: The Importance of Business Model – Starting a small-scale industry - Components of an Effective Business Model. Assessing the venture, establish venture invention, market research, presenting the business plan. Forms of Business Organization: Sole Proprietorship – Partnership – Limited liability partnership-Joint Stock Companies and Cooperatives. Case study.

UNIT – IV FINANCING THE NEW VENTURE AND GLOBALIZATION	9

Evaluating Various options and future investments – Medical Device entrepreneurship incentives and subsidies–Determining Financial Needs–Sources of Financing: support for product development, funding agencies, collaborative initiatives, and angel investors. Impact of Globalization: Medical product manufacturing, marketing, leadership, quality management.

UNIT – V MARKETING FUNCTION	9

Industry Analysis – Competitor Analysis – Marketing Research for the New Venture – Defining the Purpose or Objectives – Gathering Data from Secondary Sources – Gathering Information from Primary Sources–Analyzing and Interpreting the Results–The Marketing Process. Case study.

	Total Periods:	45

Text Books:

| | 1. Jen-ShihLee "Biomedical Engineering Entrepreneurship", World Scientific Publishing, USA. 2010 |
| | 2. Vasant Desai, The Dynamic of Entrepreneurial Development and Management‖, HimalayaPublishingHouse,2010. |

References:

1. Brant Cooper, Patrick Vlaskovits, "The Lean Entrepreneur", Wiley, 2nd edition, New Jersy, 2016.
2. Nathan Furr, Jeff Dyer, "The Innovator's Method: Bringing the Lean Start-up into Your Organization", Harvard Business Press,Boston,2014.
3. Donald F.Kuratko and Richard M.Hodgetts, "Entrepreneurship", South-Western.
4. Gupta S.L., Arun Mittal, "Entrepreneurship Development", International Book House, 2012.
5. Prasanna Chandra, "Projects-Planning, Analysis, Financing, Implementation and review ‖,TATA Mc Graw Hill, 2012.
6. Sudha G. S., "Management and Entrepreneurship Development", Indus Valley Publication,2009.

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	-	-	-	-	2	-	2	2	2	3	1	-	-
CO2	3	-	-	-	-	2	-	2	2	2	3	1	-	-
CO3	3	-	-	-	-	2	-	2	2	2	3	1	-	-
CO4	3	-	-	-	-	2	-	2	2	2	3	1	-	-
CO5	3	-	-	-	-	2	-	2	2	2	3	1	-	-
CO6	3	2	2	1	-	2	-	2	2	2	3	1	-	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231BMV22	MEDICAL DEVICE REGULATIONS	L	T	P	C
		3	0	0	3

Programme:	B.E. - Biomedical Engineering	Category:	PE

AIM:	To prevent, diagnose, treat and rehabilitate illnesses and diseases in a safe and effective way.

Course Outcomes: The Students will be able to

CO1:	Explain the basic concepts of medical device regulations.
CO2:	Summarize the ISO standards for medical device quality and safety.
CO3:	Explain IEC, USA and European regulations.
CO4:	Outline the medical device regulatory system and key regulatory bodies in India.
CO5:	Infer the regulatory strategies and clinical trial processes.
CO6:	Illustrate digital health regulations and safety compliance.

UNIT – I	MEDICAL DEVICE REGULATIONS	9

History of medical device regulation, regulatory affairs professional's roles, required competencies, medical device classification: main classifications, Risk based classification, practical examples, labeling of medical devices: elements, risk management, clinical evaluation and labeling. Differentiating medical devices IVDs and combination products from pharmaceuticals.

UNIT – II	ISO STANDARDS	9

ISO13485:2016: Requirements for regulatory purposes: Quality Management Systems, certification process. ISO14971: Application of Risk management to medical Devices ISO 14155: Clinical Investigation of Medical Devices.

UNIT – III	IEC, REGULATORY SYSTEMS IN USA & EU	9

IEC international standards and conformity assessment for medical devices, Good submission process, medical device regulatory system in the USA and European Union.

UNIT – IV	INDIAN REGULATORY SYSTEM	9

Medical device regulatory system in India: market environment, functions undertaken by DGGI, central government, FDA and state governments, guidance documents, details of key regulators, IMDRF and CDSCO, regulatory overview in India, product registration on conformity assessment, quality system regulation, technical material and labeling requirements, commercial aspects.

UNIT – V	CLINICAL TRIALS AND DIGITAL REGULATIONS	9

Regulatory strategy and competitive advantage, Preclinical and Clinical Trial Design for Medical Devices in India; FDA approved devices, post-market surveillance/vigilance, Digital health regulations: Connected care, intelligent design control, reducing design time and cost with in-silico clinical trials, Regulatory bodies ensure ambulance safety, licensing, and healthcare compliance.

	Total Periods:	45

Text Books:

1. Medical Regulatory Affairs: An International Handbook for Medical Devices and Healthcare Products, 3rd Edition, Taylor & Francis Group, 2021.

References:

1. B.S. Dhillon, " Medical Device Reliability and Associated Areas", CRC Press, 2019.
2. Medical Device Design , Innovation from Concept to Market by Peter J. Ogrodnik 2nd Edition, 2020.
3. Product Safety in the European Union by Gabor Czitan, Attila Gutassy, Ralf Wilde,

TUV Rheinland Akademia, 2008.

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	-	-	-	-	3	3	1	-	-	2	2	-	-
CO2	3	-	-	-	-	3	3	1	-	-	2	2	-	-
CO3	3	-	-	-	-	3	3	1	-	-	2	2	-	-
CO4	3	-	-	-	-	3	3	1	-	2	2	2	-	-
CO5	3	-	-	-	-	3	3	1	-	-	2	2	-	-
CO6	3	-	-	-	-	3	3	1	-	-	2	2	-	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231BMV23	PRODUCT DESIGN ENGINEERING	L	T	P	C
		3	0	0	3
Programme:	**B.E.- Biomedical Engineering**	Category:		PE	
AIM:	To satisfy consumer demand and to cultivate, maintain and increase company's market share.				

Course Outcomes: The Students will be able to

CO1:	Explain the principles of generic product development process and planning based on customer needs.
CO2:	Illustrate the requirement engineering and system design concepts.
CO3:	Apply design, prototyping, testing and certification in product development.
CO4:	Outline the Innovation & Product Development process in the Business Context
CO5:	Interpret the product development processes and trade-offs in the engineering services industry.
CO6:	Summarize the role of IPR, confidentiality, and system integration in product development.

UNIT – I INTRODUCTION TO PRODUCT DESIGN	9

Characteristics of Successful Product development –Duration and Cost of Product Development – Challenges of Product Development - Product Development Processes and Organizations – Product Planning Process - Process of Identifying Customer Needs

UNIT – II REQUIREMENTS AND SYSTEM DESIGN	9

Requirement Engineering - Types of Requirements - Requirement Engineering - traceability Matrix and Analysis - Requirement Management - System Design & Modeling - Introduction to System Modeling-System Optimization- System Specification-Sub-System Design-Interface Design.

UNIT – III DESIGN AND TESTING	9

Conceptualization-Industrial Design and User Interface Design – Challenges in Integration of Engineering Disciplines - Concept Screening & Evaluation - Component Design and Verification – Mechanical, Electronics and Software Subsystems-High Level Design/ Low Level Design of S/W Program-Types of Prototypes, S/W Testing-Hardware Schematic, Component design, Layout and Hardware Testing - System Integration, Testing, Certification and Documentation.

UNIT – IV SUSTENANCE ENGINEERING AND END-OF-LIFE(EOL) SUPPORT	9

Introduction to Product verification processes and stages-Introduction to Product Validation processes and stages - Product Testing Standards and Certification - Product Documentation-Sustenance-Maintenance   and   Repair–Enhancements-Product   EoL-Obsolescence Management–Configuration Management-EoL Disposal.

UNIT – V BUSINESS DYNAMICS–ENGINEERING SERVICES INDUSTRY	9

The Industry-Engineering Services Industry-Product Development in Industry versus Academia –The IPD Essentials-Introduction to Vertical Specific Product Development processes Manufacturing/Purchase and Assembly of Systems - Integration of Mechanical, Embedded and Software Systems–Product Development Trade-offs-Intellectual Property Rights and Confidentiality– Security and Configuration Management.

	Total Periods:	**45**
Text Books:		

1. Karl T Ulrich and Stephen D Eppinger, "Product Design and Development", Tata McGraw Hill, Seventh Edition,2020.
2. John W Newstorm and Keith Davis, "Organizational Behavior", TataMcGrawHill, Twelfth Edition,2021.

References:
1. Fred R David, Forest R.David,Meredith E.David " Strategic Management: A Competitive Advantage Approach, Concepts and Cases", Pearson ,2025.
2. Vinod Kumar Garg and Venkita Krishnan N K, "Enterprise Resource Planning – Concepts", Second Edition, Prentice Hall, 2003.
3. Mark S Sanders and Ernest J Mc Cormick, "Human Factorsin Engineering and Design", McGraw Hill Education, Seventh Edition,2013

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	1	1	2	2	-	-	-	3	2	-	-
CO2	3	2	2	1	1	2	2	-	-	-	3	2	-	-
CO3	3	2	2	1	1	2	2	-	-	-	3	2	-	-
CO4	3	2	2	1	1	2	2	-	-	-	3	2	-	-
CO5	3	2	2	1	1	2	2	-	-	-	3	2	-	-
CO6	3	2	2	1	1	2	2	-	-	-	3	2	-	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231BMV24	RAPID PROTOTYPING	L	T	P	C
		3	0	0	3
Programme:	**B.E.- Biomedical Engineering**	**Category:**			**PE**

AIM:	To help engineers, mechanics, designers, etc understand, visualize, test, examine, monitor, and refine their ideas before their further production at a large scale

Course Outcomes: The Students will be able to

CO1:	Explain the principles, processes, and applications of additive manufacturing.
CO2:	Apply design tools and DFAM principles for developing additive manufacturing products.
CO3:	Illustrate the photopolymerization and powder bed fusion processes in additive manufacturing.
CO4:	Explain extrusion-based and sheet lamination processes.
CO5:	Interpret droplet formation and 3D printing processes in additive manufacturing.
CO6:	Outline the beam deposition techniques and their applications.

UNIT – I	INTRODUCTION	9

Overview –Need - Development of Additive Manufacturing Technology - Principle – AM Process Chain - Classification–Rapid Prototyping-Rapid Tooling–Rapid Manufacturing– Applications and Benefits.

UNIT – II	DESIGN FOR ADDITIVE MANUFACTURING	9

Design tools: Data processing - CAD model preparation – Part orientation and support structure generation –Model slicing –Tool path generation-Design for Additive Manufacturing: Concepts and objectives-AM unique capabilities –DFAM for part quality improvement- Customized design and fabrication form medical applications.

UNIT – III	PHOTO POLYMERIZATION AND POWDER BED FUSION PROCESSES	9

Photo polymerization: SLA- Photo curable materials–Process-Advantages and Applications. Powder Bed Fusion: SLS-Process description –powder fusion mechanism – Process Parameters –Typical Materials and Application. Electron Beam Melting.

UNIT – IV	EXTRUSION BASED AND SHEET LAMINATION PROCESSES	9

Extrusion Based System: FDM- Introduction– Basic Principle–Materials–Applications and Limitations –Bio extrusion. Sheet Lamination Process: LOM-Gluing or Adhesive bonding – Thermal bonding.

UNIT – V	PRINTING PROCESSES AND BEAM DEPOSITION PROCESSES	9

Droplet formation technologies –Continuous mode –Drop on Demand mode –Three Dimensional Printing –Advantages –Bio plotter -Beam Deposition Process: LENS-Process description –Material delivery–Process parameters –Materials –Benefits–Applications.

	Total Periods:	45

Text Books:

1. Chee Kai Chua.,Kah Fai Leong,''3D Printing and Additive Manufacturing: Principles and Applications",WorldScientificFifth Edition,2017.
2. Fuewen Frank Liou, " Rapid Prototyping and Engineering applications: A tool box for prototype development" CRC Press,2nd Edition 2019.
3. Kamrani A.K. and Nasr E.A., Rapid Prototyping: Theory and practice, Springer, 2006.

References:
1. Ian Gibson, David W. Rosen, Brent Stucker, Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, Springer, 2010.
2. Tom Page Design for Additive Manufacturing, LAP Lambert Academic Publishing, 2012.
3. Hilton, P.D. and Jacobs, P.F., Rapid Tooling: Technologies and Industrial Applications, CRC press, 2005.

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	-	-	2	2	-	-	-	2	1	-	-
CO2	3	2	2	-	2	2	2	-	-	-	2	1	-	2
CO3	3	2	2	-	-	2	-	-	-	-	2	1	-	-
CO4	3	2	2	-	-	2	-	-	-	-	2	1	-	-
CO5	3	2	2	-	-	2	2	-	-	-	2	1	-	-
CO6	3	2	2	-	-	2	-	-	-	-	2	1	-	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231BMV25	PATIENT SAFETY, STANDARDS AND ETHICS	L	T	P	C
		3	0	0	3

Programme:	B.E. - Biomedical Engineering	Category:	PE

AIM:	To provide comfort and prevent and relieve suffering.

Course Outcomes: The Students will be able to

CO1:	Outline the importance of patient safety against electrical hazards.
CO2:	Classify the patient safety laws and regulations
CO3:	Summarize the standards and testing of electric system in patient safety
CO4:	Infer the concept of the patient safety in clinical specialties
CO5:	Explain the scope of ethics in medicine.
CO6:	Apply the concept of ethics in healthcare organization.

UNIT – I EFFECTS OF ELECTRICITY	9

Physiological effects of electricity-important susceptibility parameters-micro shock-macro shock hazards -patient's electrical environment-isolated power system –conductive surfaces

UNIT – II PATIENT SAFETY LAWS AND REGULATIONS	9

Mandatory Reporting systems. Anatomy of a patient safety Law: Compliance Tips, Federal patient safety Legislation Initiatives, Medical Device Reporting, Clinical trials and Adverse-Event Reporting, Patient safety Goals and standards, The Quality Assessment and performance Improvement rule.

UNIT – III STANDARDS AND TESTING	9

Guidelines and safety practices to improve patient safety, Electrical safety codes and standards -IEC 60601-1 2005 standard, Basic Approaches to protection against shock, protection equipment design, Electrical safety analyzer-Testing the electric system

UNIT – IV PATIENT SAFETY IN MAIN CLINICAL SPECIALITIES	9

Intensive care and Anesthesiology, safety surgery save lives, Emergency department clinical risk, Obstetric safety patient, Patient safety in internal medicine, Patient safety in Radiology.

UNIT – V MEDICAL ETHICS	9

Definition of Medical ethics, Scope of ethics in medicine, American medical Association code of ethics, CMA code of ethics-Fundamental Responsibilities, The Doctor and The Patient, The Doctor and The Profession, Professional Independence, The Doctor and Society, Case Studies.

	Total Periods:	45

Text Books :

1.John Webster, "Medical Instrumentation Application and design", 4th edition, Wiley India Pvt Ltd, New Delhi, 2015.

2.Liam Donaldson, Walter Riccardo, "Textbook of patient safety and clinical Risk management", Springer 2021.

3.Fay A.Rozovsky, James R.Woods, Jr, "The Hand book of Patient Safety Compliance", 2016.

References:

1.Physical Environment online: A Guide to the Joint Commission's Safety Standards is published by HCPro, Inc., 2010.

2.Joint Commission Accrediation Standards for Hospitals, 2nd Edition, 2003.

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	-	-	-	-	2	3	-	-	-	2	2	-	-
CO2	3	-	-	-	-	2	3	-	-	-	2	2	-	-
CO3	3	-	-	-	-	2	3	-	-	-	2	2	-	-
CO4	3	-	-	-	-	2	3	-	-	-	2	2	-	-
CO5	3	-	-	-	-	2	3	-	-	-	2	2	-	-
CO6	3	-	-	-	-	2	3	-	-	-	2	2	-	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231BMV26	QUALITY CONTROL FOR MEDICAL DEVICES	L	T	P	C
		3	0	0	3

Programme:	B.E Biomedical Engineering	Category:	PE

AIM:	To equip learners with the knowledge and skills needed to ensure the safety, efficacy, and compliance of medical devices with international quality systems and regulatory frameworks.

Course Outcomes: The Students will be able to

CO1:	Explain the concepts of quality control of an organization.
CO2:	Outline the various quality management principles and good management practices.
CO3:	Identify the various tools of quality control.
CO4:	Infer the various quality management tools.
CO5:	Classify the standards of medical device for safety and quality management.
CO6:	Outline the roles of FDA, ASTM, CE marking, and IEC in medical device regulation.

UNIT – I INTRODUCTION TO QUALITY	9

Quality: Terminologies-Dimensions of Quality-Quality Planning- Total Quality Management Basic concepts -Principles of TQM-Leadership – Concepts-Role of Senior Management-Quality Council-Quality Statements- Strategic Planning- Barriers to TQM Implementation.

UNIT – II TQM PRINCIPLES	9

Customer satisfaction – Customer Perception of Quality-Customer Complaints-Service Quality Customer Retention-Employee Involvement-Motivation-Empowerment-Teams-Team Work Recognition and Reward- Performance Appraisal.

UNIT – III STATISTICAL PROCESS CONTROL	9

The seven tools of quality-Cause-and-effect diagram-Check sheet-Control chart-Histogram Pareto chart-Scatter diagram- -Stratification- Six sigma.

UNIT – IV TQM TOOLS	9

Benchmarking-Reasons to Benchmark-Benchmarking Process-Quality Function Deployment (QFD-House of Quality- QFD Process –Total Productive Maintenance (TPM) –-FMEA-Stages of FMEA.

UNIT – V STANDARDS FOR MEDICAL DEVICES	9

Standards-Need Types-Medical device safety-medical device quality management systems requirements-ISO 9000:2000 Quality System-Clauses-FDA-Functions-ASTM International-CE marking-IEC-Specifications.

	Total Periods:	45

Text Books:

1. Ross J.E., *Total Quality Management Text, Cases, and Readings*, Third Edition, E-book, Taylor & Francis, 2017.
2. Shanmugam P.S.T., Nandakumar Palani, Thamizharsan Sampath, *Medical Device Guidelines and Regulations Handbook*, 2022.
3. Giuseppe Ioppolo, Cristina Ciliberto, Katarzyna Szopik-Depczyńska, *Total Quality Management and Lean Thinking 5.0 – Theories and Methods*, 1st Edition, 2025.

References:

1. Bhavana S. Karmore, *Elements of Electronics Instrumentation and Measurement*, LAP LAMBERT Academic Publishing, 2020.

2. Jerrold T. Bushberg, John M. Boone, *The Essential Physics of Medical Imaging*, 3rd ed., Lippincott Williams & Wilkins, 2011.

CO's- PO's & PSO's MAPPING

Course Outcomes	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO 1	3	-	-	-	-	2	2	-	-	-	2	2	-	-
CO 2	3	-	-	-	-	2	2	-	-	-	2	2	-	-
CO 3	3	-	-	-	-	2	2	-	-	-	2	2	-	-
CO 4	3	-	-	-	-	2	2	-	-	-	2	2	-	-
CO 5	3	-	-	-	-	2	2	-	-	-	2	2	-	-
CO 6	3	-	-	-	-	2	2	-	-	-	2	2	-	-

1: Slight (Low)   2: Moderate (Medium) 3: Substantial (High)

231BMV27	ELECTRICAL SAFETY AND QUALITY ASSURANCE	L	T	P	C
		3	0	0	3
Programme:	B.E.-Biomedical Engineering	Category:		PE	

AIM:	To provide knowledge and insight into the procedures used in quality control and assurance activities as well as safety measures to be followed in hospitals.

Course Outcomes:

CO1:	Explain the concept of electrical hazards.
CO2:	Interpret national electrical safety codes and statutory requirements.
CO3:	Explain the hazardous area classifications and related equipment standards.
CO4:	Infer the electrical protection, safety, maintenance and CPR.
CO5:	Summarize the quality management and assurance practices in hospital.
CO6:	Outline the regulations and accreditation requirements in hospitals.

UNIT – I ELECTRICAL HAZARDS	9
Review of Electrical concept, Electrostatic – Electro magnetism – Electrical Hazards – Energy leakage – Clearance and insulation– Current surges – Electrical causes of fire and explosion –Human interface with electricity – Human resistance to electricity.	

UNIT – II STANDARDS AND REQUIREMENTS	9
National electrical Safety code - Standards and statutory requirements – Indian electricity acts and rules – statutory requirements from Electrical inspectorate. Hazardous area classification and classification of electrical equipments for hazardous areas (IS, NFPA, API and OSHA standards).	

UNIT – III ELECTRICAL PROTECTION AND MAINTENANCE	9
Selection of Environment, Protection and Interlock – Discharge rods and earthing device – Safety in the use of portable tools - Preventive maintenance. First aid-cardio pulmonary resuscitation(CPR).	

UNIT – IV STANDARDIZATION OF QUALITY MEDICAL CARE IN HOSPITALS	9
Overview of Quality- Need for Standardization & Quality Management, QM in Health care organization ,Quality assurance methods, QA in (Medical Imaging & Nuclear medicine) Diagnostic services –Classification of equipments.	

UNIT – V REGULATORY REQUIREMENT FOR HEALTH CARE	9
CE and FDA regulations, Accreditation for hospitals-JCI, NABH and NABL, Other regulatory Codes.	

Total Periods:	45

Text Books:	

1. B.M.Sakharkar, Principles of Hospital administration and Planning, JAYPEE Brothers, Medical Publishers (P) Ltd.
2. Cesar A. Cacere & Albert Zana, The Practice of Clinical Engineering. Academic press, New York, 1977.

References:	

1. Webster J.G and Albert M.Cook, Clinical Engg, Principles & Practices, Prentice Hall Inc., Engle wood Cliffs, New Jersy, 1979.
2. Karen Parsley, Karen Parsley Philomena Corrigan" Quality improvement in Healthcare, 2nd edition,Nelson Thrones Pub, 2002
3. Sharon Myers "Patient Safety & Hospital Accreditation - A Model for Ensuring Success"

Springer Publishers 2012
4. Joseph F Dyro "Clinical Engineering Handbook" Elsevier Publishers, 2004

CO's- PO's & PSO's MAPPING

Course Outcomes	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	-	-	-	-	2	2	-	-	-	2	2	-	-
CO2	3	-	-	-	-	2	2	-	-	-	2	2	-	-
CO3	3	-	-	-	-	2	2	-	-	-	2	2	-	-
CO4	3	-	-	-	-	2	2	-	-	-	2	2	-	-
CO5	3	-	-	-	-	2	2	-	-	-	2	2	-	-
CO6	3	-	-	-	-	2	2	-	-	-	2	2	-	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231BMV28	TESTING AND TROUBLESHOOTING OF MEDICAL DEVICES	L	T	P	C
		3	0	0	3
Programme:	B.E -Biomedical Engineering	Category:			PE

AIM:	To gain the knowledge and skills to find and fix problems in medical devices for safe use in hospitals.

Course Outcomes: The Students will be able to

CO1:	Outline basic troubleshooting methods and types of faults.
CO2:	Summarize the grounding issues and electrical hazards in medical devices.
CO3:	Infer the active and passive components for faults using standard tools.
CO4:	Explain the troubleshooting and preventive maintenance techniques for diagnostic equipments.
CO5:	Illustrate troubleshooting and preventive maintenance techniques for therapeutic equipments.
CO6:	Illustrate troubleshooting and preventive maintenance techniques for surgical equipments.

UNIT – I BASIC TROUBLESHOOTING TECHNIQUES & PROCEDURES	9

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

UNIT – II GROUNDING SYSTEMS	9

Importance of grounding-different types of grounding ,Electrical Hazards – Causes ,Types of electrical shock , Corrective Action to repair the Equipment - Tools & Aids for Servicing & Maintenance, Importance of electrical safety in a medical environment.

UNIT – III TROUBLESHOOTING ACTIVE AND PASSIVE COMPONENTS	9

Basic testing of Passive components: Resistors, capacitors ,Inductors. Testing of Active components: PN Diodes, Zener Diodes, NPN and PNP transistor -Testing of FET Methods - Typical op-amp based medical circuits - Fault diagnosis in op-amp circuits - Digital IC Troubleshooter: Logic clip, Logic probe - Logic pulser, Logic current tracer.

UNIT – IV TROUBLESHOOTING OF DIAGNOSTIC EQUIPMENTS	9

Troubleshooting of ECG Machine & its preventive maintenance – Troubleshooting of EEG Machine & its preventive maintenance - Troubleshooting of X-ray Machine & its preventive maintenance   - Troubleshooting of endoscope & its preventive maintenance - Troubleshooting of Ultrasound system & its preventive maintenance - Troubleshooting of Pulse oximeter & Sphygmomanometers.

UNIT – V TROUBLESHOOTING OF THERAPEUTIC & SURGICAL EQUIPMENTS	9

Troubleshooting of Defibrillator & its preventive maintenance - Troubleshooting of Electrosurgical unit & its preventive maintenance - Troubleshooting of Incubator & its preventive maintenance   -Troubleshooting of Suction apparatus & its preventive maintenance - Troubleshooting of Anaesthesia Machine & its preventive maintenance - Troubleshooting of Nebulizer Machine & its preventive maintenance - Trouble shooting of Radiation Monitors-Troubleshooting of sterilizers-Autoclaves & its preventive maintenance

	Total Periods:	45

Text Books:	

1. Joseph D Bronzino & Donald R Peterson, "Medical Devices and Human Engineering", CRC Press, 4th Edition, 2015.
2. Myer Kutz, "Biomedical Engineering and Design Handbook- Volume 2: Applications", McGraw-Hill, 2nd Edition, 2009.
3. Richard Fries, "Reliable Design of Medical Devices", CRC Press, 3rd Edition, 2012.
4. Elizabeth A. Cudney, Tina Kanti Agustiady., " Design for Six Sigma: A Practical Approach through Innovation", CRC Press; 1st edition, 2016.
5. John J Tobin & Gary Walsh, "Medical Product Regulatory Affairs- Pharmaceutical, Diagnostics, Medical Devices",Wiley-Blackwell, 2nd Edition, 2023.
6. Jack Wong and Raymond K Y Tong, "Handbook of Medical device regulatory affairs in Asia", Pan Stanford Publishing Pte. Ltd., 2nd Edition, 2018.
7. Sudeep Singh K, " Trouble Shooting & Maintenance of Electronic Equipments", S.K.Kataria & Sons, Reprint -2024.
8. Dan Tomal & Neal Widmer, "Electronic Troubleshooting", McGraw Hill, 3rd edition, 2014.

References:	

1. "Medical Device Regulations Global overview and guiding principles", World Health Organization Geneva, 2012.
2. Michael Jay Geier, "How to Diagnose and Fix Everything Electronic, Third Edition, McGraw-Hill ,2024.
3. P. V. Kumar , " Fundamentals of Medical Electronics ", White Falcon Publishing , 2024.
4. Jayet Moon, Arun Mathew" Mastering Safety Risk Management for Medical and In Vitro Devices, ASQ Quality Press,2024

CO's- PO's & PSO's MAPPING

Course Outcomes	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO 1	3	-	-	-	-	2	2	-	-	-	2	3	-	-
CO 2	3	-	-	-	-	2	2	-	-	-	2	3	-	-
CO 3	3	-	-	-	-	2	2	-	-	-	2	3	-	-
CO 4	3	-	-	-	-	2	2	-	-	-	2	3	3	-
CO 5	3	-	-	-	-	2	2	-	-	-	2	3	3	-
CO 6	3	-	-	-	-	2	2	-	-	-	2	3	3	-

1: Slight (Low)   2: Moderate (Medium) 3: Substantial (High)

VERTICAL - III

231BMV31	PHYSIOLOGICAL MODELLING	L	T	P	C
		3	0	0	3

Programme:	B.E-Biomedical Engineering	Category:	PE

AIM:	To equip the students with the knowledge and tools to analyze biological systems using mathematical and computational models.

Course Outcomes: The Students will be able to

CO1:	Explain the basics of Physiological models.
CO2:	Describe the methods and techniques for analysis of dynamic system
CO3:	Describe Nonlinear models of physiological systems.
CO4:	Develop differential equations to describe the compartmental physiological model.
CO5:	Demonstrate the various physiological systems using software
CO6:	Develop model of physiological system.

UNIT I- INTRODUCTION TO PHYSIOLOGICAL MODELING	9

Approaches to modeling: The technique of mathematical modeling, classification of models, characteristics of models. Time invariant and time varying systems for physiological modeling. Introduction to physiology (homeostasis, cell biology) Modeling physical systems, linear models of physiological systems, the Laplace transform, Transfer functions and block diagram analysis Physiology.

UNIT II- MODELING OF DYNAMIC PHYSIOLOGICAL SYSTEM	9

Dynamic systems and their control, modeling and block diagrams, the pupil control systems (Human Eye), general structure of control systems, the dynamic response characteristics of the pupil control system, open & close loop systems instability ,automatic aperture control.

UNIT III- NON LINEAR MODELS OF PHYSIOLOGICAL SYSTEMS	9

Nonparametric Modelling- Volterra Models. Wiener Models. Efficient Volterra Kernel Estimation. Parametric Modelling – Basic Parametric Model Forms and Estimation Procedures-Volterra Kernels of Non linear Differential Equations. Discrete- Time Volterra Kernels of NARMAX Models.

UNIT IV- COMPARTMENTENTAL PHYSIOLOGICAL MODEL	9

Modeling the body as compartments, behavior in simple compartmental system, pharmacokinetic model, and multi compartmental system. Physiological modeling: Electrical analogy of blood vessels, model of systematic blood flow and model of coronary circulation. Mathematical modeling of the system: Thermoregulation of cold bloodedness& warm bloodedness.

UNIT –V SIMULATION OF PHYSIOLOGICAL SYSTEMS	9

Simulation of physiological systems using Open CV / MATLAB software. Biological receptors: -Introduction, receptor characteristics, transfer function models of receptors, receptor and perceived intensity. Neuromuscular model, Renal System, Drug Delivery Model

	Total Periods:	45

Text Books:	

1. Michel C Khoo, "Physiological Control Systems -Analysis, simulation and estimation", PrenticeHall ofIndia,2001.
2. Marmarelis, "Nonlinear Dynamic Modeling of Physiological Systems", Wiley-IEEEPress,2004.

References:	

1. BenjaminCKuo, "Automatic control systems", Tenth Edition, McGraw- Hill Education, 2017.
2. MinruiFei, Shiwei Ma, Xin Li, Xin Sun, Li Jia and Zhou Su, "Advanced Computational Methods in Life System Modeling and Simulation", Springer,2017
3. David T West wick, Robert E. Kearney, Identification of Nonlinear Physiological Systems,Wiley-IEEEPress,2003

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	2	-	2	-	-	-	-	2	3	-	-
CO2	3	2	2	2	-	2	-	-	-	-	2	3	-	-
CO3	3	2	2	2	-	2	-	-	-	-	2	3	-	-
CO4	3	2	2	2	-	2	-	-	-	-	2	3	-	-
CO5	3	2	2	2	2	2	-	-	-	-	2	3	-	2
CO6	3	2	2	2	-	2	-	-	-	-	2	3	-	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231BMV32	BIOFLUIDS AND DYNAMICS	L	T	P	C
		3	0	0	3
Programme:	**B.E.- Biomedical Engineering**	**Category:**			**PE**
AIM:	To study the mathematical modeling of fluid biological system.				

Course Outcomes: The Students will be able to

CO1:	Analyze the biofluids with its properties.
CO2:	Develop mathematical models of biofluids.
CO3:	Explain the mechanics of cellular and ocular system.
CO4:	Explain the rheology of blood and mechanics of blood vessels.
CO5:	Explain the concept of fluid mechanics.
CO6:	Apply the computational fluid dynamics for biological system.

UNIT – I BIOFLUID MECHANICS	9

Basic fluid properties: Density, Viscosity, Compressibility, Surface Tension - Fluid motion: Shear stress, Bernoulli's equation, Reynolds number, Poiseuille's law - Blood flow: Velocity, Pressure, Resistance, Newtonian and Non-Newtonian behavior - Viscoelastic fluids: Models and biological examples (mucus, saliva, synovial fluid)

UNIT – II CELLULAR AND OCCULAR MECHANICS	9

Cell Structure & Mechanics: Eukaryotic cell architecture, Cytoskeleton, Cell-matrix interactions-Measurement Techniques: AFM, Optical Trapping, Magnetic Beads, Micropipette Aspiration- Biomechanical Models: Cellular behavior models, Chondrocyte modeling, Mechanotransduction-Tissue Mechanobiology: Endothelial, Smooth Muscle Cells, Chondrocytes, Osteoblasts- Ocular Biomechanics: Eye anatomy, Glaucoma biomechanics, Ocular blood flow

UNIT – III BLOOD RHEOLOGY AND BLOOD VESSEL MECHANICS	9

Blood Components & Properties: Elements, Viscosity, Einstein's and Casson's equations-Red Cell Mechanics: Membrane biomechanics, Apparent & relative viscosity-Microcirculation: Blood rheology in microvessels, Fahraeus-Lindquist effect - Vessel Mechanics: Blood vessel anatomy, Arterial wall loading (uniaxial, biaxial, torsion) - Hemodynamics: Large artery flow, Ventricular outflow, Pressure-flow relationship, Vascular impedance

UNIT – IV CARDIO RESPIRATORY MECHANICS AND SPACE MEDICINE	9

Cardiac Cycle: Pressure-volume diagram, Ventricular performance, Valvular disease, Prosthetic valves - Respiratory System: Lung volumes, Mechanics & work of breathing, Gas exchange, Oxygen dissociation curve, Lung compliance, Pulmonary pathologies - Space Medicine: Hypoxia, Decompression sickness.

UNIT – V COMPUTATIONAL FLUID DYNAMICS	9

CFD Basics: CFD code and problem-solving approach - Core Concepts: Conservation laws, Boundary conditions, Turbulence modeling - Numerical Methods: Finite Volume Method (diffusion, convection-diffusion, unsteady flows) - Solution Techniques: Pressure-velocity coupling, Discretized equation solving - Applications: Cardiac flow modeling, Virtual cardiography.

	Total Periods:	**45**

Text Books:	

1. Krishnan B. Chandran, Ajit P. Yoganathan, Stanley E. Rittgers, ―Biofluid Mechanics- The human circulation‖, CRC Taylor and Francis, 2012.

	2.	Y.C Fung, ―Biomechanics- Mechanical properties of living tissues‖, 2nd Edition, Springer-Verlag, 1993.
	3.	Jeffery R. Davis et. Al., ―Fundamentals of Aerospace Medicine‖, Wolter Kluwer Health, Lippincott Williams and Wilkins, 2008
References:		
	1.	Jung HeeSeo, Vijay Vedula, Theodore Abraham and Rajat Mittal, ―Multiphysics computational models for cardiac flow and virtual cardiography‖, Int. J. Numer. Meth. Biomed. Engng. (2013) Published online in Wiley Online Library
	2.	Lee Waite, Jerry Fine, ―Applied Biofluid Mechanics‖, McGraw Hill, 2007
	3.	John K-J Li, ―Dynamics of Vascular System‖, World Scientific, 2004
	4.	C. Ross Ethier, Craig A Simmons, ―Introduction to Biomechanics- From Cells to Organisms‖, Cambridge Texts in Biomedical Engineering, 2007
	5.	H K Versteeg, W Malalasekera, ―An Introduction to Computational Fluid Dynamics The Finite Volume Method‖, Longman Scientific and Technical, 1995

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	2	-	2	-	-	-	-	2	3	-	-
CO2	3	2	2	2	-	2	-	-	-	-	2	3	-	-
CO3	3	2	2	2	-	2	-	-	-	-	2	3	-	-
CO4	3	2	2	2	-	2	-	-	-	-	2	3	-	-
CO5	3	2	2	2	-	2	-	-	-	-	2	3	-	-
CO6	3	2	2	2	-	2	-	-	-	-	2	3	-	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231BMV33	ERGONOMICS	L	T	P	C
		3	0	0	3

Programme:	B.E.- Biomedical Engineering	Category:	PE

AIM:	To create safe, comfortable and protective workspaces.

Course Outcomes: The Students will be able to

CO1:	Explain the principles of ergonomics in visual, auditory system.
CO2:	Describe muscle physiology for human posture
CO3:	Explain the arrangement, design of displays and controls.
CO4:	Apply ergonomic principles to the creation of safe, healthy, and efficient workplace.
CO5:	Illustrate anthropometrics design principle for an individual work space .
CO6:	Outline the ergonomics concept in the biomedical applications.

UNIT – I VISUAL AND AUDITORY ERGONOMICS	9

Process of seeing – visual capabilities – factors affecting visual acuity and contrast sensitivity – human factor aspects of hard copy text and computer screen text, factors in selecting graphic representations symbols, qualitative visual display – process of hearing – principles of auditory display. Measures for monitoring control & mitigation.

UNIT – II MUSCLE PHYSIOLOGY	9

Muscle physiology – muscle metabolism – respiratory response – joint motion study – measure of physiological in-efficiency and energy consumption – work rest cycles – aspects of manual and posture study, material handling (MMH) Bio-mechanical recommended limits of MMH.

UNIT – III CONTROLS AND DISPLAYS	9

Spatial compatibility and physical arrangement of displays and controls - Design of displays and controls–movement capability–rotary controls and rotor displays movement of displays orientation of the operator and movement relationships control orders and control responses – human limitations in tracking task.

UNIT – IV ANTHROPOMETRY	9

Anthropometry – anthropometric design principles – Physical work load and energy expenditure -work space envelope – factors in design of work space surfaces – principles of seat design – principles of control panel. ergonomic implications. Organization classification of human errors theories of accident causation-reducing accidents by altering behavior

UNIT – V CASE STUDIES	9

Case Study 1: Computer design, control panel design of an electronic instrument, computer keyboard, hand drill etc.
Case Study2: Biomedical Application, Design optimization of Medical Equipment

	Total Periods:	45

Text Books:	

1. Pascale Carayon,"Handbook of Human Factors and Engineering", Second Edition, CRC Press,2017
2. MartinHelander,"GuidetoHumanFactorsandErgonomics",SecondEdition,CRC Press,2005 Benjamin W. Niebel ,"Motion and Time Study", Richard, D.IrwinInc., SeventhEdition,2002

References:	

1.Shrawan Kumar, Biomechanics in Ergonomics, Second Edition, CRC Press 2007.
2.George Kanawaty, "Introduction to work study", ILO,3rd edition, Oxford & IBH publishing,2001 Stephen Pheasant, Christine M.Haslegrave, Bodyspace: Anthropometry, Ergonomics and the Design of Work,CRC Press,2005.

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	-	-	-	-	2	-	-	-	-	2	3	-	-
CO2	3	-	-	-	-	2	-	-	-	-	2	3	-	-
CO3	3	-	-	-	-	2	-	-	-	-	2	3	-	-
CO4	3	-	-	-	-	2	2	-	-	-	2	3	-	-
CO5	3	-	-	-	-	2	-	-	-	-	2	3	-	-
CO6	3	-	-	-	-	2	2	-	-	-	2	3	-	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231BMV34	BIOMIMETICS	L	T	P	C
		3	0	0	3

Programme:	B.E.-Biomedical Engineering	Category:	PE
AIM:	To bridge biology and technology, encouraging students to apply principles observed in nature to solve real-world scientific and engineering challenges.		

Course Outcomes: The Students will be able to

CO1:	Explain the basic mechanism in biomimetic design in various applications
CO2:	Interpret the basic biologically inspired mechanism, materials and process
CO3:	Compare the mechanism of cognition and open ended design automation
CO4:	Outline the importance bio-inspired sensors and biomimetic actuators
CO5:	Infer the biomechanics and rhythmics of motion
CO6:	Classify the application of biomimetic technologies

UNIT – I INTRODUCTION TO BIOMIMETICS	9

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

UNIT – II MECHANISM OF COGNITION AND OPEN ENDED DESIGN AUTOMATION	9

Cognition: Language, Sound, Visual processing - Machine Evolution: Evolving bodies, brains, and controllers - Morphology Representations: Tree, Developmental, Regulatory networks - Physical Implementation: Evolving machines, Design automation principles - Design & Research: Economy of design, Research methodology

UNIT – III BIO-INSPIRED SENSORS AND BIOMIMETIC ACTUATOR	9

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

UNIT – IV BIOMIMETICS OF MOTION	9

Actuation: Passive & active (external/internal), Control centers- Agonist Mechanisms: Hygroscopic, Muscular - Antagonist Mechanisms: Spring, Muscular - Hydrostatic Systems: Single & multiple compartments - Locomotion: Gait, Passive, Limbless, and Multi-limb movement

UNIT – V APPLICATION OF BIOMIMETIC TECHNOLOGIES	9

Symbolic Connectionism: Localist, Distributed, Biological models - Neuro-Fuzzy Systems - Bio-Inspired Technologies: Adhesion, Locomotion, Size and technology constraints - Quadruped Robots: Mechanical and electrical components - Bio-Inspired Antennas: Array and beam pattern design.

	Total Periods:	45

Text Books:	

1. Yoseph Bar-Cohen, "BIOMIMETICS Biologically Inspired Technologies", CRC Press, 1st Edition, 2006.
2. Trung Dung Ngo, "Biomimetic Technologies: Principles and Applications", Wood

	head Publishing Ltd, 1st Edition, 2015.
References:	
	1. Sandra Persiani, "Biomimetics of Motion: Nature-Inspired Parameters and Schemes for Kinetic Design",Springer, 1st Edition, 2019.
	2. P Gruber, D Bruckner, C Hellmich, · H B. Schmiedmayer, H. Stachelberger, I C. Gebeshuber, "Biomimetics– Materials,Structuresand ProcessesExamples, Ideas and Case Studies", Springer, 1st Edition, 2011

CO's- PO's & PSO's MAPPING

Course Outcomes	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO 1	3	2	2	-	-	2	2	-	-	-	2	3	-	-
CO 2	3	2	2	-	-	2	2	-	-	-	2	3	-	-
CO 3	3	2	2	-	-	2	-	-	-	-	2	3		-
CO 4	3	2	2	-	-	2	-	-	-	-	2	3	-	-
CO 5	3	2	2	-	-	2	-	-	-	-	2	3	-	-
CO 6	3	2	2	-	-	2	2	-	-	-	2	3	-	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231BMV35	**BIOMECHATRONICS**		L	T	P	C
			3	0	0	3
Programme:	**B.E.-Biomedical Engineering**		**Category:**		**PE**	
AIM:	To explore biomechanics, bio-sensors, medical measurements, assistive devices, and prosthetics in healthcare applications.					

Course Outcomes: The Students will be able to

CO1:	Explain the principles of biomechanics, biomedical signal processing, and bio-image analysis for medical applications.
CO2:	Interpret the concept of bio-mechatronics, electrodes, and biological measurements.
CO3:	Outline the principle of heart rate, pulmonary function, and physiological measurements using medical devices.
CO4:	Explain the principles and applications of sensory assist devices.
CO5:	Describe the design and functionality of wearable mechatronic devices.
CO6:	Infer the principles, design, and control of active and passive prosthetic systems.

UNIT – I BIO MECHANICS AND SIGNAL PROCESSING	**9**

Cardiovascular biomechanics, Musculoskeletal and orthopedic biomechanics, human ergonomic, Rehabilitation. Bio-medical signals, Signal acquisition and signal processing-Isolation barriers, Bio-image processing.

UNIT – II BIO SENSORS AND ACTUATORS	**9**

Introduction to Bio mechatronics, Electrodes - Types, - Measurement of blood pressure - Blood Gas analyzers: pH of blood, Smart actuators for biological applications

UNIT – III MEDICAL MEASUREMENTS	**9**

Heart rate - Heart Sound - Pulmonary Function Measurements – Spirometer-Fingertip oximeter - ESR, GSR Measurements

UNIT – IV SENSORY ASSIST DEVICES & WEARABLE MECHATRONICS	**9**

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 – V ACTIVE AND PASSIVE PROSTHETIC LIMBS	**9**

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 Periods:	**45**

Text Books:	

1. Graham M. Brooker, Introduction to Bio-Mechatronics, Sci Tech Publishing, 2012.

References:	

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.

CO's- PO's & PSO's MAPPING

Course Outcomes	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO 1	3	-	-	-	-	2	2	-	-	-	2	3	-	-
CO 2	3	-	-	-	-	2	2	-	-	-	2	3	-	-
CO 3	3	-	-	-	-	2	2	-	-	-	2	3	2	-
CO 4	3	-	-	-	-	2	2	-	-	-	2	3	2	-
CO 5	3	-	-	-	-	2	2	-	-	-	2	3	2	-
CO 6	3	-	-	-	-	2	2	-	-	-	2	3	2	-

1: Slight (Low)   2: Moderate (Medium)   3: Substantial (High)

231BMV36	REHABILITATION ENGINEERING	L	T	P	C
		3	0	0	3

Programme:	B.E. Biomedical Engineering	Category:		PE

Aim: To study the orthopaedic and prosthetics in rehabilitation.

Course Outcomes: The Students will be able to

CO1:	Explain the basic concepts of rehabilitation and the roles of the rehabilitation team.
CO2:	Interpret the basic concepts of sensory augmentation.
CO3:	Explain the different sensory assist devices, orthotics and prosthetics for rehabilitation applications
CO4:	Outline the virtual reality tools for different aids.
CO5:	Illustrate the legal aspects for building rehabilitation aids for the needed people.
CO6:	Summarize the concepts for future development and applications in Rehabilitation engineering

UNIT I INTRODUCTION	9

Definition - Impairments, disabilities and handicaps, Primary and secondary disabilities, Activities of daily living, Appropriate Technology, Residual function. Rehabilitation. Rehabilitation team – members and their functions. Rehabilitation care –Need for proper delivery of rehabilitation care, Community based rehabilitation and its aspects.

UNIT II ENGINEERING CONCEPTS IN SENSORY REHABILITATION ENGINEERING	9

Sensory augmentation and substitution- Visual system: Visual augmentation, Tactual vision substitution, and Auditory vision substitution. Auditory system- Auditory augmentation, Hearing aids, cochlear implants, visual auditory substitution, tactual auditory substitution. Tactual system- Tactual augmentation, Tactual substitution, Computerized wheel chairs.

UNIT III ORTHOPEDIC PROSTHETICS AND ORTHOTICS IN REHABILITATION	9

Engineering concepts in motor rehabilitation, Artificial limbs- body powered, externally powered and controlled orthotics and prosthetics, Myoelectric hand and arm prosthetics. Functional Electrical Stimulation systems-Restoration of hand function, restoration of standing and walking, Hybrid Assistive Systems (HAS).

UNIT IV VIRTUAL REALITY IN REHABILITATION	9

Introduction to virtual reality, Virtual reality based rehabilitation, Hand motor recovery systems with Phantom haptics, Robotics and Virtual Reality Applications in Mobility Rehabilitation.

UNIT V REHABILITATION MEDICINE AND ADVOCACY	9

Physiological aspects of Function recovery, Psychological aspects of Rehabilitation therapy, Legal aspect available in choosing the device and provision available in education, job and in day-to-day life.

Total Periods:	
	45

Text Books:	

1. Joseph D Bronzino, "The Biomedical Engineering Handbook". 2nd edition, CRC Press,2000.
2. Robinson C.J, "Rehabilitation Engineering", CRC Press , 2006.

References:	

1. Sashi S Kommu, "Rehabilitation Robotics", 1st edition, CRC Press, 2007.
2. Sunder, "Textbooks of Rehabilitation", Jaypee Brothers Medical Publishers Pvt. Ltd, New Delhi,

2nd Edition, Reprint 2007.

3. Horia- Nocholai Teodorecu, L.C.Jain, "Intelligent systems and technologies in rehabilitation Engineering", CRC; December 2000.

4. Etienne Grandjean, Harold Oldroyd, "Fitting the task to the man", Taylor & Francis,1988.

5. Keswick. J., "what is Rehabilitation Engineering, Annual Reviews of Rehabilitation", Springer-Verlag, New York, 1982.

6. Warren E. Finn, Peter G. Lopressor, "Handbook of Neuroprosthetic Methods",CRC, 2002.

7. Rory A Cooper (Editor), Hisaichi Ohnabe (Editor), Douglas A. Hobson (Editor), "An Introduction to Rehabilitation Engineering (Series in Medical Physics and Biomedical Engineering" CRC Press, 2006.

CO's- PO's & PSO's MAPPING

Course Outcomes	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
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CO2	3	-	-	-	-	2	2	-	-	-	2	3		-
CO3	3	-	-	-	-	2	2	-	-	-	2	3	2	-
CO4	3	-	-	-	-	2	2	-	-	-	2	3	2	-
CO5	3	-	-	-	-	2	2	-	-	-	2	3		-
CO6	3	-	-	-	-	2	2	-	-	-	2	3	2	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231BMV37	BRAIN COMPUTER INTERFACE	L	T	P	C
		3	0	0	3

Programme:	B.E.-Biomedical Engineering	Category:	PE

AIM:	To analyse systems that allow direct communication between the human brain and external devices

Course Outcomes: The Students will be able to

CO1:	Describe BCI system and its potential applications.
CO2:	Outline the significance of brain activation
CO3:	Analyze the features suitable for BCI.
CO4:	Choose machine learning algorithms for translation
CO5:	List different Invasive BCIs
CO6:	Examine different Non-invasive BCIs

UNIT – I INTRODUCTION TO BCI	9

Introduction - Brain structure and function, Brain Computer Interface Types - Synchronous and Asynchronous -Invasive BCI -Partially Invasive BCI - Non Invasive BCI, Structure of BCI System, BCI Monitoring Hardware, EEG, ECoG, MEG, fMRI.

UNIT – II BRAIN ACTIVATION	9

Brain activation patterns - Spikes, Oscillatory potential and ERD, Slow cortical potentials, Movement related potentials-Mu rhythms, motor imagery, Stimulus related potentials - Visual Evoked Potentials – P300 and Auditory Evoked Potentials, Potentials related to cognitive tasks

UNIT – III FEATURE EXTRACTION METHODS	9

Data Processing – Spike sorting, Frequency domain analysis, Wavelet analysis, Time domain analysis, Spatial filtering -Principal Component Analysis (PCA), Independent Component Analysis

UNIT – IV MACHINE LEARNING METHODS FOR BCI	9

Classification techniques –Binary classification, Ensemble classification, Multiclass Classification, Evaluation of classification performance, Regression - Linear, Polynomial, RBF's, Perceptron's, Multilayer neural networks, Support vector machine, Graph theoretical functional connectivity analysis

UNIT – V APPLICATIONS OF BCI	9

Case Studies - Invasive BCIs: decoding and tracking arm (hand) position, controlling prosthetic devices such as orthotic hands, Cursor and robotic control using multi electrode array implant, Cortical control of muscles via functional electrical stimulation. Non-invasive BCIs:P300 Mind Speller, Visual cognitive BCI, Emotion detection. Ethics of Brain Computer Interfacing.

	Total Periods:	45

Text Books:

1. Rajesh.P.N.Rao, ―Brain-Computer Interfacing: An Introduction‖, Cambridge University Press, First edition, 2013.
2. Jonathan Wolpaw, Elizabeth Winter Wolpaw, ―Brain Computer Interfaces: Principles and practice‖, Oxford University Press, USA, Edition 1, January 2012.

References:

1. Ella Hassianien, A &Azar.A.T (Editors), ―Brain-Computer Interfaces Current Trends and Applications‖, Springer, 2015.
2. Bernhard Graimann, Brendan Allison, GertPfurtscheller, "Brain-Computer Interfaces: Revolutionizing Human-Computer Interaction", Springer, 2010
3. Ali Bashashati, MehrdadFatourechi, Rabab K Ward, Gary E Birch,‖ A survey of signal Processing algorithms in brain–computer interfaces based on electrical brain signals‖ Journal of Neural Engineering, Vol.4, 2007, PP.32-57
4. Arnon Kohen, ―Biomedical Signal Processing‖, Vol I and II, CRC Press Inc, Boca Rato,

Florida.

5. Bishop C.M., ―Neural networks for Pattern Recognition‖, Oxford, Clarendon Press, 1995

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	-	-	-	-	2	-	-	-	-	2	2	-	-
CO2	3	-	-	-	-	2	-	-	-	-	2	2	-	-
CO3	3	2	2	-	-	2	-	-	-	-	2	2	-	-
CO4	3	2	2	2	2	2	-	-	-	-	2	2	-	2
CO5	3	-	-	-	-	2	-	-	-	-	2	2	-	-
CO6	3	-	-	-	-	2	-	-	-	-	2	2	-	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231BMV38	HAPTICS INHEALTHCARE	L	T	P	C
		3	0	0	3
Programme:	**B.E.- Biomedical Engineering**	**Category:**			**PE**
AIM:	To understand how robotics technologies can be integrated into healthcare to improve patient care.				

Course Outcomes: The Students will be able to

CO1:	Explain the physiological aspects of the haptic system and its role in touch perception
CO2:	Interpret the design and functioning of haptic interface systems.
CO3:	Summarize sensory and motor systems and their interspecies interactions.
CO4:	Outline bioinspired designs of sensors, actuators, and adaptive structures.
CO5:	Apply haptic rendering techniques to develop and evaluate haptic systems.
CO6:	Apply haptic technologies for medical applications.

UNIT – I HUMAN HAPTICS	**9**

Neurophysiological and physiological aspects: Anatomy of receptors- Physiological mechanisms of the receptor system- Neural basis of haptic perception- The neural bases of haptic working memory- Neuronal plasticity of the haptic system. Psychological aspects: Haptic perception in the human foetus- Haptic behavior in social interaction- Learning effects in haptic perception- Implicit and explicit memory effects in haptic perception- Attention in sense of touch- Haptic object identification.

UNIT – II MACHINE HAPTICS	**9**

Introduction- Haptic Interfaces: Robotics Perspective- Haptic Interface System. Design of Haptic devices; The Tactile Mouse- CyberTouch Glove - The Displaced Temperature Sensing System – Performance Specifications: Physical Attributes Spatial Attributes- Temporal Attributes.

UNIT – III BIOINSPIRED ACTUATORS AND SENSORS	**9**

Introduction- Sensory and motor systems of the living world: Sensory systems in living systems-Movements in living systems- Interactions between species of different kingdoms. Bioinspired designs of sensors, actuators: Bio-inspired morphing structures- Bio-inspired tactile sensors- Synthetic photon energy harvesting system- Bioinspired optical layered structures, structured colors, camouflage skin, and color change strain sensor- Bioinspired inchworm actuators.

UNIT – IV COMPUTATIONAL HAPTICS	**9**

Introduction- Haptic Rendering Subsystem-Collision Detection Techniques and Bounding Volumes-Penetration Depth and Collision Response- Haptic Rendering of Surface Properties Haptic Rendering for Other Representation Methods- Haptic Rendering of More Than 3-DOFControl Methods for Haptic Systems-Benchmarking Haptic Rendering Systems-Haptic Software Frameworks-Closing Remarks.

UNIT – V HAPTICS FOR MEDICAL APPLICATIONS	**9**

Haptics for Sensory Impairments: Enabling Learning Experiences for Visually Impaired - Haptically-Assisted Interfaces for Persons with Visual Impairments. - Haptics for Sensory Substitution. Haptics for Health and Wellbeing: Haptics in Rehabilitation, Exergames and Health- Therapeutic Haptics for Mental Health and Wellbeing- Applications of Haptics in Medicine.

Total Periods:	**45**
Text Books:	

1. Kay M.Stanney, Handbook of Virtual Environments: Design, Implementation, and Applications, Lawrence Erlbaum Associates, Publications. N. I. Durlach and A. S. Mavor, eds., Virtual Reality: Scientific and Technological Challenges, National Academy Press, Washington, D.C., 1994.
2. G.C. Burdea, Force and Touch Feedback for Virtual Reality, John Wiley & Sons, 1996.
3. Kandel, Eric R., et al., eds. Principles of neural science. Vol. 4. New York: McGraw-hill, 2000.

References:

1. Chang Liu, Foundations of MEMS, Pearson Education Inc., 2012.
2. Marc J. Madou, Fundamentals of Micro fabrication: the Science of miniaturization,CRC Press, 2002.
3. Nadim Maluf and Kirt Williams, An introduction to Microelectro Mechancial Systems Engineering, Second Edition, Artech House Inc, MA,2004.
4. Chang Liu, Foundations of MEMS, Pearson Education International, New Jersey,USA,2006.
5. Nitaigour Premch and Mahalik, MEMS, Tata McGraw Hill Publishing Company, New Delhi, 2007

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	-	-	-	-	2	-	-	-	-	2	3	3	-
CO2	3	-	-	-	-	2	-	-	-	-	2	3	3	-
CO3	2	-	-	-	-	2	-	-	-	-	2	3	3	-
CO4	3	-	-	-	-	2	-	-	-	-	2	3	3	-
CO5	2	2	2	2	-	2	-	-	-	-	2	3	3	2
CO6	2	2	2	2	-	2	2	-	-	-	2	3	3	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

VERTICAL - IV

231BMV41	COMPUTATIONAL TOOLS IN BIOENGINEERING	L	T	P	C
		3	0	0	3

Programme:	B.E. Biomedical Engineering	Category:	PE

AIM:	To equip students with computational tools and modeling skills to solve bioengineering challenges.

Course Outcomes: The Students will be able to

CO1:	Explain the basics of computational tools, modeling, and mechanics used in bioengineering.
CO2:	Apply fluid and solid mechanics principles to simulate aortic dissection using 3D modeling techniques.
CO3:	Analyze antioxidant mechanisms through computational methods and reaction modeling
CO4:	Design and evaluate cochlear models using finite element methods for sound mechanics
CO5:	Explain the role of advanced mathematical models in simulating biological systems
CO6:	Make use of computational tools to solve bioengineering problems

UNIT – I NEED FOR COMPUTATIONAL TOOLS	9

Elements of computational tools-Elements of mathematical modeling-Elements of physics-The rational continuum -mechanics approach to matter in motion-Balance laws in integral form Balance laws in integral form- Balance laws in local form-Continuum approach for multicomponent mixtures-Constitutive relations for fluids- Constitutive relations for solids Constitutive relations for electromagnetism and electrodynamics

UNIT – II COMPUTATIONAL APPROACH IN AORTIC DISSECTION	9

Diagnostic techniques of acute aortic dissection-Treatment of acute aortic dissection-Basic equations of fluid flow-Basic equations of solid motion-Solid fluid interaction-Concept of aortic dissection-Need for 3D reconstruction- -Need for geometric 3D modeling

UNIT – III COMPUTATIONAL APPROACH IN ANTI OXIDATIVE MECHANISMS	9

Prevention of oxidative stress-Characteristics of good antioxidants-The proposed reaction mechanisms-Mechanistic approach-Thermo dynamical parameters for quercetin and gallic acid Antiradical mechanisms in the presence of different free radicals-Mechanistic approach to analyze antioxidant action-Radical adduct formation (RAF) mechanism.

UNIT – IV COMPUTATIONAL APPROACH IN COCHLEAR MECHANICS	9

Cochlear mechanics-Concepts of modeling-Solid model-Fluid model-Loose coupling algorithm--Strong coupling algorithm-Need for finite element modeling of cochlea-Basic criteria for finite element modeling of- cochlea- Concept of finite element modeling of cochlea-Finite element models of cochlea-Model of cochlea including feed forward and feed backward forces.

UNIT – V ADVANCED COMPUTATIONAL APPROACH	9

Functional Spaces and Functional Inequalities-Metric Spaces-Complete Metric Spaces- Normed Spaces- Banach Spaces-Hilbert Spaces- Hilbert Spaces-The Nonlinear Differential Model System Time Semi discretization- Block Nonlinear Jacobi and Gauss–Seidel-Iterations-Application of Functional Iterations to Biological Models.

	Total Periods:	45

Text Books:

1. Nenad Filipovic, Computational Modeling in Bioengineering and Bioinformatics, Academic Press, 1st Edition, 2020.
2. Z.C.Yang, Finite Element Analysis for Biomedical Engineering Applications, CRC Press,1st Edition,2020
3. Butta Singh, Computational Tools and Techniques for Biomedical Signal Processing, IGI Global, 1st edition, 2021.

References:

1. Andreas Öchsner, Holm Altenbach, Applications of Computational Tools in Biosciences and Medical engineering, Springer, 1st edition, 2020.

2. Geris, Liebet, Computational Modeling in Tissue Engineering, Springer, 1st edition, 2021

CO's- PO's & PSO's MAPPING

Course Outcomes	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO 1	3	2	2	-	-	2	-	-	-	-	2	3	-	-
CO 2	3	2	2	-	2	2	-	-	-	-	2	3	-	2
CO 3	3	2	2	-	2	2	-	-	-	-	2	3	-	2
CO 4	3	2	2	-	-	2	-	-	-	-	2	2	-	2
CO 5	3	2	2	-	-	2	-	-	-	-	2	3	-	2
CO 6	3	2	2	-	2	2	-	-	-	-	2	3	-	-

1: Slight (Low)   2: Moderate (Medium) 3: Substantial (High)

231BMV42	VIRTUAL INSTRUMENTATION FOR BIOMEDICAL ENGINEERING		L	T	P	C
			3	0	0	3
Programme:	**B.E./B.Tech. Biomedical Engineering**		**Category:**		**PE**	
AIM:	To explain virtual instrumentation, LabVIEW programming, hardware integration, and their applications in biomedical engineering.					

Course Outcomes: The Students will be able to

CO1:	Explain the basics of virtual instrumentation and LabVIEW.
CO2:	Infer the data flow programming in LabVIEW.
CO3:	Interpret the concept of digital I/O techniques and data acquisition in LabVIEW
CO4:	Summarize the communication standards and bus interfaces in virtual instrumentation.
CO5:	Apply signal processing techniques in biomedical data acquisition.
CO6:	Make use of biomedical workbenches and tools for recording and analyzing various biomedical signals.

UNIT – I	VIRTUAL INSTRUMENTATION	9

Virtual Instrumentation - Conventional Instrumentation Vs Virtual Instrumentation - Architecture of VI - Conventional Virtual Instrumentation - Distributed Virtual Instrumentation - Advantages of VI - Evolution of LabVIEW- LabVIEW - Creating Virtual Instruments Using LabVIEW - Advantages of LabVIEW - Front Panel of Virtual Instruments - Block Diagram of Virtual Instruments - LabVIEW Environment and its Menus Palletes of LabVIEW

UNIT – II	PROGRAMMING MODEL AND TECHNIQUES	9

Data Flow Programming - G' Programming Concepts - Creating and Saving VIs, SubVIs - Wiring, Editing, and Debugging VI - Control Structures such as the For Loop and the While Loop - Shift Registers and Their function Selection Structures: Case and sequence structures - Formulae nodes, feedback nodes – Arrays – Cluster: Creating Cluster Controls and Indicator - Cluster functions - Waveform Chart and graph – XY Graph - Strings, Creating String Controls and Indicators - String Functions - Tables and List Boxes - File Input/Output Functions

UNIT – III	HARDWARE INSTRUMENT	9

Digital I/O Techniques - Data Acquisition in LabVIEW - Hardware Installation and Configuration - Components of DAQ - DAQ Signal Accessory - DAQ Assistant: Create a MAX Based Task - Create a Project-Based Task DAQ Hardware - DAQ Hardware - DAQ Software - 4–20mA Current Loop - 60 mA Current Loop

UNIT – IV	HARDWARE INSTRUMENT	9

General Purpose Interface Bus(GPIB) - :IEEE 488.2 STANDARD - RS232 - RS485 - Virtual Instrument Software Architecture(VISA) – VXI – USB – PCI - PCI Express – PXI – PCMCIA – SCXI – LXI

UNIT – V	LAB VIEWS TOOLS AND ITS APPLICATIONS	9

Fourier transform - Power spectrum – Correlation – Windowing – Filters – Oscilloscope - Waveform generation - Multi-channel data acquisition - Vision and Motion tools- problems – Bio Bench - Biomedical work bench - ECG recording - EMG recording - EEG recording - EOG recording

Total Periods:		45
Text Books:		

| 1. | Robert H. Bishop," Learning with LabVIEW" , Pearson, First edition, 2014 |
| 2. | John Essick, Hands-On Introduction to LabVIEW for Scientists and Engineers,Oxford University Press, Fourth edition, 2018 |

References:

1. S. Sumathi and P. Surekha, "Labview based Advanced Instrumentation Systems ", Springer, First edition, 2007
2. Gary Jonson, "Labview Graphical Programming", Second Edition, McGraw Hill, New York,Fourth edition 2006.
3. Lisa K. wells and Jeffrey Travis, "Labview for everyone", Prentice Hall Inc., New Jersey;First edition 1997.
4. Gupta S and Gupta J P, "PC interfacing for Data Acquisition & Process Control", Instrument Society of America, Second Edition, 1994
5. Jon B. Olansen and Eric Rosow, "Virtual Bio-Instrumentation: Biomedical, Clinical, and Healthcare Applications in LabVIEW ",Prentice Hall,First edition, 2001
6. Ronald W. Larsen ,"LabVIEW for Engineers", Pearson ,First edition, 2010

CO's- PO's & PSO's MAPPING

Course Outcomes	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO 1	3	-	-	-	-	-	-	-	-	-	2	2	-	-
CO 2	3	2	2	-	2	-	-	-	-	-	2	2	-	2
CO 3	3	2	2	-	2	-	-	-	-	-	2	2	-	2
CO 4	3	2	2	-	-	-	-	-	-	-	2	2	-	2
CO 5	3	2	2	-	-	-	-	-	-	-	2	3	-	2
CO 6	3	2	2	-	2	-	-	-	-	-	2	3	-	2

1: Slight (Low)   2: Moderate (Medium)   3: Substantial (High)

231BMV43	BIOSIGNAL PROCESSING	L	T	P	C
		3	0	0	3
Programme:	**B.E.-Biomedical Engineering**	**Category:**			**PE**
AIM:	To study and understand the choice of filters to remove noise and artifacts from biomedical signals.				

Course Outcomes: The Students will be able to

CO1:	Characterize the biosignals using density function.
CO2:	Explain the biological signals by spectral estimation in time domain.
CO3:	Apply wavelet detection techniques for bio signal processing.
CO4:	Use adaptive filtering for ECG signal processing.
CO5:	Classify Bio signals based on statistical classifiers.
CO6:	Apply the multivariate component analysis for biomedical signals.

UNIT – I BIOSIGNAL AND SPECTRAL CHARACTERISTICS	**9**
Characteristics of some dynamic biomedical signals, Noises- random, structured and physiological noises. Filters- IIR and FIR filters. Spectrum – power spectral density function, cross-spectral density and coherence function, cepstrum and homomorphic filtering. Estimation of mean of finite time signals.	
UNIT – II TIME SERIES ANALYSIS AND SPECTRAL ESTIMATION	**9**
Time series analysis – linear prediction models, process order estimation, lattice representation, non-stationary process, fixed segmentation, adaptive segmentation, application in EEG, PCG signals, Time varying analysis of Heart-rate variability, model based ECG simulator. Spectral estimation –Blackman Tukey method, periodogram, and model based estimation. Application in Heart rate variability, PCG signals.	
UNIT – III ADAPTIVE FILTERING AND WAVELETDETECTION	**9**
Filtering–LMS adaptive filter, adaptive noise cancelling in ECG, improved adaptive filtering in ECG, Wavelet detection in ECG – structural features, matched filtering, adaptive wavelet detection, detection of overlapping wavelets.	
UNIT – IV BIOSIGNAL CLASSIFICATION AND RECOGNITION	**9**
Signal classification and recognition – Statistical signal classification, linear discriminate function, direct feature selection and ordering, Back propagation neural network based classification. Application in Normal versus Ectopic ECG beats.	
UNIT – V TIME FREQUENCY AND MULTIVARIATE ANALYSIS	**9**
Time frequency representation, spectrogram, Wigner distribution, Time-scale representation, scalogram, wavelet analysis– Data reduction techniques, ECG data compression, ECG characterization, Feature extraction-Wavelet packets, Multivariate component analysis-PCA,ICA.	
Total Periods:	**45**
Text Books:	
1.Rangaraj M. Rangayyan, "Biomedical Signal Analysis-A case study approach", Wiley, 2nd Edition,2016. 2.Willis.J.Tompkins,"Biomedical Digital Signal Processing", Prentice Hall of India, New Delhi, 2000. 3. Arnon Cohen, "Bio-Medical Signal Processing Vol-I and Vol-II", CRC Press Inc., BocaRato, Florida,2021.	
References:	

1. Kayvan Najarian and Robert Splerstor, "Biomedical signals and Image processing'', CRC –Taylor and Francis,NewYork,2nd Edition,2012.
2. K.P.Soman, K.Ramachandran, "Insight into wave let from theory to practice", PHI, New Delhi, 3rdEdition, 2010.
3. D.C.Reddy, "Biomedical Signal Processing – Principles and Techniques'', Tata McGraw-Hill Publishing Co.Ltd,2005.
4. John L. Semmlow, "Biosignal and Biomedical Image Processing Matlab Based applications'', Taylor & Francis Inc, 2019.

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	1	-	2	-	-	-	-	2	3	-	-
CO2	3	2	2	1	-	2	-	-	-	-	2	3	-	-
CO3	3	2	2	1	-	2	-	-	-	-	2	3	-	-
CO4	3	2	2	1	-	2	-	-	-	-	2	3	-	-
CO5	3	2	2	1	-	2	-	-	-	-	2	3	-	-
CO6	3	2	2	1	-	2	-	-	-	-	2	3	-	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231BMV44	SPEECH AND AUDIO SIGNAL PROCESSING	L	T	P	C
		3	0	0	3

Programme:	B.E.-Biomedical Engineering	Category:	PE

AIM:	To study and understand the choice of filters to remove noise and artifacts from biomedical signals.

Course Outcomes: The Students will be able to

CO1:	Explain the auditory models to design perceptual audio quality measure.
CO2:	Make use of filter banks and transforms to process audio signals.
CO3:	Interpret the different audio coding methods.
CO4:	Identify the important time-domain features of speech signals
CO5:	Apply time and frequency domain techniques to extract pitch and formant information from speech signals.
CO6:	Implement pitch detection and formant analysis in speech signals.

UNIT – I MECHANICS OF SPEECH AND AUDIO	9

Speech Processing: Speech production, Signal nature, Discrete-time modeling, Speech sound classification, Phones & Phonemes, Articulatory features - Hearing & Perception: Absolute threshold, Critical bands, Masking (simultaneous & non-simultaneous), Perceptual entropy - Audio Quality: Subjective vs. objective testing, PAQM, Cognitive effects in audio judgment

UNIT – II TIME-FREQUENCY ANALYSIS: FILTER BANKS AND TRANSFORMS	9

Filter Banks: M-band framework, Design for audio coding - Filter Types: QMF, CQF, Tree-structured banks, Cosine-modulated banks - Transforms: MDCT, DFT, DCT- Audio Artifacts: Pre-echo distortion and control strategies

UNIT – III AUDIO CODING AND TRANSFORM CODERS	9

Coding Types: Lossless and Lossy - Standards: ISO-MPEG-1A, 2A, Advanced Audio Coding - Techniques: Frequency-domain coding, Perceptual coders (Brandenburg-Johnston, CNET) - Advanced Methods: Spectral entropy coding, Differential perceptual coding, Noise substitution, DFT/DCT/MDCT with vector quantization.

UNIT – IV TIME AND FREQUENCY DOMAIN	9

Time domain parameters of Speech signal – Methods for extracting the parameters: Energy, Average Magnitude – Zero crossing Rate – Silence Discrimination using ZCR and energy Short Time Fourier analysis – Formant extraction – Pitch Extraction using time and frequency domain Methods

UNIT – V LINEAR PREDICTIVE ANALYSIS	9

Formulation of Linear Prediction problem in Time Domain – Basic Principle – Auto correlation method – Covariance method – Solution of LPC equations – Cholesky method – Durbin's Recursive algorithm – lattice formation and solutions – Comparison of different methods – Application of LPC parameters – Pitch detection using LPC parameters – Formant analysis – VELP – CELP.

	Total Periods:	45

Text Books:	

1.Rabiner. L. R and Schaffer. R. W., "Digital Processing of Speech signals", Prentice Hall,1978

2. Andreas Spanias, Ted Painter, Venkatraman AttiWayne Tomasi, "Audio signal processing and coding", John Wiley & Sons, 2007

References:	

1.Udo Zölzer , Digital Audio Signal Processing, A John Wiley& sons Ltd Publication, Second Edition, 2008.
2. Mark Kahrs, Karlheinz Brandenburg, "Applications of Digital Signal Processing to Audio And Acoustics", KLUWER ACADEMIC PUBLISHERS NEW YORK, BOSTON, DORDRECHT, LONDON, MOSCOW, 2002.
3. Blake, "Electronic Communication Systems", Thomson Delmar Publications, 2002.
4. Martin S. Roden, "Analog and Digital Communication System", Prentice Hall of India, 3rd Edition, 2002.
5. Sklar. B, "Digital Communication Fundamentals and Applications" Pearson Education, 2nd Edition, 2007.

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	1	-	2	-	-	-	-	2	3	-	-
CO2	3	2	2	1	-	2	-	-	-	-	2	3	-	-
CO3	3	2	2	1	2	2	-	-	-	-	2	3	-	2
CO4	3	2	2	1	-	2	-	-	-	-	2	3	-	-
CO5	3	2	2	1	-	2	-	-	-	-	2	3	-	-
CO6	3	2	2	1	-	2	-	-	-	-	2	3	-	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231BMV45	NEURAL NETWORK AND PATTERN RECOGNITION	L	T	P	C
		3	0	0	3
Programme:	**B.E.Biomedical Engineering**	Category:		PE	
AIM:	To equip students with the knowledge and skills required to understand, design, and implement neural network models for solving pattern recognition problems.				

Course Outcomes: The Students will be able to

CO1:	Describe basic biological and artificial neural networks, including Hebb Net, Perceptron, Adaline, and Madaline.
CO2:	Classify MLPs, backpropagation, associative memory models, and their applications.
CO3:	Explain competitive learning and key competitive network models.
CO4:	Explain pattern recognition techniques and classification methods with error estimation.
CO5:	Estimate supervised learning techniques for pattern classification problems
CO6:	Classify unsupervised learning algorithms and clustering techniques

UNIT – I INTRODUCTION AND SIMPLE NEURAL NET	9
Elementary neurophysiology and biological neural network- Artificial neural network-Architecture, biases and thresholds, Hebb net, Perceptron, Adaline and Madaline.	
UNIT – II BACK PROPAGATION AND ASSOCIATIVE MEMORY	**9**
Introduction to Multilayer Perceptrons (MLPs), Back propagation network, generalized delta rule, Applications, Bidirectional Associative memory, Hopfield Network	
UNIT – III NEURAL NETWORKS BASED ON COMPETITION	**9**
Introduction to Competitive Learning, Types of Competitive Networks , Learning Rules for Competitive Networks, Kohonen Self organizing map, Learning Vector Quantization, Counter Propagation network.	
UNIT – IV INTRODUCTION AND SUPERVISED LEARNING	**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 – V UNSUPERVISED LEARNING AND CLUSTERING ANALYSIS	**9**
Unsupervised learning- Hierarchical 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 Periods:	**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 Hagan, Demuth and Beale, "Neural network design", Vikas Publishing House Pvt Ltd., New Delhi, 2002
3. Freeman J.A., and Skapura B.M, "Neural networks, algorithms, applications and programming techniques", Addison- Wesley, 2003.

References:

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.

CO's- PO's & PSO's MAPPING

Course Outcomes	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO 1	3	2	2	-	-	2	-	-	-	-	2	2	-	2
CO 2	3	2	2	-	-	2	-	-	-	-	2	2	-	2
CO 3	3	2	2	-	-	2	-	-	-	-	2	2	-	2
CO 4	2	2	2	-	-	2	-	-	-	-	2	2	-	2
CO 5	3	2	2	-	-	2	-	-	-	-	2	2	-	2
CO 6	3	2	2	-	-	2	-	-	-	-	2	2	-	2

1: Slight (Low)   2: Moderate (Medium)   3: Substantial (High)

231BMV46	BIOELECTROMAGNETISM AND COMPATIBILITY	L	T	P	C
		3	0	0	3

Programme:	B.E./B.Tech. Biomedical Engineering	Category:		PE

AIM:	To understand the interaction between electromagnetic fields and biological systems, and to ensure the safe and compatible operation of biomedical devices in clinical environments.

Course Outcomes: The Students will be able to

CO1:	Explain the fundamental principles of electromagnetic interference (EMI) and electromagnetic compatibility (EMC)
CO2:	Describe various coupling mechanisms in electronic systems.
CO3:	Analyze EMI mitigation techniques such as shielding, grounding, filtering, PCB layout, and transient protection methods.
CO4:	Summarize the electrical properties of biological tissues and electromagnetic fields interaction with the human body.
CO5:	Outline the safety aspects and therapeutic applications of electromagnetic energy in biomedical devices.
CO6:	Apply EMI/EMC concepts to medical devices in compliance with standards

UNIT – I BASIC CONCEPTS	9

Definition of EMI and EMC; Intra and Inter system EMI; Sources and victims of EMI, Conducted and Radiated EMI emission and susceptibility; Transient & ESD; Case Histories; Radiation Hazards to humans

UNIT – II COUPLING MECHANISM	9

Common made coupling; Differential mode coupling; Common impedance coupling; Ground loop coupling; Field to cable coupling; Cable to cable coupling; Power mains and Power supply coupling.

UNIT – III EMI MITIGATION TECHNIQUES	9

Shielding – principle, choice of materials for H, E and free space fields, and thickness; EMI gaskets; Bonding; Grounding – circuits, system and cable grounding; Filtering; Transient EMI control devices and applications; PCB Zoning, Component selection, mounting, trace routing

UNIT – IV ELECTROMAGNETIC RADIATION AND ITS INTERACTION WITH BIOLOGICAL SYSTEMS	9

Electrical properties of human system – conductivity, permittivity, impedance; human body as volume conductor, source field models, inductive power transfer in implanted devices, RF/microwave interaction mechanism with human system and its effects, therapeutic applications of microwaves

UNIT – V ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY IN MEDICAL EQUIPMENTS	9

EMI-EMC definitions and Units of parameters; Sources and victim of EMI; Conducted and Radiated EMI Emission and Susceptibility, EM coupling, EMI control -Shielding, filtering and grounding, Standards for medical devices - ISO 14117:2012, IEC 60601-1-2, testing Case study on EM interference during MR imaging

Total Periods:		45
Text Books:		

1. V.P. Kodali, "Engineering EMC Principles, Measurements and Technologies", IEEE Press,New york, 2nd Edition, 2010
2. Henry W.Ott., "Noise Reduction Techniques in Electronic Systems", A Wiley Inter Science Publications, John Wiley and Sons, Newyork, 2009
3. Clayton R.Paul, "Introduction to Electromagnetic Compatibility", John Wiley Publications, 2008
   Bioelectromagnetism–"Principles and Applications of Bioelectric and Biomagnetic Fields" by Jaakko Malmivuo, Oxford University press, 1995

References:

1. Don R.J.White Consultant Incorporate, "Handbook of EMI/EMC", Vol I-V, 1988
2. Bemhard Keiser, "Principles of Electromagnetic Compatibility", 3rd Edition, Artech house, Norwood, 1987
3. C.R. Paul, "Introduction to Electromagnetic Compatibility", John wiley& sons Inc. 2006.
4. John D. Kraus & Keith R. Carver, "Electromagnetics", McGraw-Hill Inc. 1973
5. Edward Conrad Jordan, Keith George Balmain, "Electromagnetic waves and radiating
   systems", Prentice Hall, 1968.
6. Andre Vander Vorst, Arye Rosen, Youji Kotsuka, John Wiley & Sons, "RF/Microwave Interaction with Biological Tissues", Inc., 2006.

CO's- PO's & PSO's MAPPING

Course Outcomes	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO 1	3	2	2	-	-	2	-	-	-	-	2	2	-	-
CO 2	3	2	2	-	-	2	-	-	-	-	2	2	-	-
CO 3	3	2	2	-	-	2	-	-	-	-	2	2	-	-
CO 4	3	2	2	-	-	2	-	-	-	-	2	3	-	-
CO 5	3	2	2	-	-	2	2	-	-	-	2	2	2	-
CO 6	3	2	2	-	-	2	2	-	-	-	2	2	2	-

1: Slight (Low)   2: Moderate (Medium) 3: Substantial (High)

231BMV47		BIOMETRIC SYSTEMS		L	T	P	C
				3	0	0	3
Programme:	**B.E.-Biomedical Engineering**			Category:			PE
AIM:	To understand how to use biometric data to identify individuals and perform automated actions based on that recognition.						

Course Outcomes: The Students will be able to

CO1:	Explain the principles of biometric systems.
CO2:	Interpret the finger print recognition technique.
CO3:	Develop the face recognition and hand geometry system.
CO4:	Explain the iris recognition system.
CO5:	Explain various speech recognition systems
CO6:	Describe the multi modal biometric systems

UNIT – I INTRODUCTION TO BIOMETRICS	9

Introduction and back ground – biometric technologies – passive biometrics – active biometrics –Biometric characteristics, Biometric applications – Biometric Authentication systems-Taxonomy of Application Environment, Accuracy in Biometric Systems- False match rate-False non match rate-Failure to enroll rate-Derived metrics-Biometrics and Privacy.

UNIT – II FINGER PRINT TECHNOLOGY	9

History of fingerprint pattern recognition - General description of fingerprints- fingerprint sensors, finger print enhancement, Feature Extraction- Ridge orientation, ridge frequency, fingerprint matching techniques- correlation based, Minutiae based, Ridge feature based, finger print classification, Applications of fingerprints, Finger scan- strengths and weaknesses, Evaluation of fingerprint verification algorithms.

UNIT – III FACE RECOGNITION AND HAND GEOMETRY	9

Introduction to face recognition, face recognition using PCA, LDA, face recognition using shape and texture, face detection in color images, 3D model based face recognition in video images, Neural networks for face recognition, Hand geometry–scanning–Feature Extraction–classification.

UNIT – IV IRIS RECOGNITION	9

Introduction, Anatomical and Physiological underpinnings, Iris sensor, Iris representation and localization- Daugman and Wilde's approach, Iris matching, Iris scan strengths and Weaknesses, System performance, future directions.

UNIT – V VOICE SCAN AND MULTIMODAL BIOMETRICS	9

Voice scan, speaker features, short term spectral feature extraction, Mel frequency cepstral coefficients, speaker matching ,Gaussian mixture model, NIST speaker Recognition Evaluation Program, Introduction to multimodal biometric system – Integration strategies – Architecture – level of fusion – combination strategy, Securing and trusting a biometric transaction – matching location – local host -authentication server-cyber security – match on card(MOC)

Total Periods:	45

Text Books:	

1. James Wayman & Anil Jain, "Biometric Systems- Technology Design
 and Performance Evaluation", SPRINGER(SIE),1stEdition,2011
2. PaulReid,"Biometrics for Network Security", Pearson Education,2004
3. S.Y. Kung, S.H. Lin, M.W., "Biometric Authentication: A Machine Learning Approach",PrenticeHall,2004

References:	

1. Nalini K Ratha, Ruud Bolle,"Automatic fingerprint recognition system'', Springer,2003.
2. LCJain, IHayashi, SBLee, UHalici, "Intelligent Biometric Techniques in Finger print a

Face Recognition", CRC Press, 1st Edition, 1999.
3. John Chirillo, Scott Blaul, "Implementing Biometric Security", John Wiley & Sons, 2003.

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	-	-	-	-	2	-	-	-	-	2	3	-	-
CO2	3	-	-	-	-	2	-	-	-	-	2	3	-	-
CO3	3	-	-	-	-	2	-	-	-	-	2	3	-	-
CO4	3	-	-	-	-	2	-	-	-	-	2	3	-	-
CO5	3	-	-	-	-	2	-	-	-	-	2	3	-	-
CO6	3	2	2		-	2	-	-	-	-	2	3	-	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231BMV48	FORENSIC SCIENCE IN HEALTHCARE		L	T	P	C
			3	0	0	3
Programme:	**B.E.-Biomedical Engineering**		**Category:**			**PE**
AIM:	To train students to apply medical knowledge to legal investigations.					

Course Outcomes: The Students will be able to

CO1:	Explain the basics of forensic sciences.
CO2:	Summarize the observations and crime scenes.
CO3:	Classify Trauma and Diseases from skeletal remains.
CO4:	Describe the function of various microscope used for forensic science.
CO5:	Explain the blood stain identification process.
CO6:	Illustrate the visual analytical procedure for finger print identification.

UNIT – I BASICS OF FORENSIC SCIENCE	9

Forensic science, Introduction to the Forensic Sciences, History and Development of Forensic Science, Deductive Reasoning, Organization of a Crime Laboratory Case Studies: The Enrique Camarena Case.   A Forensic Nightmare Organization of forensic science laboratories of center and state -NCRA AND NICFS, fundamental rights, criminal profiling, concept of quality control management in forensic institutions.

UNIT – II OBSERVATION AND CRIMESCENE	9

Observational Skills - Sherlock Holmes and Deductive Reasoning - Observations by Witnesses. Case Studies. The Crime Scene -Locard's Exchange Principle, Securing and Recording the Crime Scene, Legal Considerations at the Crime Scene, Evidence Collection and Recordation Techniques. Mock Crime Scene: Processing and Documenting a Crime Scene.

UNIT – III FORENSIC MICROSCOPE AND ANTHROPOLOGY	9

Forensic Use of the Microscope -The Compound, Comparison, and Stereoscopic Microscope, The   Scanning   Electron Microscope (SEM). Forensic Anthropology- Introduction, Human Anatomy–The Skeletal System, Skeletal Determination of Demographic Data from Skeletal Remains, Determining Types of Trauma and Disease from Skeletal Remains, Case Studies.

UNIT – IV BLOOD STAIN IDENTIFICATION	9

Detection and identification of Bloodstains, Determination of species of origin, Blood Group systems, Techniques of Determination of Blood groups of Blood stains, Determination of seminal and other fluids and their Blood Grouping, DNA, DNA Phenotyping and RNA Profiling & their applications. Wild life forensics.

UNIT – V FINGERPRINT APPLICATION	9

Fingerprints-Fundamental Principles of Finger print Analysis, Classification of Fingerprints, Collection of Fingerprint Evidence, Automated Fingerprint Identification Systems (AFIS), Track marks, Case Studies.

Total Periods:	45

Text Books:	

1.Nanda, B.B.and Tewari, R.K Forensic Science in India: A vision for the twenty first century Select Publisher, New Delhi,2014

2.James,S.HandNordby,.J.Forensic Science: An introduction to scientific and investigative techniques CRC Press,2005

References:	

1.Saferstein:Criminalistics Prentice Hall Inc.,USA,2008

2.Deforest, Gansellen & Lee: Introduction to Criminalistics,1983

3.Sharma, B.R. Forensic Science in Criminal Investigation and Trials, Central Law Agency,

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	-	-	-	-	2	2	-	-	-	2	3	-	-
CO2	3	-	-	-	-	2	2	-	-	-	2	3	-	-
CO3	3	-	-	-	-	2	2	-	-	-	2	3	-	-
CO4	3	-	-	-	-	2	2	-	-	-	2	3	-	-
CO5	3	-	-	-	-	2	2	-	-	-	2	3	-	-
CO6	3	-	-	-	-	2	2	-	-	-	2	3	-	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

VERTICAL - V

231BMV51	COMPUTER NETWORKS	L	T	P	C
		3	0	0	3

Programme:	B.E. Biomedical Engineering	Category:	PE

AIM:	To provide a fundamental understanding of computer networking concepts, protocols, architectures, and technologies, enabling students to design, analyze, and troubleshoot network systems effectively.

Course Outcomes: The Students will be able to

CO1:	Explain data communication and OSI/TCP models.
CO2:	Identify and compare application layer protocols.
CO3:	Explain transport layer protocols and flow control.
CO4:	Illustrate IP addressing and subnetting.
CO5:	Analyze routing protocols like RIP, OSPF, and BGP.
CO6:	Explain data link layer protocols and Ethernet basics.

UNIT – I INTRODUCTION AND APPLICATION LAYER	9

Data Communication - Networks – Network Types – Protocol Layering – TCP/IP Protocol suite – OSI Model – Introduction to Sockets - Application Layer protocols: HTTP – FTP – Email protocols (SMTP - POP3 - IMAP - MIME) – DNS – SNMP.

UNIT – II TRANSPORT LAYER	9

Introduction - Transport-Layer Protocols: UDP – TCP: Connection Management – Flow control - Congestion Control - Congestion avoidance (DECbit, RED) – SCTP – Quality of Service.

UNIT – III NETWORK LAYER	9

Switching : Packet Switching - Internet protocol - IPV4 – IP Addressing – Subnetting - IPV6, ARP, RARP, ICMP, DHCP.

UNIT – IV ROUTING	9

Routing and protocols: Unicast routing - Distance Vector Routing - RIP - Link State Routing – OSPF – Path-vector routing - BGP - Multicast Routing: DVMRP – PIM.

UNIT – V DATA LINK AND PHYSICAL LAYERS	9

Data Link Layer – Framing – Flow control – Error control – Data-Link Layer Protocols – HDLC – PPP - Media Access Control – Ethernet Basics – CSMA/CD – Virtual LAN – Wireless LAN (802.11) - Physical Layer: Data and Signals - Performance – Transmission media- Switching – Circuit Switching.

	Total Periods:	45

Text Books:	

1. James F. Kurose, Keith W. Ross, Computer Networking, A Top-Down Approach Featuring the Internet, Eighth Edition, Pearson Education, 2021.
2. Behrouz A. Forouzan, Data Communications and Networking with TCP/IP Protocol Suite, Sixth Edition TMH, 2022.

References:	

1. Larry L. Peterson, Bruce S. Davie, Computer Networks: A Systems Approach, Fifth Edition, Morgan Kaufmann Publishers Inc., 2012.
2. William Stallings, Data and Computer Communications, Tenth Edition, Pearson Education, 2013.
3. Nader F. Mir, Computer and Communication Networks, Second Edition, Prentice Hall, 2014.
4. Ying-Dar Lin, Ren-Hung Hwang, Fred Baker, "Computer Networks: An Open

Source Approach", McGraw Hill, 2012.

CO's- PO's & PSO's MAPPING

Course Outcomes	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO 1	3	-	-	-	-	-	2	-	-	-	2	1	-	-
CO 2	3	-	-	-	-	-	2	-	-	-	2	1	-	-
CO 3	3	-	-	-	-	-	2	-	-	-	2	1	-	-
CO 4	3	3	3	-	-	-	2	-	-	-	2	1	-	-
CO 5	3	-	-	-	-	-	2	-	-	-	2	1	-	-
CO 6	3	-	-	-	-	-	2	-	-	-	2	1	-	-

1: Slight (Low)   2: Moderate (Medium)   3: Substantial (High)

231BMV52	COMMUNICATION SYSTEMS	L	T	P	C
		3	0	0	3

Programme:	**B.E. Biomedical Engineering**	Category:	PE

AIM:	To understand how information is transmitted and received using analog and digital communication systems.

Course Outcomes : The Students will be able to

CO1:	Explain the fundamental concepts of analog modulation techniques
CO2:	Extend the behavior of communication system and apply sampling and quantization techniques for signal processing.
CO3:	Explain pulse modulation, PCM noise, multiplexing, and basic error-correcting codes with decoding techniques.
CO4:	Interpret and compare different digital modulation schemes based on performance metrics
CO5:	Design synchronization and carrier recovery mechanisms for coherent and non-coherent digital communication systems.
CO6:	Apply detection methods to design efficient demodulators and minimize errors.

UNIT – I AMPLITUDE MODULATION	9

Review of signals and systems, Time and Frequency domain representation of signals, Principles of Amplitude Modulation Systems- DSB, SSB and VSB modulations. Angle Modulation, Representation of FM and PM signals, Spectral characteristics of angle modulated signals. SSB Generation – Filter and Phase Shift Methods, VSB Generation – Filter Method, Hilbert Transform, Pre-envelope & complex envelope AM techniques, Superheterodyne Receiver,FTTH.

UNIT – II RANDOM PROCESS & SAMPLING	9

Review of probability and random process. Gaussian and white noise characteristics, Noise in amplitude modulation systems, Noise in Frequency modulation systems. Pre-emphasis and De- emphasis, Threshold effect in angle modulation. Low pass sampling – Aliasing-Signal Reconstruction-Quantization - Uniform & non-uniform quantization - quantization noise - Nyquist criterion- Logarithmic Companding –PAM, PPM, PWM, PCM – TDM, FDM

UNIT – III DIGITAL TECHNIQUES	9

Pulse modulation Differential pulse code modulation. Delta modulation, Noise considerations in PCM,Digital Multiplexers, Channel coding theorem - Linear Block codes - Hamming codes – Cyclic codes - Convolutional codes - Viterbi Decoder

UNIT – IV DIGITAL MODULATION SCHEME	9

Geometric Representation of signals - Generation, detection, IQ representation, PSD & BER of Coherent BPSK, BFSK, & QPSK - QAM - Carrier Synchronization - Structure of Non-coherent Receivers Synchronization and Carrier Recovery for Digital modulation, Spectrum Analysis – Occupied bandwidth – Adjacent channel power, EVM, Principle of DPSK

UNIT – V DEMODULATION TECHNIQUES	9

Elements of Detection Theory, Optimum detection of signals in noise, Coherent communication with waveforms- Probability of Error evaluations. Baseband Pulse Transmission- Inter symbol Interference, Optimum demodulation of digital signals over band-limited channels.

	Total Periods:	45

Text Books:	

1. Simon Haykins, Communication Systems, Wiley, 5th Edition, 2009. 2. B.P.Lathi, "Modern Digital and Analog Communication Systems", 4th Edition, Oxford University Press, 2011.	
References:	
1. Wayner Tomasi, Electronic Communication System, 5th Edition, Pearson Education,2008. 2. D.Roody, J.Coolen, Electronic Communications, 4th edition PHI 2006 3. A.Papoulis, Probability, Random variables and Stochastic Processes, McGraw Hill, 3rd edition, 1991. 4. B.Sklar, Digital Communications Fundamentals and Applications, 2nd Edition Pearson Education 2007 5. H P Hsu, Schaum Outline Series - Analog and Digital Communications, TMH 2006 6. Couch.L., Modern Communication Systems, Pearson, 2001	

CO's- PO's & PSO's MAPPING

Course Outcomes	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO 1	3	-	-	-	-	-	-	-	-	-	2	1	-	-
CO 2	3	2	2	-	-	-	-	-	-	-	2	1	-	-
CO 3	3	2	2	-	-	-	-	-	-	-	2	1	-	-
CO 4	3	2	2	-	-	-	-	-	-	-	2	1	-	-
CO 5	3	2	2	-	-	-	-	-	-	-	2	1	-	-
CO 6	3	2	2	-	-	-	-	-	-	-	2	1	-	-

1: Slight (Low)   2: Moderate (Medium) 3: Substantial (High)

231BMV53	NETWORKING AND INFORMATION SYSTEM IN MEDICINE	L	T	P	C
		3	0	0	3
Programme:	**B.E. Biomedical Engineering**	**Category:**		**PE**	

AIM: To provide the knowledge of artificial neural networks and their applications in pattern recognition and medical data analytics.

Course Outcomes: The Students will be able to

CO1:	Explain the components of networked systems and basic security principles in system administration.
CO2:	Describe different types of information and communication networks
CO3:	Outline the need, capabilities, and functional areas of Hospital Management Information Systems.
CO4:	Summarize the features, modules, and development tools of Clinical Patient Records (CPR) within HMIS.
CO5:	Explain DICOM, PACS, and image handling in medical databases.
CO6:	Interpret the impact of health systems and mobile technologies on healthcare through case studies.

UNIT – I INTRODUCTION TO NETWORKING	9

Introduction, System Components, Networked Communities, Host Management, User Management- Application Level Services, Network Level Services, Principles of Security, Security Implications, and Analytical System Administration.

UNIT – II COMMUNICATION NETWORK AND SERVICES	9

Types of information: Audio, Video, Still Images, Text and data, and Fax - Types of Communication and Network: PSTN, POTS, ATN, and ISDN - Basic concepts of Communication and Network: Internet, and Wireless communications.

UNIT – III HOSPITAL MANAGEMENT & INFORMATION SYSTEMS	9

Need for HMIS, Capabilities & Development of HMIS, functional area, modules forming HMIS, (like Pathology Lab, Blood bank, Pharmacy, Diet planning). Maintenance and development of HMIS-Ideal Features and functionality of CPR, Development tools for CPR.

UNIT – IV PICTURE ARCHIVAL COMMUNICATION SYSTEMS	9

Types of image formats, DICOM standard, PACS system: Block diagram, Storing & retrieving images, Algorithm for retrieving images, Compressions and its significance, Lossless data Storage and in-house communication, Computer aided diagnosis (CAD), Centralized Database.

UNIT – V RECENT TRENDS IN MEDICAL HEALTHCARE MANAGEMENT	9

Impact of Systems on Health Care, Care Providers and Organizations, mobile health care technologies. Case studies.

Total Periods:	**45**
Text Books:	

1.A.S. Tanenbaum, "Computer Networks", 2012, 5th Edition, Pearson Education, London.
2.Kenneth R. Ong, "Medical Informatics: An Executive primer", 2015, 1st Edition, HIMSS Publishing, Chicago.

References:	

  1. Bernard Fong, A.C.M. Fong and C.K. Li, "Telemedicine Technologies: Information Technologies in Medicine and Tele-health", 2011, 1st Edition, Wiley- Blackwell, New

Jersey.
 2.Lazakidu, "Web-based Application in Healthcare and Biomedicine", 2012, 1st Edition, Springer, New York.

CO's- PO's & PSO's MAPPING

Course Outcomes	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO 1	3	-	-	-	-	-	-	-	-	-	2	2	-	-
CO 2	3	-	-	-	-	-	-	-	-	-	2	2	-	-
CO 3	3	-	-	-	-	2	2	-	-	-	2	2	-	-
CO 4	3	-	-	-	-	2	2	-	-	-	2	2	-	2
CO 5	3	2	2	-	-	2	2	-	-	-	2	2	-	2
CO 6	3	-	-	-	-	2	2	-	-	-	2	2	-	-

1: Slight (Low)   2: Moderate (Medium) 3: Substantial (High)

231BMV54	BIG DATA ANALYTICS IN MEDICAL APPLICATIONS	L	T	P	C
		3	0	0	3
Programme:	B.E. Biomedical Engineering	Category:		PE	
AIM:	To explain big data technologies and their applications in healthcare, enabling them to analyze medical data and develop data-driven solutions for improving healthcare outcomes.				

Course Outcomes: The Students will be able to

CO1:	Explain the fundamental concepts of Big Data analytics and types of healthcare data.
CO2:	Outline then Big Data infrastructure and technologies used for medical data storage, integration, and processing.
CO3:	Classify the data preprocessing, machine learning, and visualization techniques to healthcare datasets.
CO4:	Infer data-driven solutions for medical applications such as clinical decision support and personalized medicine.
CO5:	Explain advanced analytical models including deep learning and NLP in solving medical domain challenges.
CO6:	Discuss ethical, legal, and data governance issues related to Big Data applications in healthcare.

UNIT – I INTRODUCTION TO BIG DATA AND HEALTHCARE DOMAIN	9

Overview of Big Data- Definitions, characteristics, Comparison- Traditional Data vs Big Data, Introduction to Medical Applications- EHR, EMR, PACS, genomic data, wearable and sensor data, Challenges in healthcare data- privacy, integration, heterogeneity, Legal and ethical issues- HIPAA, GDPR, regulatory policies in healthcare data management, Big Data lifecycle in medical context.

UNIT – II BIG DATA INFRASTRUCTURE FOR HEALTHCARE	9

Data acquisition and ingestion from medical devices, imaging systems, and hospital records, Storage technologies- Hadoop Distributed File System (HDFS), Data Lakes, Cloud storage, Introduction to distributed computing: Hadoop MapReduce, Apache Spark, Databases for healthcare- Relational (SQL), Non-relational (NoSQL - MongoDB, Cassandra), Interoperability and healthcare data standards- HL7, DICOM, FHIR.

UNIT – III DATA PROCESSING AND ANALYTICS TECHNIQUES	9

Data preprocessing- data cleaning, normalization, transformation, handling missing values, Feature selection and dimensionality reduction techniques, Exploratory Data Analysis (EDA) and visualization tools, Introduction to machine learning for medical data- classification, regression, clustering, Tools and frameworks- Python (Pandas, Scikit-learn), R, Apache Spark MLlib.

UNIT – IV MEDICAL APPLICATIONS OF BIG DATA ANALYTICS	9

Clinical Decision Support Systems (CDSS), Predictive modeling- disease outbreak prediction, risk analysis, Genomics and personalized medicine, Real-time monitoring using wearable/IoT data, Drug discovery and development analytics.

UNIT – V ADVANCED TRENDS IN MEDICAL BIG DATA ANALYTICS	9

Deep Learning in medical imaging and diagnostics, Natural Language Processing (NLP) for clinical notes and records, Federated learning for decentralized healthcare data, Digital twins and simulation of patient conditions, Data security, governance, and compliance in medical big data, Ethical AI and future directions in intelligent healthcare systems.

| | | **Total Periods:** | **45** |

Text Books:	

1. Katherine Marconi, Harold Lehmann, "Big Data and Health Analytics", CRC Press, 1st Edition, 2014.
2. Poonam Tanwar, Bhuvnesh Kumar, Raghvendra Kumar, "Big Data Analytics in Healthcare", Springer, 1st Edition, 2020.
3. Farrokh Alemi, David G. Levy, "Big Data in Healthcare: Statistical Analysis for the Healthcare Professional", Routledge, 1st Edition, 2019.
4. David Stephenson, "Big Data Analytics: A Practical Guide for Managers", Pearson FT Press, 1st Edition, 2015.

References:	

1. Chandan K. Reddy, Charu C. Aggarwal, "Healthcare Data Analytics", CRC Press, 1st Edition, 2015.
2. Sergio Consoli, Diego Reforgiato Recupero, Milan Petković, "Data Science for Healthcare: Methodologies and Applications", Springer, 1st Edition, 2019.
3. Aboul Ella Hassanien, Nilanjan Dey, S. A. Ashour, "Machine Learning and Big Data Analytics Paradigms: Analysis, Applications and Challenges", Springer, 1st Edition, 2020.
4. Miltiadis Lytras, Amit Kumar Tyagi, Akshi Kumar, "Artificial Intelligence and Big Data Analytics for Smart Healthcare", Springer, 1st Edition, 2021.

CO's- PO's & PSO's MAPPING

Course Outcomes	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO 1	3	-	-	-	-	2	-	-	-	-	2	2	-	-
CO 2	3	-	-	-	-	2	-	-	-	-	2	2	-	-
CO 3	3	2	2	-	2	2	-	-	-	-	2	2	-	2
CO 4	3	-	-	-	-	2	-	-	-	-	2	2	-	-
CO 5	3	2	2	-	2	2	-	-	-	-	2	2	-	2
CO 6	3	-	-	-	-	2	2	-	-	-	2	2	-	-

1: Slight (Low)   2: Moderate (Medium)   3: Substantial (High)

231BMV55	DATA MINING IN HEALTHCARE		L	T	P	C
			3	0	0	3

Programme:	**B.E. Biomedical Engineering**	**Category:**	**PE**

AIM:	To extract patterns, trends, and knowledge from large datasets using data mining techniques

Course Outcomes: The Students will be able to

CO1:	Explain the basics of data mining and various types of data preprocessing techniques
CO2:	Apply association rule mining techniques to discover useful patterns and relationships from large datasets
CO3:	Make use of classification methods such as decision trees, Bayesian models, SVM, and others to categorize and analyze data.
CO4:	Apply prediction models and evaluate their accuracy using different statistical measures
CO5:	Summarize advanced data mining techniques for mining spatial, multimedia, text, and web data
CO6:	Identify data mining applications in healthcare, including areas like predictive medicine, fraud detection, and treatment analysis.

UNIT – I INTRODUCTION TO DATA MINING	**9**

Data Mining Functionalities – Data Pre-processing – Data Cleaning – Data Integration and Transformation – Data Reduction – Data Discretization and Concept Hierarchy Generation-Architecture Of A Typical Data Mining Systems- Classification Of Data Mining Systems.

UNIT – II ASSOCIATION RULE MINING	**9**

Association Rule Mining: - Efficient and Scalable Frequent Item set Mining Methods – Mining Various Kinds of Association Rules – Association Mining to Correlation Analysis – Constraint-Based Association Mining

UNIT – III CLASSIFICATION TECHNIQUES IN DATA MINING	**9**

Issues Regarding Classification- Classification by Decision Tree Introduction – Bayesian Classification – Rule Based Classification – Classification by Back propagation – Support Vector Machines – Associative Classification – Lazy Learners – Other Classification Methods

UNIT – IV PREDICTION & ADVANCED DATA MINING	**9**

Issues Regarding Prediction – Accuracy and Error Measures – Evaluating the Accuracy of a Classifier or Predictor – Ensemble Methods – Model Section. Mining Object, Spatial, Multimedia, Text and Web Data: Multidimensional Analysis and Descriptive Mining of Complex Data Objects – Spatial Data Mining – Multimedia Data Mining – Text Mining – Mining the World Wide Web Introduction to big data, big data analytics, NoSQL systems, Hadoop, PIG and HIVE

UNIT – V APPLICATIONS OF DATA MINING IN HEALTHCARE	**9**

Applications of data mining in Healthcare-predictive medicine, customer relationship management, detection of fraud and abuse, management of healthcare and measuring the effectiveness of certain treatments

	Total Periods:	45

Text Books:	

1. Jiawei Han, Micheline Kamber and Jian Pei, "Data Mining Concepts and Techniques", Third Edition, Elsevier, 2011.

References:	

1. Pang-Ning Tan, Michael Steinbach and Vipin Kumar, "Introduction to Data Mining", Pearson Education, 2006.
2. Ian H. Witten, Eibe Frank and Mark A. Hall, "Data Mining: Practical Machine Learning Tools and Techniques", Third Edition, Elsevier, 2011.
3. Mohammed J. Zaki and Wagner Meira Jr., "Data Mining and Analysis: Fundamental Concepts and Algorithms", Cambridge University Press, 2014.
4. Christopher M. Bishop, "Pattern Recognition and Machine Learning", Springer, 2006.

CO's- PO's & PSO's MAPPING

Course Outcomes	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO 1	3	-	-	-	-	-	-	-	-	-	2	2	-	-
CO 2	3	2	2	-	-	-	-	-	-	-	2	2	-	-
CO 3	3	2	2	-	-	-	-	-	-	-	2	2	-	-
CO 4	3	2	2	-	-	-	-	-	-	-	2	2	-	-
CO 5	3	2	2	-	-	-	-	-	-	-	2	2	-	-
CO 6	3	2	2	-	-	2	2	-	-	-	2	2	-	-

1: Slight (Low)   2: Moderate (Medium) 3: Substantial (High)

231BMV56	BODY AREA NETWORKS	L	T	P	C
		3	0	0	3

Programme:	B.E.-Biomedical Engineering	Category:	PE

AIM:	To teach students about the technology that uses small, low-power wireless devices to monitor and communicate with the human body.

Course Outcomes: The Students will be able to

CO1:	Explain basic concepts of Body Area Network.
CO2:	Describe the hardware components used in Body Area Network.
CO3:	Analyze the role of wireless communication in Body Area Network.
CO4:	Evaluate the coexistence issues in Body Area Network.
CO5:	Interpret the security challenges and privacy concerns in Body Area Network.
CO6:	Outline the applications of Body Area Network

UNIT – I INTRODUCTION	9

Definition, BAN and Healthcare, Technical Challenges- Sensor design, biocompatibility, Energy Supply, optimal node placement, number of nodes, System security and reliability, BAN Architecture – Introduction

UNIT – II HARDWARE FOR BAN	9

Processor-Low Power MCUs, Mobile Computing MCUs ,Integrated processor with radio transceiver, Memory ,Antenna-PCB antenna, Wire antenna, Ceramic antenna, External antenna, Sensor Interface, Power sources- Batteries and fuel cells for sensor nodes.

UNIT – III WIRELESS COMMUNICATION AND NETWORK	9

RF communication in Body, Antenna design and testing, Propagation, Base Station-Network topology-Stand –Alone BAN, Wireless personal Area Network Technologies-IEEE 802.15.1,IEEE P802.15.13, IEEE 802.15.14, Zigbee

UNIT – IV COEXISTENCE ISSUES WITH BAN	9

Interferences – Intrinsic - Extrinsic, Effect on transmission, Counter measures- on physical layer and data link layer, Regulatory issues-Medical Device regulation in USA and Asia, Security and Self-protection-Bacterial attacks, Virus infection, Secured protocols, Self-protection.

UNIT – V APPLICATIONS OF BAN	9

Monitoring patients with chronic disease, Hospital patients, Elderly patients, Cardiac arrythmias monitoring, Multi patient monitoring systems, Multichannel Neural recording, Gait analysis, Sports Medicine, Electronic pill.

Total Periods:	45

Text Books:	

1. Annalisa Bonfiglio, Danilo De Rossi, "Wearable Monitoring Systems", Springer, 2011.
2. Sandeep K.S. Gupta, Tridib Mukherjee, Krishna Kumar Venkata Subramanian, "Body Area Networks Safety, Security, and Sustainability'', Cambridge University Press, 2013.

References:	

1. Zhang, Yuan-Ting, "Wearable Medical Sensors and Systems'', Springer, 2024
2. Guang-Zhong Yang (Ed.), "Body Sensor Networks'', Springer, 2006.
3. Mehmet R. Yuce, Jamil Y.Khan, "Wireless Body Area Networks Technology, Implementation, and Applications", Pan Stanford Publishing Pte. Ltd., Singapore, 2012.

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	-	-	-	-	2	2	-	-	-	2	2	-	-
CO2	3	-	-	-	-	2	2	-	-	-	2	2	-	-
CO3	3	2	2	-	-	2	2	-	-	-	2	2	-	-
CO4	3	2	2	-	-	2	2	-	-	-	2	2	-	-
CO5	3	-	-	-	-	2	2	-	-	-	2	2	-	-
CO6	3	-	-	-	-	2	2	-	-	-	2	2	-	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231BMV57	**TELE HEALTH TECHNOLOGY**	L	T	P	C
		3	0	0	3

Programme:	**B.E.- Biomedical Engineering**	**Category:**	**PE**

AIM:	Gain the knowledge of concept in telemedicine and to know the Security Standards in Telemedicine Applications.

Course Outcomes: The Students will be able to

CO1:	Explain the fundamental need of telemedicine.
CO2:	Comprehend the various types of information and communication in telemedicine.
CO3:	Interpret ethical and legal aspects of telemedicine.
CO4:	Realize the various data acquisition and storage system in medical field.
CO5:	Describe the role of Internet in telemedicine
CO6:	Illustrate the e health system using telemedicine

UNIT – I FUNDAMENTALS OF TELEMEDICINE	9

History of telemedicine, definition of telemedicine, tele-health, tele-care, scope, Telemedicine Systems, benefits & limitations of telemedicine.

UNIT–II COMMUNICATION INFRASTRUCTURE FOR TELEMEDICINE	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 – III ETHICAL AND LEGAL ASPECTS OF TELEMEDICINE	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 – IV PICTURE ARCHIVING AND COMMUNICATION SYSTEM	9

Introduction to radiology information system and ACS, DICOM, PACS strategic plan and needs assessment, technical Issues, PACS architecture.

UNIT – V APPLICATIONS OF TELEMEDICINE	9

Tele radiology, tele pathology, tele cardiology, tele oncology, tele dermatology, tele surgery, e Health and Cyber Medicine.

Total Periods:		**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)

References:	

1. Richard Wootton, John Craig, Victor Patterson, "Introduction to Telemedicine, second edition, 2013.
2. Olga Ferrer Roca, Marcelo Sosa Iudicissa, ―Handbook of Telemedicine‖, IOS Press, Netherland, 2002.
3. Khandpur R S, ―Handbook of Biomedical Instrumentation‖, Tata McGraw Hill, New Delhi, 2003.
4. Keith J Dreyer, Amit Mehta, James H Thrall, ―Pacs: A Guide to the Digital Revolution‖, Springer, New York, 2002.
5. Khandpur R S, ―TELEMEDICINE – Technology and Applications‖, PHI Learning Pvt Ltd., New Delhi, 2017

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	-	-	-	-	2	2	-	-	-	2	2	-	-
CO2	3	-	-	-	-	2	2	-	-	-	2	2	-	-
CO3	3	-	-	-	-	2	2	-	-	-	2	2	-	-
CO4	3	-	-	-	-	2	2	-	-	-	2	2	-	-
CO5	3	-	-	-	-	2	2	-		-	2	2	-	-
CO6	3	-	-	-	-	2	2	-	-	--	2	2	-	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231BMV58	VIRTUAL REALITY AND AUGMENTED REALITY IN HEALTHCARE	L	T	P	C
		3	0	0	3
Programme:	**B.E.- Biomedical Engineering**	**Category:**		**PE**	
AIM:	To improve patient care and access to healthcare services.				

Course Outcomes: The Students will be able to

CO1:	Explain the concept of virtual environment with I/O devices.
CO2:	Explain the various VR modelling techniques.
CO3:	Build the VR system for content creation
CO4:	Develop web based VR system.
CO5:	Develop mobile based VR system.
CO6:	Explain use of VR and AR applications in different fields.

UNIT – I INTRODUCTION to VR and AR	9
Introduction- difference between AR and VR , The three I's of virtual reality-commercial VR technolgy and the five classic components of a VR system - Input Devices: (Trackers, Navigation, and Gesture Interfaces): Three-dimensional position trackers, navigation and manipulation-interfaces and gesture interfaces-Output Devices: Graphics displays-sound displays & haptic feedback, Mixed reality.	
UNIT – II VR DEVELOPMENT PROCESS	**9**
Geometric modeling-kinematics modeling-physical modeling- behaviour modeling-model management.	
UNIT – III CONTENT CREATION CONSIDERATIONS	**9**
Methodology and terminology-user performance studies-VR health and safety issues-Unstability of virtual reality system- cyber sickness -side effects of exposures to virtual reality environment.	
UNIT – IV VR ON THE WEB & VR ON THE MOBILE	**9**
JS-pros and cons-building blocks (WebVR, WebGL, Three.js, device orientation events)-frameworks (A-frame, React VR)-Google VR for Android-Scripts, mobile device configuration, building to android-cameras and interaction-teleporting-spatial audio-Assessing human parameters-device development and drivers-Design Haptics.	
UNIT – V APPLICATIONS	**9**
Extended Reality in Medical applications-military applications-robotics applications-Advanced Real time Tracking-other applications- games, movies, simulations, therapy.	
Total Periods:	**45**

Text Books:	

1. *Virtual Reality Technology* by **Grigore C. Burdea and Philippe Coiffet is the 3rd edition, 2024.**
2. C. Burdea& Philippe Coiffet, "Virtual Reality Technology", Second Edition, Gregory, JohnWiley& Sons,Inc.,2008.
3. Jason Jerald. 2015. The VR Book: Human-Centred Design for Virtual Reality. Association for Computing Machinery and Morgan & Claypool, NewYork, NY, USA.

References:	

1. Augmented Reality: Principles and Practice (Usability) by Dieter Schmalstieg & Tobias Hollerer, Pearson Education (US), Addison-Wesley Educational Publishers Inc, New Jersey, United States, 2016. ISBN: 9780321883575.

2. Practical Augmented Reality: A Guide to the Technologies, Applications, and Human Factors for AR and VR (Usability),Steve Aukstakalnis, Addison-Wesley Professional; 1edition,2016.

3. The Fourth Transformation: How Augmented Reality & Artificial Intelligence Will Change Everything, Robert Scoble & Shel Israel, Patrick Brewster Press;1 edition, 2016.

4. Learning Virtual Reality: Developing Immersive Experiences and Applications for Desktop, Web, and Mobile, Tony Parisi, O'Reilly Media;1 edition,2015.

5. Programming 3D Applications with HTML5 and Web GL: 3D Animation and Visualization for Web Pages,Tony Parisi, O'Reilly Media;1 edition,2014.

6. Learning Three.js: The JavaScript 3D Library for WebGL - Second Edition, Jos Dirksen, Packet Publishing- ebooks Account;2nd Revised ed.Edition 2015.

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	-	-	-	-	2	-	-	-	-	2	2	-	-
CO2	3	2	2	-	-	2	-	-	-	-	2	2	-	-
CO3	3	-	-	-	-	2	-	-	-	-	2	2	-	-
CO4	3	2	2	-	-	2	-	-	-	-	2	2	-	-
CO5	3	2	2	-	-	2	-	-	-	-	2	2	-	-
CO6	3	-	-	-	-	2	-	-	-	-	2	2	2	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

VERTICAL - VI

231BMV61	ADVANCEMENTS IN HEALTHCARE TECHNOLOGY	L	T	P	C
		3	0	0	3

Programme:	B.E. - Biomedical Engineering	Category:	PE

AIM:	To equip students with knowledge of emerging digital health tools and wearable devices.

Course Outcomes: The Students will be able to

CO1:	Interpret the fundamental requirements and regulations of digital healthcare systems.
CO2:	Explain digital radiology systems, image archiving, and hospital system integration.
CO3:	Summarize the e-health applications in healthcare networking.
CO4:	Illustrate the technologies of mobile healthcare and wearable device.
CO5:	Outline the multimodal healthcare solutions and standards.
CO6:	Apply the government health schemes in digital healthcare systems.

UNIT – I DIGITAL HEALTH	9

Digital Health: Requirements and best practices, Laws and regulations in Digital health, Ethical issues, barriers and strategies for innovation.

UNIT – II DIGITAL RADIOLOGY	9

Digital history of radiology, Digital radiology for digital hospital, picture archiving and communication, system integration, medical image archives, storage and networks.

UNIT – III E-HEALTH	9

E-Health: Health care networking (LAN/WAN, HIS), medical reporting using speech recognition, physiological tests and functional diagnosis with digital methods, tele-consultation in medicine and radiology.

UNIT – IV M-HEALTH	9

Introduction to mobile healthcare device, components of M-Health, Wireless communication- WiFi,BLE,4G/5G, Cloud computing and software platform, Case study – Chronic disease management(diabetes and cardiac care), Mobile telemedicine and virtual consultant, Maternal and child health monitoring.

UNIT – V MODALITY AND STANDARDS FOR INTER-OPERABILITY	9

Multimodality registration in daily clinical practice. Mobile healthcare. Selection and Implementation in e-Health project, design of medical equipment based on user needs. Security and privacy in digital health care. Case study- Case study for Government Health Schemes - Information on Drug delivery for lysosomal Storage Diseases.

Total Periods:	45

Text Books:	

1. Christoph Thuemmler, ChunxueBai, "Health 4.0: How Virtualization and Big Data are Revolutionizing Healthcare", Springer, 1st ed. 2017.
2. WlaterHruby, "Digital revolution in radiology – Bridging the future of health care, second edition, Springer, New York. 2006.
3. Samuel A. Fricker, ChristophThümmler ,AnastasiusGavras, "Requirements Engineering For Digital Health", Springer, 2015.

References:	

1. Rick Krohn (Editor), David Metcalf, Patricia Salber, "Health-e Everything: Wearables and The Internet of Things for Health, ebook. 2016.
2. Khandpur, R.S,"Handbook of Biomedical Instrumentation ",Third Edition. Tata McGraw Hill Pub. Co., Ltd. 2014

3. John, G. Webster. Medical Instrumentation: Application and Design. Third Edition. Wiley Publisher, New Delhi. 2020McGraw Hill Pub. Co., Ltd. 2020.

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	-	-	-	-	2	2	-	-	-	2	2	-	-
CO2	3	-	-	-	-	2	2	-	-	-	2	2	-	-
CO3	3	-	-	-	-	2	2	-	-	-	2	2	-	-
CO4	3	-	-	-	-	2	2	-	-	-	2	2	2	-
CO5	3	-	-	-	-	2	2	-	-	-	2	2	-	-
CO6	3	-	-	-	-	2	2	-	-	-	2	2	2	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231BMV62	WEARABLE DEVICES	L	T	P	C
		3	0	0	3
Programme:	**B.E. - Biomedical Engineering**	**Category:**		**PE**	
AIM:	To gain knowledge of sensors and its application in wearable systems on the basis of different case studies.				

Course Outcomes: The Students will be able to

CO1:	Outline the concepts of wearable system and the wearable sensors to monitor vital parameters.
CO2:	Explain the principle of signal processing for wearable devices
CO3:	Analyze the various energy harvesting techniques for wearable devices
CO4:	Demonstrate the concepts of BAN for healthcare.
CO5:	Illustrate the principle of smart textiles
CO6:	Identify the application of various wearable devices for patients.

UNIT – I INTRODUCTION TO WEARABLE SYSTEMS AND SENSORS	9

Wearable Systems- Introduction, Need for Wearable Systems, Drawbacks of Conventional Systems for Wearable Monitoring, Applications of Wearable Systems, Types of Wearable Systems, Components of wearable Systems. Sensors for wearable systems-Inertia movement sensors, Respiration activity sensor, Impedance plethysmography, pneumography, Wearable ground reaction force sensor.

UNIT – II SIGNAL PROCESSING AND ENERGY HARVESTING FOR WEARABLE DEVICES	9

Wearability issues -physical shape and placement of sensor, Technical challenges - sensor design, signal acquisition, sampling frequency for reduced energy consumption, Rejection of irrelevant information. Power Requirements- Solar cell, Vibration based, Thermal based, Human body as a heat source for power generation, Hybrid thermoelectric photovoltaic energy harvests, Thermopiles.

UNIT – III WIRELESS HEALTH SYSTEMS	9

Need for wireless monitoring, Definition of Body area network, BAN and Healthcare, Technical Challenges- System security and reliability, BAN Architecture – Introduction, Wireless communication Techniques.

UNIT – IV SMART TEXTILE	9

Introduction to smart textile- Passive smart textile, active smart textile. Fabrication Techniques- Conductive Fibres, Treated Conductive Fibres, Conductive Fabrics, and Conductive Inks. Case study- smart fabric for monitoring biological parameters - ECG, respiration.

UNIT – V APPLICATIONS OF WEARABLE SYSTEMS	9

Medical Diagnostics, Medical Monitoring-Patients with chronic disease, Hospital patients, Elderly patients, neural recording, Gait analysis, Sports Medicine.

Total Periods:	45

Text Books:	

1.Annalisa Bonfiglo and Danilo De Rossi, Wearable Monitoring Systems, Springer, August 2021
2.Zhang and Yuan-Ting, Wearable Medical Sensors and Systems,Springer, May 2024
3.Edward Sazonov and Micheal R Neuman, Wearable Sensors: Fundamentals, Implementation and Applications, Elsevier, august 2014
4.Mehmet R. Yuce and JamilY.Khan, Wireless Body Area Networks Technology, Implementation applications,Pan Stanford Publishing Pte.Ltd, Singapore, 2012

References:	

1. Sandeep K.S, Gupta, Tridib Mukherjee and Krishna Kumar Venkatasubramanian, Body Area Networks Safety, Security, and Sustainability, Cambridge University Press, 2013.
2. Guang-Zhong Yang, Body Sensor Networks, Springer, 2014.

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	-	-	-	-	2	2	-	-	-	2	2	2	-
CO2	3	-	-	-	-	2	2	-	-	-	2	2	2	-
CO3	3	-	-	-	-	2	2	-	-	-	2	2	2	-
CO4	3	-	-	-	-	2	2	-	-	-	2	2	2	-
CO5	3	-	-	-	-	2	2	-	-	-	2	2	2	-
CO6	3	-	-	-	-	2	2	-	-	-	2	2	2	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231BMV63	3D PRINTING IN MEDICINE	L	T	P	C
		3	0	0	3

Programme:	**B.E.-Biomedical Engineering**	**Category:**	**PE**

AIM:	To understand the use of 3D printing technology in improving medical treatment, surgical planning, and patient-specific healthcare solutions.

Course Outcomes: The Students will be able to

CO1:	Outline the fundamentals and classifications of additive manufacturing processes.
CO2:	Explain various 3D printing technologies, file formats, and materials used.
CO3:	Apply DICOM image processing and CAD tools for 3D model generation.
CO4:	Interpret medical 3D printing workflows and their application in radiology-based labs.
CO5:	Utilize the applications of 3D printing in different medical specialties.
CO6:	Make use of FDA regulations and quality control for 3D-printed medical devices.

UNIT – I INTRODUCTION TO ADDITIVE MANUFACTURING AND BASIC PRINCIPLES	9

Introduction to Additive Manufacturing - Overview and classification of processes- Process Principles - Basic and physical principles of layer generation - Digital Workflow - Layer information generation (CAD to slicing) - Integration and Applications - Role in product development and rapid prototyping evaluation

UNIT – II 3D PRINTING TECHNOLOGIES	9

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 – III POST-PROCESSING OF DICOM IMAGES	9

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 – IV APPLICATION OF 3D PRINTING IN MEDICINE	9

3D Printing in Neurosurgery, Cardiovascular 3D Printing, Musculoskeletal 3D Printing, Craniofacial Applications, Medical Imaging and Digital Design of Patient-Matched Implants

UNIT – V FDA REGULATORY AND TECHNICAL CONSIDERATIONS	9

The FDA's Role, 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 Periods:	**45**

Text Books:	

1. Rybicki, Frank J., and Gerald T. Grant. "3D printing in medicine." Cham: Springer International Publishing (2017).

References:	

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).

CO's- PO's & PSO's MAPPING

Course Outcomes	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO 1	3	-	-	-		2	-	-	-	-	2	3	-	-
CO 2	3	-	-	-		2	-	-	-	-	2	3	-	-
CO 3	3	2	2	-	2	2	-	-	-	-	2	3	-	2
CO 4	3	-	-	-		2	-	-	-	-	2	3	-	-
CO 5	3	-	-	-		2	2	-	-	-	2	3	-	-
CO 6	3	-	-	-		2	3	-	-	-	2	3	-	-

1: Slight (Low)   2: Moderate (Medium) 3: Substantial (High)

231BMV64	ADVANCED MEDICAL DEVICES		L	T	P	C
			3	0	0	3
Programme:	**B.E.- Biomedical Engineering**		Category:		**PE**	
AIM:	To provide the students with in-depth knowledge of advanced medical instruments and emerging trends in medical technology.					

Course Outcomes: The Students will be able to

CO1:	Explain the principles and safety of physiotherapy equipment.
CO2:	Interpret the functionality and applications of neonatal care devices.
CO3:	Explain the operation and applications of key dental equipment.
CO4:	Explain the principles, components, and applications of ENT equipment
CO5:	Classify the advanced ophthalmic instruments and imaging systems.
CO6:	Outline the recent trends in medical devices to enhance healthcare solutions.

UNIT – I PHYSIOTHERAPY EQUIPMENT	9

Rehabilitation and Assistive Devices: Continuous Passive Motion (CPM) Instrument, Functional Electrical Stimulation (FES): principles and safety - Key Nerve Stimulation Technologies: Phrenic Nerve Stimulator (PNS): indications and benefits, Overview of Occipital nerve stimulator (ONS), Deep Brain Stimulator (DBS), Lower Esophageal Stimulator (LES), Percutaneous Electrical Nerve Stimulator (PENS), and Spinal Cord Stimulators (SCS).

UNIT – II NEONATAL CARE EQUIPMENT	9

Fetal monitor: Monitoring parameters- fetal heart rate (FHR), uterine activities (UA), Infant incubator- Principle, functional components and features, potential safety hazards, Phototherapy lights: Principles and Features, Infant resuscitators, fetal blood flow detector, fetal vacuum extractor, Neonatal monitoring system, radiant warmer, neonatal Ventilator and high frequency ventilator.

UNIT – III DENTAL AND ENT EQUIPMENT	9

Dental Equipment: Overview, Amalgamator, casting machine, furnace, sandblaster, Endomotors, workstations - ENT Diagnostic Tools: ENT unit principles, Otoscope, Tuning fork tests, Rigid endoscopy, Video stroboscopy, Video Nystagmography (VNG) - Hearing Assessment Technologies: Otoacoustic Emission (OAE): principle, components, types, Tympanic Thermometers: working and block diagram, Digital Hearing Aids: design, components, wireless and binaural types, Hearing Aid Analyzer: principle, setup, test types, applications.

UNIT – IV OPTHALMIC EQUIPMENT	9

Anterior Segment Examination: Keratometer, Corneal Topography, Non-contact Tonometry, Ocular Response Analyzer (ORA) - Retinal Imaging: Ophthalmoscopes (direct, indirect, binocular), Fundus Camera (Retinography), Optical Coherence Tomography (OCT) - Refraction Tests: Objective: Retinoscope, Optometers, Subjective: Visual Acuity Charts, Phoropters, Trial Lenses, Contrast Sensitivity Test.

UNIT – V RECENT TRENDS	9

Gas Chromatography Principle and components. Hyperbaric Oxygenation Chamber- Principle, construction and oxygen supply. Incinerator- Purpose, components and types (controlled air, excess air and rotary kiln), Proton therapy, CPR Manikin, calibration of devices pertaining to national and international standards ISO 17025.

Total Periods:		45
Text Books:		

1. G. Webb, Principles of Biomedical Instrumentation, Cambridge University Press First Edition, 2018. 2. Anthony Y. K Chan, Biomedical Device Technology Principles and Design, Charles C Thomas Publisher, 3rd Edition (2021) 4. Laurence J. Street, Introduction to Biomedical Engineering Technology, CRCPress, 5th Edition (2022). 5. R.S.Khandpur, Compendium of Biomedical Instrumentation Vol I, Iland III, 1st Edition, Wiley(2019). 6. Artal, Pablo- Handbook of Visual Optics, Volume One Fundamental Sand Eye Optics-CRC Press, Taylor and Francis (2017) 7. Dennis Fitzpatrick-Implantable Electronic Medical Devices - Academic Press (2014).		
References:		
1. Joseph J. Carr and John M.Brown, "Introduction to Biomedical equipment technology", Pearson Education, 4th Edition, 2014. 2. Myer Kutz, "Biomedical Engineering and Design Handbook: Volume 1 and 2", McGraw-Hill Publisher, 2nd Edition, 2009. 3. L. A Geddes and L.E.Baker, "Principles of Applied Biomedical Instrumentation", John Wiley and Sons, 3rd Edition, Reprint 2008.		

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	-	-	-	-	2	-	-	-	-	2	2	3	-
CO2	3	-	-	-	-	2	-	-	-	-	2	2	3	-
CO3	3	-	-	-	-	2	-	-	-	-	2	2	3	-
CO4	3	-	-	-	-	2	-	-	-	-	2	2	3	-
CO5	3	-	-	-	-	2	2	-	-	-	2	2	3	-
CO6	3	-	-	-	-	2	-	-	-	-	2	2	3	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

		L	T	P	C
231BMV65	**DRUG DELIVERY SYSTEMS**	3	0	0	3

Programme:	**B.E.-Biomedical Engineering**	Category:	PE
AIM:	To provide a comprehensive understanding of drug delivery systems with an emphasis on the mechanisms, challenges, and advancements in targeted and controlled drug release therapies.		

Course Outcomes: The Students will be able to

CO1:	Explain the characteristics of polymers and concepts of drug delivery systems.
CO2:	Illustrate the principles and technology used in the Organ specific drug delivery
CO3:	Outline the skin structure, drug permeation, and transdermal drug delivery systems.
CO4:	Infer the implantable drug delivery systems.
CO5:	Explain the structure, function, and barriers in peptide and protein drug delivery systems.
CO6:	Summarize the monoclonal antibody delivery and advances in insulin therapy.

UNIT – I POLYMERS & DRUG DELIVERY SYSTEMS	**9**

Polymers used in drug delivery systems - Ideal characteristics, Classification, advantages and disadvantages of polymer. Concepts of Targeted drug delivery systems. Properties of drugs - pharmacokinetic properties of drugs, Physio-chemical biological properties of drugs. Concepts - Sustained release formulations, Controlled drug delivery systems, Therapeutic index, Nanoparticles - Liposomes and its classification, Microspheres, Hydrogels.

UNIT – II ORGAN-SPECIFIC DRUG DELIVERY	**9**

Need for Non-Oral Drug Delivery: Rectal, Transdermal, Buccal, Nasal routes-Nasal Drug Delivery: Barriers and key formulation factors-Ocular Drug Delivery: Challenges and enhancement strategies-Targeted Drug Delivery: Brain targeting and blood-brain barrier, Organ-specific delivery and its advantages

UNIT – III TRANSDERMAL DRUG DELIVERY SYSTEMS	**9**

Basics of Skin and Permeation: Structure of skin, drug permeation, advantages of transdermal route,   Factors affecting percutaneous absorption- Enhancement Strategies: Permeation enhancers: physical, chemical, electrical (e.g., iontophoresis) - TDDS Development: Key components and formulation approaches, Role of polymers, Controlled release products and devices

UNIT – IV IMPLANTABLE DRUG DELIVERY SYSTEMS	**9**

Implantable Micro–Pump Systems - Peristaltic Micropump, Osmotic Micropump, Diaphragm Micropump, Fluorocarbon Propellant. Driven Micropump - Solenoid Driver Reciprocate Micropump, Programmable Implanted Drug Administrative Device (DAD)

UNIT – V DRUG DELIVERY USING LARGE MOLECULES	**9**

Delivery system for Peptides and Proteins – Protein structure and function, Protein and peptide delivery, advantages, Barriers in protein delivery, routes of drug delivery in protein and peptide delivery system. Drug delivery using monoclonal antibodies. Development in insulin therapy using biomedical controlled drug delivery systems

	Total Periods:	**45**
Text Books:		

1. Dr. Pratima S. Shinde, "Comprehensive Textbook Of Drug Delivery Systems" Shashwat Publication, July 2024.
2. Ram I. Mahato, Ajit S. Narang, "Pharmaceutical Dosage Forms and Drug Delivery", CRC press, 3rd Edition, 2018.
3. Vasant V. Ranade, John B. Cannon, "Drug delivery systems" , CRC Press, 3rd Edition, 2011.

References:	

1. Vyas S.P., Khar R.K, "Targeted & Controlled Drug Delivery: Novel Carrier Systems", CBS Publishers, 3rd Edition, 2010.
2. Junginger H.E "Drug Targeting and Delivery- concepts in dosage form design", Taylor & Francis, 4th Edition, 2010.
3. Anya M. Hillery, Andrew W. Lloyd, James Swarbrick, "Drug Delivery and Targeting For Pharmacists and Pharmaceutical Scientists", CRC Press, 1st Edition, 2001

CO's- PO's & PSO's MAPPING

Course Outcomes	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO 1	3	-	-	-	-	2	2	-	-	-	2	3	-	-
CO 2	3	-	-	-	-	2	2	-	-	-	2	3	-	-
CO 3	3	-	-	-	-	2	2	-	-	-	2	3	-	-
CO 4	3	-	-	-	-	2	2	-	-	-	2	3	-	-
CO 5	3	-	-	-	-	2	2	-	-	-	2	3	-	-
CO 6	3	-	-	-	-	2	2	-	-	-	2	3	2	-

1: Slight (Low)   2: Moderate (Medium) 3: Substantial (High)

231BMV66	BIOPROSTHETIC SYSTEMS	L	T	P	C
		3	0	0	3
Programme:	**B.E.-Biomedical Engineering**	**Category:**		**PE**	

AIM:		To provide a basic knowledge of prosthetic systems, gait analysis, materials and fabrication techniques, and the application of robotics and control systems in bio-prosthetics.

Course Outcomes: The Students will be able to

CO1:	Explain the components, types, and fitting procedures of upper and lower limb prosthetics.
CO2:	Illustrate the normal and pathological gait patterns.
CO3:	Summarize the gait assessment and functional gait analysis.
CO4:	Apply materials and Fabrication methods in prosthetic design.
CO5:	Utilize the concepts of mechatronic hand design and control in prosthetics.
CO6:	Infer the application of robotics in Bioprosthetics.

UNIT – I BIO-PROSTHETICS	**9**

Introduction to Prosthetics: Brief history: early years to modern advancements - Prosthetic Components: Key parts and prescription criteria, Major types: Ankle/Foot, Transtibial, Transfemoral, Hip disarticulation - Lower Limb Prosthetics: Fitting, evaluation, gait analysis, and training for transtibial and transfemoral prostheses, Basics of bilateral amputation management-Upper Limb Prosthetics: Replacements for hand, wrist, and forearm, Overview of prosthetic fitting process.

UNIT – II GAIT & PROSTHETICS	**9**

Normal Gait, Kinetic and Kinematic Descriptors of human walking, Gait Cycle - weight acceptance, single limb support, limb advancement. Describing Pathological Gait - common gait deviations observed during stance and swing. Qualitative gait assessment. Instrumented gait analysis - technology in gait assessment, Function based assessment. Clinical Examples of Gait Deficiencies: Impact of Functional Tasks During Gait.

UNIT – III MATERIALS AND FABRICATION PROCESS	**9**

Materials used for prosthesis, Prescription Guidelines- Prosthetic prescription. Fabrication process – Measurement, Fabricating and modifying the positive model. Computer-aided design/ computer-aided manufacture – Data acquisition, shape-manipulation software, milling and production. Central fabrication and mass production. Technologies Poised to Transform Prosthetics and Rehabilitation .Maintenance of prostheses.

UNIT – IV PROSTHETIC AND ROBOTIC MECHANISM	**9**

Mechatronic Hands- Myoelectrically controlled hands, Components, Mechanisms and actuators, Power sources, Prosthetic socket. Mechanisms- Materials, Simple clamps, Curling fingers and pulleys, one four-bar linkage, two four-bar linkages. Sensors- Forces sensors, Slip and texture sensors, Position (angle). Control - Finger position, Object slip. Hand assessment – Procedure, Calculations, Manufacture, Standardisation, Reliability and validity.

UNIT – V APPLICATIONS OF ROBOTICS IN BIO PROSTHESIS	**9**

Bionic Arm- Kinematics of Adept Three Robot Arm, Robotic Grasping of Unknown Objects, Object-Handling Tasks Based on Active Tactile and Slippage Sensations. Robot Arm to Intentional Agent: The Articulated Head - Inter- Component Communication and Sensing, Attention model. Bio-inspired control for robot arms.

	Total Periods:	**45**

Text Books:	
1.Bella J. May, "Amputations and Prosthetics A Case Study Approach", Second Edition. Jaypee Brothers Medical Publishers (P) Ltd New Delhi, 2002 2. Kevin K.Chui, "Orthotics and Prosthetics in Rehabilitaion", Fourth Edition by Elsevier, 2020.	
References:	
1.Jacob Rosen, Blake Hannaford and Richard M. Satava , Editors, "Surgical Robotics Systems Applications and Visions", Springer 2011 2. Satoru Goto ,"Robot Arms", InTech Publisher 2011. 3. Robert Schilling, "Fundamentals of Robotics-Analysis and control", Prentice Hall, 2018. 4. J.J.Craig, "Introduction to Robotics", Pearson Education, 2017. 5. Staugaard, Andrew C,"Robotics and Artificial Intelligence: An Introduction to Applied Machine Learning", Prentice Hall Of India, 1987.	

CO's- PO's & PSO's MAPPING

Course Outcomes	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO 1	3	2	2	-	-	2	2	-	-	-	2	2	-	-
CO 2	3	2	2	-	-	2	2	-	-	-	2	2	-	-
CO 3	3	2	2	-	-	2	2	-	-	-	2	2	-	-
CO 4	3	2	2	-	-	2	2	-	-	-	2	2	-	-
CO 5	3	2	2	-	-	2	2	-	-	-	2	2	-	-
CO 6	3	2	2	-	-	2	2	-	-	-	2	2	-	-

1: Slight (Low)   2: Moderate (Medium) 3: Substantial (High)

231BMV67	HUMAN ASSIST DEVICES	L	T	P	C
		3	0	0	3

Programme:	B.E. - Biomedical Engineering	Category:	PE

AIM:	To gain the knowledge about principle, design and application of various human assist devices.

Course Outcomes: The Students will be able to

CO1:	Illustrate the various building blocks of Heart Lung Machine and artificial heart.
CO2:	Classify the various cardiac assist devices.
CO3:	Explain the components of hemodialysis and its monitoring systems.
CO4:	Outline the types and operating sequence of ventilators
CO5:	Summarize the operation of hearing aids and related wearable devices.
CO6:	Analyze TENS, TMS, and TDCS techniques with biofeedback through case studies.

UNIT – I HEART LUNG MACHINE AND ARTIFICIAL HEART	9

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, Schematic for temporary bypass of left ventricle.

UNIT – II CARDIAC ASSIST DEVICES	9

Assisted through Respiration, Right and left Ventricular Bypass Pump, Auxiliary ventricle, Open Chest and Closed Chest type, Intra-Aortic Balloon Pumping, Prosthetic Cardiac valves, Principle of External Counter pulsation techniques.

UNIT – III ARTIFICIAL KIDNEY	9

Indication and Principle of Haemodialysis, Membrane, Dial sate, types of filter and membranes, Different types of hemodialyzers, Monitoring Systems.

UNIT – IV RESPIRATORY AND HEARING AIDS	9

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, wearable devices for hearing correction.

UNIT – V RECENT TRENDS	9

Transcutaneous electrical nerve stimulator, Trans cranial magnetic stimulation (TMS) and Trans cranial direct current stimulation (TDCS), bio- feedback of TMS and TDCS.case study

	Total Periods:	45

Text Books:

1. Shish-Kai Liu, Rehabilitation Robotics: Technology and Application, 2021.
2. Marion M. O'Neill, Assistive Technology for Visually Impaired and Blind People, 2020.
3. Gray E Wnek, Gray L Browlin – Encyclopedia of Biomaterials and Biomedical Engineering –Marcel Dekker Inc New York 2004.
4. John. G. Webster – Bioinstrumentation - John Wiley & Sons (Asia) Pvt Ltd – 2004.

References:

1. John Enderle, Introduction to Biomedical Engineering (4th edition), 2011.
2. Peter Scott, Human Augmentation: The Dawn of the Age of Cyber Humans, 2020.
3. Gray E Wnek, Gray L Browlin, "Encyclopedia of Biomaterials and Biomedical Engineering" Marcel Dekker Inc New York 2004.
4. D.S. Sunder, "Rehabilitation Medicine", 3rd Edition, Jaypee Medical Publication,

2010.

5. Joseph D.Bronzino, The Biomedical Engineering Handbook, Third Edition: Three Volume Set, CRC Press, 2006.

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	-	-	-	-	2	2	-	-	-	2	3	2	-
CO2	3	-	-	-	-	2	2	-	-	-	2	3	2	-
CO3	3	-	-	-	-	2	2	-	-	-	2	3	2	-
CO4	3	-	-	-	-	2	2	-	-	-	2	3	2	-
CO5	3	-	-	-	-	2	2	-	-	-	2	3	2	-
CO6	3	2	2	2	2	2	2	-	-	-	2	3	2	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231BMV68	ROBOTICS IN MEDICINE	L	T	P	C
		3	0	0	3

Programme:	B.E.- Biomedical Engineering	Category:	PE

AIM:	To understand how robotics technologies can be integrated into healthcare to improve patient care.

Course Outcomes: The Students will be able to

CO1:	Explain the basics of robotic systems
CO2:	Analyze the Robotics system and formulate Kinematics.
CO3:	Analyze the robotic vision system to perform a specific task.
CO4:	Describe the kinematic motion planning solutions for various Robotic configurations.
CO5:	Explain the planar motion simulation models for robotic movement.
CO6:	Outline the applications of Robots in medicine.

UNIT – I INTRODUCTION TO ROBOTICS AND AUTOMATION	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 – II KINEMATICS	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 – III ROBOT VISION	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 – IV PLANNING	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 – V ROBOTIC APPLICATIONS IN MEDICINE	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 Periods:	45

Text Books:	

1. Schilling, Robert J. Fundamentals of robotics: analysis and control. Simon & Schuster Trade, 2003.
2. Craig, John J. Introduction to robotics: mechanics and control, 3/E. Pearson Education India, 2009.

References:	

1. Groover, Mikell P., Mitchel Weiss, Roger N. Nagel, Nicholas G. Odrey, and Ashish Dutta. Industrial robotics: technology, programming, and applications. 121 |KARE Department of Biomedical Engineering McGraw-Hill, 2017.

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

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	2	-	2	-	-	-	-	2	2	-	-
CO2	3	2	2	2	-	2	-	-	-	-	2	2	-	-
CO3	2	2	2	2	2	2	-	-	-	-	2	2	-	2
CO4	3	2	2	2	-	2	-	-	-	-	2	2	-	-
CO5	2	2	2	2	-	2	-	-	-	-	2	2	-	2
CO6	2	2	2	2	-	2	2	-	-	-	2	2	-	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231BMH01	BIOSENSOR TECHNOLOGY		L	T	P	C
			3	0	0	3
Programme:	**B.E. Biomedical Engineering**		**Category:**		**PE**	
AIM:	To provide an overview of biosensors, their types, working principles, and applications in medical diagnosis					

Course Outcomes: The Students will be able to

CO1:	Classify the types and different key features of biosensors.
CO2:	Interpret the enzyme-based biosensors and their various transduction techniques.
CO3:	Describe the principles, formats, and technologies used in immunosensors for biological detection.
CO4:	Explain the structure, properties, and recognition role of nucleic acids in biosensing.
CO5:	Summarize the different types of nucleic acid-based sensors and their transduction methods.
CO6:	Make use of nanomaterials in biosensors and their applications in medical diagnostics.

UNIT – I	FUNDAMENTALS OF BIOSENSOR	9

Definition- Historical development- Biological Recognition elements and Transduction: Electrochemical, Optical, Piezoelectric and Thermal. Methods of Immobilization of the Biological recognition elements in Biosensors, Choice of bioreceptor, Choice of transducer. Performance factors: calibration, selectivity, sensitivity, response time and stability.

UNIT – II	ENZYMATIC SENSORS	9

Role of enzymes in biosensors, Types of enzymatic biosensors: Potentiometric and Amperometric-FET-based enzyme sensors: ISFET, ENFET- Optical enzyme sensors: Absorption and fluorescence- Thermal enzyme sensors: Thermopile and Thermistor based sensors and Multienzyme thermal sensors - Basic concept of piezoelectric enzyme sensors.

UNIT – III	IMMUNOLOGICAL SENSORS	9

Basic structure and function of antibodies-Antigen, antibody interaction – Immobilization methods: Magnetic beads, Avidin, biotin-Immunoassay types: Direct, Indirect - Membrane-based immunosensors: Inorganic, organic, composite and hybrid- Piezoelectric systems - optical immunosensors : Ellipsometry, Surface plasmon resonance- Applications: Food allergen detection.

UNIT – IV	NUCLEIC ACID BASED BIOSENSORS	9

Nucleic acid structure and properties- Stability, Principles of nucleic acid hybridization, Nucleic acid analogs, Nucleic acids as receptors in recognition processes, Immobilization of nucleic acids, Transduction methods in nucleic acids sensors: Nucleic Acid Enzyme (NAE) based sensors, Fluorescent NAE sensors, Colorimetric NAE sensors, Electrochemical NAE sensors- Aptamer based sensors.

UNIT – V	NANOTECHNOLOGY BASED BIOSENSORS	9

Nanomaterials for sensing applications - Signal amplification using nanomaterials for biosensing – Nanomaterial based electro analytical biosensors for cancer and bone disease - Gold nanostructure LSPR based biosensors for biomedical diagnosis - DNA sensors employing nanomaterials for diagnostic applications.

Total Periods:		45
Text Books:		

1.Carr and Brown, "Introduction to Medical Equipment Technology", Addison Wesley, 2nd Edition, 1999.

2. J. G. Webster, "Medical Instrumentation; Application and Design", John Wiley & Sons,

5th Edition, 2015.

References:	

1. Gabor Harshanyi, "Sensors in Biomedical Applications, Fundamentals Technology and Applications", CRC Press,2000.
2. Graham Ramsay, "Commercial Biosensors", John Wiley & Sons, 1st edition, 1998.
3. Tran Minh Canh, "Sensor Physics & Technology – Biosensors", 1st Edition, Chapman & Hall, 1993.
4. Sabrie Soloman, "Sensors Hand Book", McGraw Hill, 2010

CO's- PO's & PSO's MAPPING

Course Outcomes	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO 1	3	-	-	-	-	2	-	-	-	-	2	3	-	-
CO 2	3	-	-	-	-	2	-	-	-	-	2	3	-	-
CO 3	3	-	-	-	-	2	-	-	-	-	2	3	-	-
CO 4	3	-	-	-	-	2	-	-	-	-	2	3	-	-
CO 5	3	-	-	-	-	2	-	-	-	-	2	3	-	-
CO 6	3	-	-	-	-	2	2	-	-	-	2	3	-	-

1: Slight (Low)   2: Moderate (Medium) 3: Substantial (High)

231BMH02	MEDICAL DEVICE DESIGN	L	T	P	C
		3	0	0	3
Programme:	B.E. - Biomedical Engineering	Category:			PE
AIM:	To prevent, diagnose, treat and rehabilitate illnesses and diseases in a safe and effective way.				

Course Outcomes: The Students will be able to

CO1:	Explain the medical devices standards and requirements.
CO2:	Summarize the concept of medical device development.
CO3:	Outline the concept of medical requirements.
CO4:	Infer the engineering design and project metrics.
CO5:	Demonstrate the testing and validation of medical equipments
CO6:	Interpret the various design transfer and manufacturing methods.

UNIT – I	NEEDS FINDING AND CONCEPT GENERATION	9

Strategic Focus – observation and problem identification – Need statement development. Ideation and Brain storming–concept screening, concept selection : intellectual property basics–reimbursement basics–business models– prototyping–final concept selection. Safety and Risk Management-Tools, Documents and Deliverables.

UNIT – II	MEDICAL DEVICES STANDARDS AND REQUIREMENTS	9

FDA, Medical devices classification, Medical Devices Directive Process – Harmonized Standards, ISO13485, ISO 14971, IEC 62304. Reliability, Concept of failure, Product Design and Development Process, IS 23485 Standard.

UNIT – III	DESIGN ENGINEERING	9

Hardware Design, Hardware Risk Analysis, Design and Project Metrics, Design for Six Sigma, Software Design, Software Coding, Software Risk Analysis, Software Metrics.

UNIT – IV	TESTING AND VALIDATION	9

Basis and Types of Testing, Hardware Verification and Data Analysis, Software Verification and Data Analysis.

UNIT – V	DESIGN TRANSFER AND MANUFACTURING	9

Transfer to Manufacturing, Hardware Manufacturing, Software Manufacturing, Configuration Management, Intellectual Property-Copy Rights-Trademarks-Trade Secrets, Case Study.

	Total Periods:	45

Text Books:

1. Zenios, Makower and Yock, ―Biodesign – The process of innovating medical technologies‖, Canbridge University Press,2nd edition, 2019.
2. Theodore R. Kucklick, The Medical Device R&D Handbook, Second Edition, CRC Press,2012
3. Peter O grodnik, Medical Device Design Innovation from Concept to Market,Elsevier,2nd edition, 2020.

References:

1. Richard C.Friesand Marcel Dekker A G, Handbook of Medical Device Design, 2nd edition, 2005.
2. Gail Baura, Medical Device Technologies : A Systems Based Overview Using Engineering, Elsevier science,2012.
3. Matthew Bret Weinger, Michael E. Wiklund, Daryle Jean Gardner- Bonneau

'Handbook of Human Factors in Medical Device Design',CRCpress,2010.
4.Jagdish Chaturvedi, Inventing medical devices: A perspective from India, Create Space Independent Publishing Platform, 1st edition, 2015.

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	-	-	-	-	2	2	-	-	-	2	3	-	-
CO2	3	-	-	-	-	2	2	-	-	-	2	3	-	-
CO3	3	2	2	-	-	2	2	-	-	-	2	3	2	-
CO4	3	2	2	-	-	2	2	-	-	-	2	3	2	-
CO5	3	2	2	-	-	2	2	-	-	-	2	3	2	-
CO6	3	2	2	-	-	2	2	-	-	-	2	3	2	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231BMH03	MEDICAL INFORMATICS	L	T	P	C
		3	0	0	3

Programme:	B.E.-Biomedical Engineering	Category:	PE

AIM:	To understand the basic structure of medical informatics and functional capabilities of the hospital information.

Course Outcomes: The Students will be able to

CO1:	Explain the structure and components of medical informatics.
CO2:	Infer the role of the internet in modern medicine.
CO3:	Identify security challenges in computer-based medical information systems.
CO4:	Summarize various bioinformatics tools and explore the databases
CO5:	Describe the various standards in hospitals.
CO6:	Illustrate the recent trends of health informatics, including medical, bioinformatics, clinical, nursing, and public health informatics.

UNIT – I INTRODUCTION TO MEDICAL INFORMATICS	9

Introduction - Structure of Medical Informatics –Internet and Medicine -Security issues , Computer based medical information retrieval, Hospital management and information system, Functional capabilities of a computerized HIS, Health Informatics – Medical Informatics, Bioinformatics, Clinical informatics, Nursing informatics, Public health informatics.

UNIT – II ELECTRONIC PATIENT RECORD AND STANDARDS	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 – III ELECTRONIC DECISION SUPPORT SYSTEMS	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 – IV BIOINFORMATICS TOOLS AND NORMS FOR HOSPITALS	9

NCBI, Human Genome Project, GenBank, Sequence alignment, BLAST, FASTA, CLUSTALW, Phylogenetic analyses. Design and construction standards for the hospitals, BIS –India, JCIA, AIA and NHS.

UNIT – V RECENT TRENDS IN MEDICAL INFORMATICS	9

Virtual reality and applications in medicine, Virtual endoscopy, computer assisted surgery, Surgical simulation, Computer assisted patient education and health - Medical education and health care information, computer assisted instruction in medicine, virtual hospitals, smart medicals homes, personalized e-health services.

Total Periods:	45

Text Books:	

   1.   Biomedical Informatics: Computer Applications in Health Care and
    Biomedicine by Edward H. Shortliffe and James J. Cimino is the 5th edition,
    published in 2021.
   2.   Mohan Bansal, "Medical informatics", Tata McGraw Hill Publishing Ltd,
    2003.
   3.   R.D.Lele, "Computers in medicine progress in medical informatics", Tata
    Mcgraw Hill, 2005.

References:	

1. KathrynJ.Hannah, MarionJ Ball, "HealthInformatics", 3rdEdition, Springer, 2006.

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	-	-	-	-	2	2	-	-	-	2	2	-	-
CO2	3	-	-	-	-	2	2	-	-	-	2	2	-	-
CO3	3	-	-	-	-	2	2	-	-	-	2	2	-	-
CO4	3	-	-	-	-	2	2	-	-	-	2	2	-	-
CO5	3	-	-	-	-	2	2	-	-	-	2	2	-	-
CO6	3	-	-	-	-	2	2	-	-	-	2	2	-	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231BMH04	CLINICAL TRIALS	L	T	P	C
		3	0	0	3

Programme:	B.E.-Biomedical Engineering	Category:	PE
AIM:	To provide students with a comprehensive understanding of drug discovery, clinical research processes, ethical guidelines, regulatory requirements, and trial management in clinical trials.		

Course Outcomes: The Students will be able to

CO1:	Describe the evolution of clinical research and compare drug discovery approaches.
CO2:	Explain the drug development process and regulatory aspects of clinical trials.
CO3:	Outline the ethical guidelines in clinical research.
CO4:	Explain the role of ICH in clinical research harmonization and the regulatory responsibilities.
CO5:	Describe the essential documents used in clinical trials and their role in ensuring compliance and transparency.
CO6:	Summarize the various management principles in clinical trials.

UNIT – I	FUNDAMENTALS OF DRUG DISCOVERY AND DEVELOPMENT	9

Introduction & History of clinical research, Drug discovery methods: Ligand-based, structure-based, high-throughput, in silico - IPR in drug discovery– Drug development phases: Phase 0 to Phase IV - Trial design basics: sampling, inclusion/exclusion, randomization, blinding, Regulatory submissions – IND, NDA - Clinical trials in India – Role of CDSCO.

UNIT – II	ETHICAL CONSIDERATIONS IN CLINICAL RESEARCH	9

Animal Research Ethics: Use of animals, opposition, alternatives, Scientist responsibilities, Indian legislation: INSA, ICMR, CPCSEA, IAEC - **Human Research Ethics:** Historical guidelines: Nuremberg Code, Declaration of Helsinki, Belmont Report, ICMR guidelines, Institutional Ethics Committee (IEC)

UNIT – III	GUIDELINES IN CLINICAL RESEARCH	9

International Conference on Harmonization (ICH) -Structure of ICH, Working groups, ICH Harmonization Process, ICH products: Quality, Safety, Efficacy and multidisciplinary guidelines – Principles of Good Clinical Practice: ICH E6, FDA, Drugs & Cosmetics Act - Responsibilities of Stakeholders: Sponsors, Investigators..

UNIT – IV	ESSENTIAL DOCUMENTS	9

Essential Documents in Clinical Trials: before, during and after the conduct of clinical trial - Standard Operating Protocols, Clinical Trial Protocol and Protocol Amendment(s), Investigator Brochure, Master Files, Informed Consent Form, Case Record Form, Trial report - CONSORT

UNIT – V	TRIAL MANAGEMENT	9

Project management in clinical trials – principles, application in clinical trial management - Risk assessment in clinical trials – Risk management principles – Project Auditing, Inspection, common pitfalls – Data management in clinical trials – Pharmaco vigilance: principles, strategies, challenges and opportunities – Pharmaco vigilance program in India (PVPI): Structure and function, case studies on drug toxicity reported during post marketing surveillance

Total Periods:	

Text Books:	

1. Benjamin E Blass, "Basic Principles of Drug Discovery and Development" Academic Press, 2015
2. Lawrence M. Friedman, Curt D. Furberg, David L. DeMets, David M. Reboussin, Christopher B. Granger,
"Fundamentals of Clinical Trials" 5th edition, Springer, 2015

3. Ezekiel J. Emanuel, Christine C. Grady, Robert A. Crouch, Reidar K. Lie, Franklin G. Miller, David D. Wendler,
"Clinical Research Ethics" OUP USA, Reprint edition (17 February 2011)
4. Richard Chamberlain, "Project Management of Clinical Trials" Xlibris Us, 2019
5. David Machin, Simon Day, Sylvan Green, "Clinical Trials" Wiley India, 2nd edition, 2010
6. Patrick Waller, "An Introduction to Pharmacovigilance" John Wiley, 2nd edition, 2017

References:

1. Gabor Harshanyi, "Sensors in Biomedical Applications, Fundamentals Technology and Applications", CRC Press,2000.
2. Graham Ramsay, "Commercial Biosensors", John Wiley & Sons, 1st edition, 1998.
3. Tran Minh Canh, "Sensor Physics & Technology – Biosensors", 1st Edition, Chapman & Hall, 1993.
4. Sabrie Soloman, "Sensors Hand Book", McGraw Hill, 2010

CO's- PO's & PSO's MAPPING

Course Outcomes	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO 1	3	-	-	-	-	2	2	-	-	-	2	2	-	-
CO 2	3	-	-	-	-	2	2	-	-	-	2	2	-	-
CO 3	3	-	-	-	-	2	2	-	-	-	2	2	-	-
CO 4	3	-	-	-	-	2	2	-	-	-	2	2	-	-
CO 5	3	-	-	-	-	2	2	-	-	-	2	2	-	-
CO 6	3	-	-	-	-	2	2	-	-	-	2	2	-	-

1: Slight (Low)   2: Moderate (Medium)   3: Substantial (High)

231BMH05	CRITICAL CARE EQUIPMENTS	L	T	P	C
		3	0	0	3
Programme:	**B.E. - Biomedical Engineering**	**Category:**			**PE**

AIM:	To equip students with a thorough understanding of essential critical care devices, their applications, and the standards for safe and effective operation within healthcare settings.

Course Outcomes: The Students will be able to

CO1:	Classify the types and function of intensive care equipment.
CO2:	Explain the operation and safety protocols for critical devices.
CO3:	Infer the use and maintenance of operation theatre equipment
CO4:	Explain the centralized hospital systems,
CO5:	Apply safety procedure to prevent electrical hazards and ensure patient protection in critical care environments.
CO6:	Identify and troubleshoot critical care equipment to ensure safe and continuous operation.

UNIT – I INTENSIVE CARE UNIT EQUIPMENT	9

Suction apparatus, Different types; Sterilizers, Chemical, Radiation, Steam for small and large units. ICU ventilators. Automated drug delivery systems, Infusion pumps, components of drug infusion system, closed loop control infusion system, implantable infusion system. BMD Measurements – SXA – DXA - Quantitative ultrasound bone densitometer, C Arm.

UNIT – II CRITICAL CARE EQUIPMENT	9

Defibrillators, Hemodialysis Machine, Different types of Dialyzers, Membranes, Machine controls and measurements. Heart Lung Machine, different types of oxygenators, peristaltic pumps, Incubators.

UNIT – III OPERATION THEATRE EQUIPMENT	9

Craniotomy, Electrosurgical Machines (ESU), electrosurgical analyzers, surgical aspirator,, Instruments for operation. Anesthesia Machine, Humidification, Sterilization aspects, Boyles apparatus. Endoscopy – Laparoscopy - Cryogenic Equipment - Anesthesia gas, Anesthesia gas monitor, - surgical microscope.

UNIT – IV CENTRALISED SYSTEMS	9

Centralized Oxygen, Nitrogen, Air supply & Suction Centralized Air Conditioning, Operation Theatre table & Lighting.

UNIT – V PATIENT SAFETY	9

Patient electrical safety, Types of hazards, Natural protective mechanisms against electricity, Leakage current, Inspection of grounding and patient isolation, Hazards in operation rooms, ICCU and IMCUs, Opto couplers and Pulse transformers.

Total Periods:	45

Text Books:	

1. John G. Webster, "Medical Instrumentation Application and Design", 5th edition, Wiley India Pvt Ltd, New Delhi, August 2020
2. Joseph J. Carr and John M. Brown, "Introduction to Biomedical Equipment Technology", Pearson education, 2012 Khandpur. R.S.,"Handbook of Biomedical Instrumentation". Third Edition. Tata McGraw Hill Pub.Co.,Ltd. August 2014

References:	

1. L.A Geddes and L.E.Baker, "Principles of Applied Biomedical Instrumentation", 3rd Edition, 2008.

2. Antony Y.K.Chan,"Biomedical Device Technology, Principles and design", Charles Thomas Publisher Ltd, Illinois, USA, Third edition January 2023.
3. Leslie Cromwell, "Biomedical Instrumentation and Measurement", Pearson Education, New Delhi, 2007

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	-	-	-	-	2	2	-	-	-	2	2	-	-
CO2	3	-	-	-	-	2	2	-	-	-	2	2	-	-
CO3	3	-	-	-	-	2	2	-	-	-	2	2	-	-
CO4	3	-	-	-	-	2	2	-	-	-	2	2	-	-
CO5	3	-	-	-	-	2	2	-	-	-	2	2	-	-
CO6	3	-	-	-	-	2	2	-	-	-	2	2	-	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

		L	**T**	**P**	**C**
231BMH06	**NANOTECHNOLOGY AND APPLICATIONS**	**3**	**0**	**0**	**3**

Programme:	B.E. Biomedical Engineering	**Category:**		**PE**	
Aim:	To provide a broad view of the nascent field of nanoscience and nanotechnology to undergraduates				

Course Outcomes:

The Students will be able to

CO1:	Explain the fundamental properties, kinetics, and applications of nanostructures.
CO2:	Illustrate the fabrication methods and characterization of nanomaterials.
CO3:	Interpret the optical properties of Nanomaterials.
CO4:	Explain the measurement of nanomaterials
CO5:	Explain the basics of nanostructures and their applications.
CO6:	Illustrate the applications of nanotechnology.

UNIT I INTRODUCTION TO NANOTECHNOLOGY	**9**
Basic Structure of Nanoparticles- Kinetics in Nanostructured Materials- Zero dimensional, size and shape of nanoparticles; one-dimensional and two dimensional nanostructures- clusters of metals and semiconductors, bio Nano-particles	

UNIT II FABRICATION AND CHARACTERIZATION OF NANOMATERIALS	**9**
Types of Nanomaterials (Quantum dots, Nanoparticles, Nanocrystals, Dendrimers, Bucky balls, Nanotubes); Gas, liquid, and solid –phase synthesis of nanomaterials; Lithography techniques (Photolithography, Dip-pen and Electron beam lithography); Thin film deposition; Electrospinning. Bio-synthesis of nanomaterials.	

UNIT III PROPERTIES AND MEASUREMENT OF NANOMATERIALS	**9**
Optical Properties: Absorption, Fluorescence, and Resonance; Methods for the measurement of nanomaterials; Microscopy measurements: SEM, TEM, AFM and STM. Confocal and TIRF imaging.	

UNIT IV NANO STRUCTURES	**9**
Carbon Nanotubes, Fullerenes, Nanowires, Quantum Dots. Applications of nanostructures. Reinforcement in Ceramics, Drug delivery, Giant magnetoresistance, etc. Cells response to Nanostructures.	

UNIT V APPLICATIONS OF NANOTECHNOLOGY	**9**
Nano electronics, Nano sensors, Nanotechnology in Diagnostics applications, Environmental and Agricultural Applications of nanotechnology, Nano technology for energy systems	

	Total Periods:	**45**

Text Books:

1. Springer Handbook of Nanotechnology by Bharat Bhushan 2004.(Unit I – V)
2. Encyclopedia of Nanotechnology - Hari Singh Nalwa 2004. (Unit I – V)

References:

1. Nanomaterials, Nanotechnologies and Design: an Introduction to Engineers and Architects, D. Michael Ashby, Paulo Ferreira, Daniel L. Schodek, Butterworth-Heinemann, 2009.
2. Handbook of Nanophase and Nanostructured Materials (in four volumes), Eds: Z.L. Wang, Y. Liu, Z. Zhang, Kluwer Academic/Plenum Publishers, 2003.
3. Handbook of Nanoceramics and their Based Nanodevices (Vol. 2) Edited by Tseung-Yuen Tseng and Hari Singh Nalwa, American Scientific Publishers.

CO's- PO's & PSO's MAPPING

Course Outcomes	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	-	-	-	-	2	-	-	-	-	2	2	-	-
CO2	3	-	-	-	-	2	-	-	-	-	2	2	-	-
CO3	3	-	-	-	-	2	-	-	-	-	2	2	-	-
CO4	3	-	-	-	-	2	-	-	-	-	2	2	-	-
CO5	3	-	-	-	-	2	-	-	-	-	2	2	-	-
CO6	3	-	-	-	-	2	2	-	-	-	2	2	-	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231OE8A	E-Health Systems	L	T	P	C
		3	0	0	3

Programme:	**B.E/B.tech(All Branches Except BME)**	**Category:**	**OE**

AIM:	To provide students with insights into e-Health systems, digital healthcare, and AI-driven applications.

Course Outcomes: The Students will be able to

CO1:	Explain the concept of E-Health and its regulations
CO2:	Analyze the medical data and records
CO3:	Interpret the digital transformation in the field of medicine
CO4:	Describe the AI in E-Health.
CO5:	Explain the Android Application of E-Health System.
CO6:	Explain the web based Application of E-Health System.

UNIT I- INTRODUCTION TO E-Health	**9**

Overview and introduction to E-Health and flow of health information- International regulations in E-Health-Advantages, Challenges and future of E-Health

UNIT II-MEDICAL DATA ANALYTICS AND WEARABLE DEVICES	**9**

Health care data and Electronic Health Records (EHR) systems Medical data bases –Wearable devices-Data collection from wearable devices- Clinical use of personal health data- Big data in the field of Medicine.

UNIT III-DIGITAL HEALTH	**9**

Introduction to health care digital transformation- Digital health: Tools Strategies of digital health-Technologies in digital health Implementation of Digital health- Advantages and challenges of Digital health.

UNIT IV- ARTIFICIAL INTELLIGENCE IN E-Health	**9**

History of AI in health care-Impacts and Aspects of AI in health care-Current research in AI in E-Health-Regulations and Ethical concerns in using AI in E-Health.

UNIT V- APPLICATION DEVELOPMENT FOR E-Health	**9**

Introduction to Android, Creating Android Activities, Android Use interface design, Access Wi-Fi and Bluetooth with mobile applications Web based App for E-Health applications.

Total Periods:	**45**

TextBooks/References	

1. Shortliffe, Edward H and Cimino James J. Biomedical Informatics, Computer Applications in Health Care and Biomedicine, Springer-Verlag London 2014

2. Lavis, JN (ed). Ontario's Health System: Key Insights for Engaged Citizens, Professionals and Policymakers. 2016.

3. Hoyt RE, Yoshihashi A, Bailey N. Health informatics: Practical guide for healthcare and information technology professionals. Lulu Press. 2014 Seventh edition.

4. GaddiCapello F, Man ca M.EHealth, Care and Quality of Life. 2014 electronic library holding in the Health Science Library.

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	-	-	3	3	-	1	-	2	3	-	-
CO2	3	2	1	-	-	3	-	-	1	-	2	3	-	-
CO3	3	2	1	-	-	3	-	-	1	-	2	3	-	-
CO4	3	2	1	-	2	3	-	-	1	-	2	3	-	2
CO5	3	2	1	-	2	3	-	-	1	-	2	3	-	2
CO6	3	2	1	-	2	3	-	-	1	-	2	3	-	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231OE8B	NANOTECHNOLOGY IN MEDICINE	L	T	P	C
		3	0	0	3
Programme:	**B.E/B.tech(All Branches Except BME)**	**Category:**			**OE**

AIM:	This course explores nanotechnology fabrication, characterization, and medical applications.

Course Outcomes: The Students will be able to

CO1:	Describe the synthesis, characterization, and properties of nanoparticles and identify various types of nanobiomaterials
CO2:	Outline the structure and functions of protein and DNA based nanostructures.
CO3:	Explain the role of nanoparticles in diagnostics, including imaging techniques and the associated ethical issues and toxicology
CO4:	Describe the design, development, and application of nanoparticles in drug delivery and other therapeutic areas such as cancer treatment and infectious diseases.
CO5:	Summarize the potential applications of nanotechnology in advanced medical innovations, including tissue engineering and organ printing.
CO6:	Outline the emerging trends and future directions in nanotechnology, emphasizing its impact on personalized medicine and medical devices.

UNIT I- FUNDAMENTALS OF NANOSCIENCE AND NANOPARTICLES	9

Overview of nanotechnology from medical perceptive, different types of nano biomaterials and Nanostructure interactions. Synthesis, characterization, and properties of smart nanomaterials.

UNIT II-BIOFUNCTIONALIZATION OF NANOMATERIALS	9

Nanocarriers, liposomes, polymer capsules, polymer nanoparticles. Protein based Nano structures; DNA based nanostructures.

UNIT III- NANOPARTICLES IN DIAGNOSIS	9

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 IV- NANOTHERAPEUTICS	9

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 V- POTENTIAL APPLICATIONS OF NANOTECHNOLOGY IN MEDICINE	9

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 Periods:	45

Text Books:	

1. CM, Niemeyer, C.A. Mirkin, "Nano biotechnology Concepts, Applications and Perspectives", Wiley, 2004.

References:	

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.

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	-	-	-	-	2	-	-	-	-	1	2	-	-
CO2	3	-	-	-	-	2	-	-	-	-	1	2	-	-
CO3	3	-	-	-	-	2	-	-	-	-	1	2	-	-
CO4	3	-	-	-	-	2	-	-	-	-	1	2	-	-
CO5	3	-	-	-	-	2	-	-	-	-	1	2	-	-
CO6	3	-	-	-	-	2	-	-	-	-	1	2	-	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231OE8C	INTERNET OF THINGS IN MEDICINE	L	T	P	C
		3	0	0	3
Programme:	**B.E/B.tech(All Branches Except BME)**	**Category:**			**OE**
AIM:	To design IoT systems, analyze protocols and data analytics, and develop medical applications for real-time monitoring and patient management.				

Course Outcomes: The Students will be able to

CO1:	Illustrate the various architecture of IoT
CO2:	Compare the protocols used for IoT
CO3:	Develop IoT system using programmable devices.
CO4:	Compare the data analytics in IoT
CO5:	Infer the support service of IoT
CO6:	Develop medical applications using IoT

UNIT I- FUNDAMENTALS OF IoT	9
Evolution of Internet of Things - Enabling Technologies – IoT Architectures: oneM2M, IoT World Forum (IoTWF) and Alternative IoT models – Simplified IoT Architecture and Core IoT Functional Stack – Fog, Edge and Cloud in IoT – Functional blocks of an IoT ecosystem – Sensors, Actuators, Smart Objects and Connecting Smart Objects.	
UNIT II- IoT PROTOCOLS	9
IoT Access Technologies: IEEE 802.15.4,802.15.4g, 802.15.4e, 1901.2a,802.11ah, LoRaWAN-Networking for IoT: 6LoWPAN, RPL, IP for constrained networks- Application Layer Protocols : CoAP, MQTT- Application Transport Methods: Supervisory Control and Data Acquisition.	
UNIT III- DESIGN AND DEVELOPMENT	9
Design Methodology - Embedded computing logic - Microcontroller, System on Chips - IoT system building blocks - Arduino - Board details, IDE programming - Raspberry Pi - Interfaces and Raspberry Pi with Python Programming.	
UNIT IV- DATA ANALYTICS AND SUPPORTING SERVICES	9
Data Types and Processing: Structured vs Unstructured Data, Data in Motion vs Data at Rest- Core Technologies: Role of Machine Learning, NoSQL Databases , Hadoop, Kafka, Spark-Platforms & Tools: Xively, AWS IoT, Django, Edge & Network Analytics- System Management: NETCONF-YANG	
UNIT V- APPLICATIONS OF IOT IN MEDICINE	9
IoT in Health Monitoring: Cyber-physical systems, neuro-sensors, diabetes care-AI in Diagnosis:Alzheimer's, cancer, chest diseases, diabetic retinopathy- Smart Health Systems: Secure IoT architecture, Mobile and cloud-based healthcare apps	
Total Periods:	45

Text Books:	

 1. David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Rob Barton and Jerome Henry, "IoT Fundamentals: Networking Technologies, Protocols and Use Cases for Internet of Things, Cisco Press, 2017.

 2. Venkata Krishna, SasikumarGurumoorthy, Mohammad S. Obaidat, "Internet of Things and Personalized Healthcare Systems", Springer Briefs in Applied Sciences, and Technology, Forensic and Medical Bioinformatics, 2019.

References:	

1. Arshdeep Bahga, Vijay Madisetti, "Internet of Things – A hands-on approach", Universities Press, 2015.
2. Olivier Hersent, David Boswarthick, Omar Elloumi , "The Internet of Things – Key applications and Protocols", Wiley, 2012.
3. Jan Ho¨ller, Vlasios Tsiatsis , Catherine Mulligan, Stamatis , Karnouskos, Stefan Aves and. David Boyle, "From Machine-to-Machine to the Internet of Things - Introduction to a New Age of Intelligence", Elsevier, 2014.
4. Dieter Uckelmann, Mark Harrison, Michahelles, Florian (Eds), "Architecting the Internet of Things", Springer, 2011.
5. Michael Margolis, Arduino Cookbook, "Recipes to Begin, Expand, and Enhance Your Projects", O'Reilly Media, 2nd Edition.

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	2	1		-	-	2		-	2	2	-	1
CO2	2	2	2	1		-	-	2		-	2	2	-	1
CO3	2	2	2	1	2	-	-	2		-	2	2	-	1
CO4	2	2	2	1	2	-	-	2		-	2	2	-	1
CO5	2	2	2	1	2	-	-	2		-	2	2	-	1
CO6	2	2	2	1	2	-	-	2		-	2	2	-	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231OE8D	COMPUTERS IN MEDICINE		L	T	P	C
			3	0	0	3
Programme:	**B.E/B.tech(All Branches Except BME)**	**Category:**		OE		

AIM:	To teach students how to use computers in various medical fields

Course Outcomes: The Students will be able to

CO1:	Describe the impact of internet on healthcare, including online medical resources.
CO2:	Infer the computer assisted medical imaging and therapy for biological problems.
CO3:	Examine the various computer assisted decision making methods.
CO4:	Explain the function of hospital information systems.
CO5:	Compare drug delivery and monitoring system.
CO6:	Explain the computer assisted drug discovery methods.

UNIT-I ROLE OF COMPUTERS IN MEDICINE	9

Introduction –Historical review of the development of computers and informatics –Foundation ontology – use of internet in medicine –Internet vs online services-computer based medical information retrieval.

UNIT-II COMPUTERISED PATIENT DATABASE MANAGEMENT	9

Lab Automation: Hematology, cytology, semen analysis, LIS- Diagnostic Systems: ECG, EEG, EMG (computerized) - Medical Imaging: Ultrasound, CT, NMR, radiation therapy planning.

UNIT-III COMPUTER ASSISTED DECISION MAKING	9

Decision Support in Medicine: CMD models and approaches, CBR, Production Rule Systems , cognitive systems - Clinical Information Systems: Key functions, benefits, decision modes, Application in Obstetrics & Gynecology - Hospital Information Systems: Functional needs, security, cost-effectiveness

UNIT-IV COMPUTERISED PATIENT RECORD	9

Patient Records & Communication : Computerized patient records, prescriptions, adverse drug reactions, Electronic communication with Patients, Computer assisted patient education and health care - Clinical Support & Monitoring: Critical care systems, fluid/metabolic balance, pulmonary function Evaluation - Assistive & Surgical Technologies: Computer aids for the handicapped, Computer-assisted surgery

UNIT-V COMPUTER ASSISTED INSTRUCTION IN MEDICINE	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 –Combinational Chemistry-Metabolomics-Knowledge Based Drug Discovery-Pharmaco Metabolomics Role Of PET And SPECT In Drug Discovery. Computer Assisted Instruction In Medicine.

	Total Periods:	**45**

Text Books:	

1.R. D. Lee, Computers in Medicine, Tata McGraw Hill Publishing Company Limited, New Delhi, 2nd edition 2022.

References:	

1. Harold Sackamn, Biomedical Information Technology, Academic Press, New York.
2. S.K.Chachan, PC Organisation, S.K. Kataria and Sons, Delhi 2000.

CO's- PO's & PSO's MAPPING

Course Outcome	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	-	-	-	-	2	-	-	-	-	2	2	-	-
CO2	3	-	-	-	-	2	-	-	-	-	2	2	-	-
CO3	3	-	-	-	-	2	-	-	-	-	2	2	-	-
CO4	3	-	-	-	-	2	-	-	-	-	2	2	-	-
CO5	3	-	-	-	-	2	-	-	-	-	2	2	-	-
CO6	3	-	-	-	-	2	-	-	-	-	2	2	-	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

231OE8E	MEDICAL PHYSICS	L	T	P	C
		3	0	0	3

Programme:	B.E/B.tech(All Branches Except BME)	Category:	OE
Aim:	To effects of radiation in matter and how isotopes are produced.		

Course Outcomes: The Students will be able to

CO1:	Explain about non-ionizing radiation, interaction with tissue and its effects
CO2:	Compare the intensities of sensory stimuli
CO3:	Summarizes how ionizing radiation interacts with the human body, how to quantify it and its levels seen in the environment and healthcare
CO4:	Explain the fundamentals of radioactivity and radioactive isotopes(
CO5:	Illustrate the methods of detecting and recording the ionizing radiation and its interaction with matter
CO6:	Describe the production of radio nuclides

NON-IONIZING RADIATION AND ITS MEDICAL APPLICATIONS	**9**

Introduction and objectives - Tissue as a leaky dielectric - Relaxation processes, Debye model, Cole–Cole model, Overview of non-ionizing radiation Effects-Low Frequency Effects- Higher frequency effects. Physics of light, Measurement of light and its unit- limits of vision and color vision an overview, Ultraviolet

PHYSICS OF THE SENSES	**7**

Introduction and objectives - Cutaneous sensation - The chemical senses – Audition –Vision - Psychophysics

PRINCIPLES OF RADIOACTIVE NUCLIDES	**10**

Radioactive Decay – Spontaneous Emission – Isometric Transition – Gamma ray emission, alpha, beta, Positron decay, electron capture, Sources of Radioisotopes Natural and Artificial radioactivity, Radionuclide used in Medicine and Technology ,Decay series, Production of radionuclides – Cyclotron produced Radionuclide- Reactor produced Radio- nuclide-fission and electron Capture reaction, Target and Its Processing Equation for Production of Radionuclides, radionuclide Generator-Technetium generator.

RADIOACTIVE DECAY AND INTERACTIONOF RADIATION WITH MATTER	**11**

Spontaneous Fission- Isomeric Transition-Alpha Decay-Beta Decay-Positron Decay-Electron Capture-Interaction of charged particles with matter –Specific ionization, Linear energy transfer range, Bremsstrahlung, Annihilation,Interaction of X and Gamma radiation with matter- Photoelectric effect, Compton Scattering , Pair production, Attenuation of Gamma Radiation ,Interaction of neutron with matter and their clinical significance.

SCINTILLATION, SEMICONDUCTOR and GAS FILLED DETECTORS	**8**

Scintillation Detectors - Solid Scintillation Counters - Gamma-Ray Spectrometry-Liquid Scintillation Counters-Characteristics of Counting Systems-Gamma Well Counters-Thyroid Probe-Principles of Gas-Filled Detectors - Ionization Chambers-Geiger–Müller Counters

Total Periods:	**45**
Text Books:	

1. Gopal B. Saha, ―Physics and Radiobiology of Nuclear Medicine‖, 4th Edition, Springer, 2013.
2. B H Brown, R H Smallwood, D C Barber, P V Lawford and D R Hose, ―Medical Physics and Biomedical Engineering‖, 2nd Edition, IOP Publishers.2001.

References:	

1. S.Webb — The Physics of Medical Imaging‖, Taylor and Francis, 1988
2. J.P.Woodcock, —Ultrasonic,Medical Physics Handbook series 1‖, Adam Hilger, Bristol, 2002
3. HyltonB.Meire and Pat Farrant —Basic Ultrasound‖ John Wiley & Sons, 1995.

CO's- PO's & PSO's MAPPING

Course Outcomes	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	-	-	-	-	2	-	-	-	-	2	3	-	-
CO2	3	-	-	-	-	2	-	-	-	-	2	3	-	-
CO3	3	-	-	-	-	2	-	-	-	-	2	3	-	-
CO4	3	-	-	-	-	2	-	-	-	-	2	3	-	-
CO5	3	-	-	-	-	2	-	-	-	-	2	3	-	-
CO6	3	-	-	-	-	2	-	-	-	-	2	3	-	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)