Avinashilingam Institute for Home Science and Higher Education for Women
(Deemed to be University Estd. u/s 3 of UGC Act 1956, Category A by MHRD)
Re-accredited with A++ Grade by NAAC. CGPA 3.65/4, Category I by UGC
Coimbatore - 641 043, Tamil Nadu, India

B.E. Biomedical Instrumentation Engineering

(Syllabus for Students Admitted during 2021-22 & Onwards)

School of Engineering
Approved by AICTE
Ayya Avinashilingam Nagar, Chinna Thadagam Post,
Coimbatore - 641 108
Website: http://www.avinuty.ac.in * Email: hod_bmie@avinuty.ac.in
University Campus – Ph:0422-2440241/2435550
Campus II – Ph : 0422-2658145/2658716

VISION OF FACULTY OF ENGINEERING

"Develop and create women technocrats who can meet the challenges of the corporate world and emerge as leaders contributing to industry and society"

MISSION OF FACULTY OF ENGINEERING

- To produce global women technologists by imparting quality education through pursuit of excellence that stimulates the intellect and the heart
- Inculcate in all the staff and students scientific temper and research attitude

DEPARTMENT OF BIOMEDICAL INSTRUMENTATION ENGINEERING

VISION OF THE DEPARTMENT

"To achieve excellence in imparting education, developing technical skills among women and to be recognized as a research-driven department in the field of Biomedical Instrumentation Engineering"

MISSION OF THE DEPARTMENT

- To provide educational opportunities to the rural women and prepare them for a productive career in the discipline of Biomedical Instrumentation Engineering
- To be the driving force in creating Engineering knowledge and novel Biomedical Technology that improves the human health condition
- To address the major concerns of our society through quality education and new teaching and learning methodologies
- To prepare the students to be the next generation leaders and entrepreneurs to advance the field of Biomedical Instrumentation Engineering with societal concern

Avinashilingam Institute for Home Science and Higher Education for Women

(Deemed to be University under Category 'A' by MHRD, Estd. u/s 3 of UGC Act 1956) Re-accredited with 'A++' Grade by NAAC. Recognised by UGC under Section 12 B Coimbatore - 641 043, Tamil Nadu, India

School of Engineering

B.E. Biomedical Instrumentation Engineering

Programme Specific Outcomes:

PSO1: Create engineers who can work in the field of Image Processing, Sensors & Actuators, Biomedical Instruments, Communication, MEMS and allied fields to develop innovative Biomedical systems for the public wellness and safety.

PSO2: Develop skills for design, maintenance and testing of medical equipment.

Corrected Scheme of Instruction & Examination

(For students admitted from **2021-2022** and onwards)

Part	*Course Code*	*Name of Course/component*	*Hours of Instruction/week*		*Scheme of Examination*				
			Theory	*Tutorial/ Practical*	*Duration of exam*	*CIA*	*CE*	*Total*	*Credit*
First Semester									
I		**Humanities and Social Sciences (HS)**							
	21BEHS01	Professional English	1	0/2	3	50	50	100	2
II		**Basic Sciences (BS)**							
	21BESM01	Algebra and Calculus	3	1/0	3	50	50	100	4
	21BESP01/ 21BESC01	Engineering Physics*/ Engineering Chemistry	3	1/0	3	50	50	100	4
	21BESP02/ 21BESC02	Physics Practicals* / Chemistry Practicals	-	0/3	3	50	50	100	1.5
III		**Core Courses Engineering Sciences (ES)**							
	21BEES01/ 21BEES04	Basic Electrical and Electronics Engineering (ECE) / Programming for Problem Solving using C and Python (CSE)*	3	1/0	3	50	50	100	4
	21BEES02	Engineering Graphics (Civil)	1	0/4	3	50	50	100	3
	21BEES03/ 21BEES06	Basic Electrical Engineering Practicals (ECE)/ Programming for Problem Solving using C and Python Practicals (CSE)*	-	0/2	3	50	50	100	1
IV		**Non-Credit Mandatory Courses (NCMC)**							
	21BEMC01	Environmental Science	3	-	2	100	-	100	Remark
	21BENSS1	NSS-I	-	-	2	100	-	100	Remark
		Second Semester							
I		**Humanities and Social Sciences (HS)**							
	21BEHS02	Professional English Practicals	-	0/2	3	50	50	100	1
II		**Basic Sciences (BS)**							
	21BESM02	Laplace Transforms and Complex Variables	3	1/0	3	50	50	100	4
	21BESC01/ 21BESP01	Engineering Chemistry **/ Engineering Physics	3	1/0	3	50	50	100	4
	21BESC02/ 21BESP02	Chemistry Practicals**/ Physics Practicals	-	0/3	3	50	50	100	1.5
III		**Core Courses Engineering Sciences (ES)**							
	21BEES04/ 21BEES01	Programming for Problem Solving using C and Python (CSE)/ Basic Electrical and Electronics Engineering (ECE)**	3	1/0	3	50	50	100	4
	21BEES05	Workshop Practicals (Civil, ECE and FPPT)	1	0/4	3	50	50	100	3
	21BEES06/ 21BEES03	Programming for Problem Solving using C and Python Practicals (CSE)/ Basic Electrical Engineering Practicals (ECE)**	-	0/2	3	50	50	100	1
IV		**Non-Credit Mandatory Courses (NCMC)**							
	21BEMC02	Constitution of India	2	-	2	100	-	100	Remark
	21BENSS2	NSS-II	-	-	2	100	-	100	Remark
	21BAFU01	Fundamentals of Research	2	-	2	100	-	100	Remark

*** and ** 50% of the I BE students will learn in I and II semester respectively.**

Part	*Course Code*	*Name of course/component*	*Hours of Instruction/week*		*Scheme of Examination*				
			Theory	*Tutorial/ Practical*	*Duration of exam*	*CIA*	*CE*	*Total*	*Credits*
Third Semester									
I		**Humanities and Social Sciences (HS)**							
	21BEHS03	Human Values and Medical Ethics	3	-	3	50	50	100	3
II		**Basic Sciences (BS)**							
	21BESM03	Transforms, Partial Differential Equations and Applications for Biomedical Engineering	3	1/0	3	50	50	100	4
III		**Core Courses Engineering Sciences (ES)**							
	21BEBS01	Electron Devices and Circuits (ECE)	3	-	3	50	50	100	3
	21BEBS02	Devices and Circuits Practicals (ECE)	-	0/3	3	50	50	100	1.5
	21BEBS03	Signals and Systems (ECE)	4	-	3	50	50	100	4
		Core Courses Professional Core (PC)							
	21BEBC01	Human Anatomy and Physiology	3	-	3	50	50	100	3
	21BEBC02	Biomedical Sensors and Measurement Devices	3	-	3	50	50	100	3
	21BEBC03	Biomedical Sensors and Measurement Practicals	-	0/3	3	50	50	100	`1.5
IV		**Non-Credit Mandatory Courses (NCMC)**							
	21BEMC03	Consumer Affairs	3	-	2	100	-	100	Remark
		Value Added Course	2	-	-	100	-	100	Remark
	21BENSS3	NSS-III	-	-	2	100	-	100	Remark
Fourth Semester									
I		**Humanities and Social Sciences (HS)**							
	21BEHS07	Biomedical Waste Management	3	-	3	50	50	100	3
III		**Core Courses Professional Core (PC)**							
	21BEBC04	Medical Biochemistry	3	-	3	50	50	100	3
	21BEBC05	Biomaterials	3	-	3	50	50	100	3
	21BEBC06	Control Systems	4	-	3	50	50	100	4
	21BEBC07	Pathology and Microbiology	3	-	3	50	50	100	3
	21BEBC08	Analog and Digital ICs (ECE)	3	-	3	50	50	100	3
	21BEBC09	Integrated Circuits Practicals (ECE)	-	0/3	3	50	50	100	1.5
	21BEBC10	Virtual Instrumentation Practicals	-	0/3	3	50	50	100	1.5
IV		**Non-Credit Mandatory Courses (NCMC)**							
	21BECS01	Communication Skills	3	-	2	100	-	100	Remark
	21BENSS4	NSS-IV	-	-	2	100	-	100	Remark
		# 6 to 8 weeks Industrial Internship during summer vacation							

Part	*Course Code*	*Name of Course/ component*	*Hours of Instruction/week*		*Scheme of Examination*				
			Theory	*Tutorial/ Practical*	*Duration of exam*	*CIA*	*CE*	*Total*	*Credits*
Fifth Semester									
III		**Core Courses** **Professional Core (PC)**							
	21BEBC11	Analog and Digital Communication (ECE)	3	-	3	50	50	100	3
	21BEBC12	Medical Diagnostic Equipment	3	-	3	50	50	100	3
	21BEBC13	Medical Therapeutic Equipment	4	-	3	50	50	100	4
	21BEBC14	Biomechanics	3	-	3	50	50	100	3
	21BEBC15	Diagnostic and Therapeutic Equipment Practicals	-	0/3	3	50	50	100	1.5
	21BEBC16	Digital Signal Processing for Biomedical Engineering	4	-	3	50	50	100	4
	21BEBC17	Digital Signal Processing Practicals	-	0/3	3	50	50	100	1.5
		Professional Elective (PE)							
		Elective – I (PE1/PE2)	3	-	3	50	50	100	3
IV		**Non-Credit Mandatory Courses (NCMC)**							
	21BESS01	Soft Skills	3	-	2	100	-	100	Remark
	21BENSS5	NSS-V	-	-	2	100	-	100	Remark
Sixth Semester									
III		**Core Courses** **Professional Core (PC)**							
	21BEBC18	Radiology and Nuclear Medicine	3	-	3	50	50	100	3
	21BEBC19	ICU and Operation Theatre Equipment	4	-	3	50	50	100	4
	21BEBC20	Microprocessors and Microcontrollers (ECE)	3	-	3	50	50	100	3
	21BEBC21	Microprocessors and Microcontrollers Practicals (ECE)	-	0/3	3	50	50	100	1.5
	21BEBC22	Digital Image Processing	4	-	3	50	50	100	4
	21BEBC23	Digital Image Processing Practicals	-	0/3	3	50	50	100	1.5
	21BEBC24	Mini Project	-	0/4	-	100	-	100	2
		Professional Electives (PE)							
		Elective – II (PE1/PE2)	3	-	3	50	50	100	3
		Elective – III(PE1/PE2)	3	-	3	50	50	100	3
IV		**Non-Credit Mandatory Courses (NCMC)**							
		Co-Curricular Course	-	-	-	100	-	100	Remark
	21BENSS6	NSS-VI	-	-	2	100	-	100	Remark
[#] 6 to 8 weeks Industrial Internship during summer vacation									

Part	*Course Code*	*Name of Course/component*	*Hours of Instruction/week*		*Scheme of Examination*				
			Theory	*Tutorial/ Practical*	*Duration of exam*	*CIA*	*CE*	*Total*	*Credits*
Seventh Semester									
I		**Humanities and Social Sciences (HS)**							
	21BEHS13	Hospital Management	3	-	3	50	50	100	3
III		**Core Courses** **Professional Core (PC)**							
	21BEBC25	Medical Imaging Techniques	3	-	3	50	50	100	3
	21BEBC26	Special Medical Equipment Practicals	-	0/3	3	50	50	100	1.5
	21BEBC27	Hospital Internship	-	0/3	3	50	50	100	1.5
	21BEBC28	Industrial Internship[#]	-	-	3	100	-	100	1
	21BEBC29	Research Project Phase I	-	0/4	3	100	-	100	2
		Professional Electives (PE)							
		Elective – IV (PE1/PE2)	3	-	3	50	50	100	3
		Elective – V (PE1/PE2) Title of MOOC (SWAYAM-NPTEL) [##]	3	-	-	-	100	100	3
		Elective – VI (PE1/PE2) Title of MOOC (SWAYAM-NPTEL) [##]	3	-	-	-	100	100	3
		Open Electives (OE)							
	21BEVO01/ 21BEOO01/ 21BELO01/ 21BEFO01/ 21BEPO01	Open Elective -1	3	-	3	50	50	100	3
IV		**Non-Credit Mandatory Courses (NCMC)**							
	21BEMC04	Disaster Management	3	-	2	100	-	100	Remark
	21BEMB01	Biomedical Instrumentation Engineering - Computer Based Test (CBT)	-	-	2	100	-	100	Remark

[##] Two MOOCs (12 weeks duration) through SWAYAM - NPTEL with credit transfer of 6 credits, as an alternative to two Professional Elective Courses Elective - V and Elective - VI in VII Semester which should be completed between 3rd and 7th semester. Title of the MOOC to be specified after enrollment.

Eighth Semester									
III		**Core Courses** **Professional Core (PC)**							
	21BEBC30	Research Project Phase II	-	0/20	-	100	100	200	10
								Total Credits	**165**
	21BEBMC1	**MOOC (Core/Non-Core)**	-	-	-	-	-	-	2

One core/non-core MOOC (8 weeks duration) through SWAYAM-NPTEL to be completed with 2 credits between 3rd and 7th semester (without credit transfer).

Semester	*Course Code*	*Name of Course/component*	*Hours of Instruction/ week / Course*	*Credit/ Course*
Part – IV Non-Credit Mandatory Courses (NCMC)				
	A. Ability Enhancement Compulsory Courses (AECC)			
1	21BEMC01	Environmental Science	3	Remark
2	21BEMC02	Constitution of India	2	
2	21BAFU01	Fundamentals of Research	2	
3	21BEMC03	Consumer Affairs	3	
4	21BECS01	Communication Skills (Assertive Communication Skills & Presentation skills, Interview Skills and group discussions etc.)	3	
5	21BESS01	Soft Skills • Body Language, Aptitude Preparation etc. • Work Ethics • Interpersonal Relations • Adapting to the Corporate Culture • Individual Counseling & Guidance • Career Orientation Program related aptitude (Contact followed by online)	3	
7	21BEMC04	Disaster Management	3	
7	21BEMB01	Biomedical Instrumentation Engineering - Computer Based Test (CBT)	-	
	B. Skill Enhancement Courses (SEC)			
3		**Value Added Course** (from a basket of choices offered)	40 hrs. duration	Remark
6		**Co-Curricular Courses**	Varied duration	
	C. Extra-Curricular Courses			
1-6	21BENCC 1-6/ 21BENSS 1-6/ 21BESPO 1-6	**NCC/NSS/Sports** (Representing the Institute)	-	Remark

Requirements to earn the B.E. Degree:

1. Total credits to be earned in Part I, II & III components: 165
2. Successful completion of Part IV Non – Credit Mandatory Courses (NCMC).
3. Minimum of two 3 credit (12 weeks duration) MOOCs to be completed through SWAYAM – NPTEL as an alternative to two Professional Electives, Elective V & Elective VI in the seventh semester. Additionally, one core/non-core MOOC through SWAYAM- NPTEL to be completed with 2 credits (8 weeks duration) between 3rd and 7th Semester (without credit transfer).
4. # 6 to 8 weeks Industrial Internship during 4th and/or 6th semester during summer vacation.

Other courses offered by the Departments

Value Added Course

Part	*Course code*	*Name of the course/Component*
IV	21BEBV01	Biomedical Instrumentation

Open Elective

Part	*Course Code*	*Name of course/component*
III	21BEBO01	Diagnostic Instrumentation

Discipline Specific Elective (II B.Sc., Physician Assistant)

Part	*Course code*	*Name of the course/Component*
III	21BPAI04	Biomedical Instrumentation and Scientific Measurements

List of Professional Electives (PE1) Biomedical Instrumentation domain

Part	*Semester*	*Course Code*	*Name of Course/component*
III	**V *Semester* Elective I**	21BEBE01	Medical Physics
		21BEBE02	Medical Optics
		21BEBE03	Neural Engineering
	VI *Semester* Elective II	21BEBE04	Cell and Tissue Engineering
		21BEBE05	Rehabilitation Engineering
		21BEBE06	Modeling of Physiological Systems
	VI *Semester* Elective III	21BEBE07	Telemedicine
		21BEBE08	BioMEMS and Nanotechnology
		21BEBE09	Advanced Bioanalytical and Therapeutic Techniques
	VII *Semester* Elective IV	21BEBE10	Medical Device Regulations
		21BEBE11	Electromagnetic Interference and Compatibility
		21BEBE12	Robotics and Automation in Medicine
	VII *Semester* Elective V	21BEBE13	**MOOC (12 Weeks Course in SWAYAM – NPTEL)**
	VII *Semester* Elective VI	21BEBE14	**MOOC (12 Weeks Course in SWAYAM – NPTEL**

List of Professional Electives (PE2) Biomedical Computing & Communication domain

Part	*Semester*	*Course Code*	*Name of Course/component*
III	**V *Semester* Elective I**	21BEBE21	Object Oriented Programming with C++ (CSE)
		21BEBE22	Soft Computing
		21BEBE23	Speech Processing
	VI *Semester* Elective II	21BEBE24	Embedded Systems (ECE)
		21BEBE25	Medical Data Analytics
		21BEBE26	Body Area Networks
	VI *Semester* Elective III	21BEBE27	Telehealth Technology
		21BEBE28	Biometric Systems
		21BEBE29	VLSI Design (ECE)
	VII *Semester* Elective IV	21BEBE30	Wearable Systems
		21BEBE31	Medical Informatics
		21BEBE32	Internet Technology
	VII *Semester* Elective V	21BEBE33	**MOOC (12 Weeks Course in SWAYAM – NPTEL)**
	VII *Semester* Elective VI	21BEBE34	**MOOC (12 Weeks Course in SWAYAM – NPTEL**

I year Syllabus

Professional English-1
(Common to all branches)

Semester I **Hours of instruction/week: 1T+2P**
21BEHS01 **No. of credits: 2**

Objective:

CLO 1: To familiarize students to corporate communication skills

Unit I Language through Reading **9**

Skimming, scanning, predicting the content of a given passage, identifying the lexical and contextual meanings, note making (guided & unguided) cloze reading, drawing inferences, separating facts from opinions.

Unit II Focus on Language **9**

Word formation with prefixes and suffixes, synonyms and antonyms, Impersonal passive voice, Tenses, use of prepositions, 'if clauses', use of words as nouns and verbs, subject, verb, agreement, Editing, British and American English.

Unit III Language through Practice **9**

Resume writing, writing instructions and recommendations, preparing checklists, classifying the data, analyzing / interpreting the data, Paragraph writing, Formal letters, writing to officials (leave letter, seeking permission for practical training, asking for Certificates, testimonials), unseen comprehension, creative writing, Framing Agendas, Minutes of the meeting.

Unit IV Oral Practice (Lab Sessions) **9**

Pronunciation Techniques:

Phonetics, Stress, Primary and Secondary stress, Neutral Accent, Rising and Falling Tone, Voice Modulation.

Public Speaking Skills:

Compeering, introducing a guest to the audience, welcome address, proposing a vote of thanks.

Unit V (Lab Sessions) **9**

Justifying and Summarizing Skills:

Emphasizing a point, discussing the pros and cons, focusing on reasons, Summarizing briefly and concisely

Designing an Advertisement:

Interpreting advertisements, Slogan/caption writing, creating one's own advertisement for a product.

Total Hours: 45

Reference Books:

1. ***AyshaViswamohan (2008). English for Technical Communication***. Tata McGraw-Hill Publishing Co Ltd, New Delhi.
2. ***Dr. S. Sumant, English for Engineers(2005).*** Tata McGraw Hill Publishing Co Ltd, New Delhi.
3. ***M. Ashref Rizvi (2005). Effective Technical Communication.***Tata McGraw Hill Publishing Co Ltd, New Delhi.
4. ***Raymond V Lesikar& Marie E. Flatley*****(2005).** ***Basic Business Communication***. Tenth Ed. Tata McGraw Hill Publishing Co. Ltd, New Delhi.

Course Outcomes:

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

CO 1: Create organized academic and professional writing

CO 2: Develop aural competency and oral fluency of learners

CO 3: Achieve proficiency in the effective use of language in various authentic career, related situations.

CO, PO MAPPING

Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	-	-	-	-	M	M	H	-	-
CO2	-	-	-	-	-	-	-	L	H	M	-	-
CO3	-	-	-	-	-	-	-	H	M	L	-	-

Algebra and Calculus

(Common to all branches)

Semester I **Hours of Instruction/ week: 3T+1Tu**

21BESM01 **No. of Credits : 4**

Objectives:

CLO1 Develop skills in processing matrices and applications of differential calculus

CLO2 Enrich knowledge in solving problems in multiple integrals and ordinary differential equation

CLO3 Gain practice in implementing algorithms and to use software tools

Unit I Eigenvalues and Eigenvectors **12**

Characteristic equation of matrix - Eigenvalues and Eigenvectors of a real matrix- Properties of Eigenvalues and Eigenvectors -Cayley Hamilton theorem- Reduction of quadratic form to canonical form by orthogonal transformation.

Unit II Geometrical Applications of Differential Calculus **12**

Curvature- Cartesian and polar co-ordinates - Centre and radius of curvature - Circle of curvature- Involutes and Evolutes - Envelopes of family of curves- Maxima and minima- Constrained maxima and minima -Jacobians.

Unit III Multiple Integrals **12**

Double integration - Cartesian and polar coordinates - Change of order of integration - Area as a double integral - Triple integration in cartesian coordinates and spherical polar coordinates - Volume as a triple integral.

Unit IV Ordinary Differential Equations **12**

Linear equations of second order with constant coefficients and variable coefficients - Homogeneous equations of Euler type - Method of variation of parameters -Simultaneous first order linear equations with constant coefficients.

Unit V Mathematical Solutions Using Software Tools **12**

Arithmetic Operations Commands - Elementary Math Built-in functions – Arrays -Ordinary differential equations - Multiple Integrals(Unit V is only for gaining knowledge in software applications and not included in theory exams)

Total hours –60

Text Books:

1. ***T.Veerarajan (*2016), *Engineering Mathematics (for semester I and II),*** updated 2nd Edition, Tata McGraw Hill Publishing Co.Ltd, New Delhi.
2. ***P.Kandaswamy, K.Thilagavathy and K.Gunavathy (2014), Engineering Mathematics, Volume I***, 10th Revised Edition, S. Chand & Co, New Delhi.

Reference Books:

1. ***E.Kreyszig (2014), Advanced Engineering Mathematics***, 8th Edition, John Wiley and Sons (Asia) Ltd, Singapore.
2. ***Dennis G. Zill and Michael R.Cullen(2012),Advanced Engineering Mathematics,***2nd edition, CBS Publishers.

3. ***Srimanta Pal and Subhodh C Bhunia (2012), Engineering Mathematics,*** 9th Edition, John Wiley and Sons.
4. ***Dr. B. S. Grewal (2014), Higher Engineering Mathematics***, 43rd Edition, Khanna Publishers, New Delhi.
5. ***Jain R.K. and Iyengar S.R.K. (2007), Advanced Engineering Mathematics,*** 3rd Edition, Narosa Publications, New Delhi.
6. Open Source Software tools.

Course Outcomes:

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

CO1: Apply the concepts of Algebra and calculus in engineering fields like computer science, communication, food technology etc.

CO2: Develop mathematical models to interpret and solve engineering problems

CO3: Appreciate the need of software tools to solve higher order linear ordinary integral and differential equations used in real world problems

CO, PO MAPPING

POs	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12
CO1	H	H	M	-	-	-	-	-	-	-	-	M
CO2	H	H	M	-	-	-	-	-	-	-	-	M
CO3	H	H	M	-	L	-	-	-	-	-	-	M

Engineering Physics

(Common to all branches)

Semester I/ II **Hours of instruction/week: 3T+1Tu**

21BESP01 **No. of credits: 4**

Objectives:

CLO1 To impart knowledge in basic concepts of physics relevant to engineering and technology

CLO2: To understand and apply the concepts of physics for various engineering applications

Unit I Ultrasonics& Acoustics **12**

Introduction, Magnetostriction effect, Production of ultrasonic waves: Magnetostriction generator, Inverse piezoelectric effect, Piezoelectric generator, Detection of ultrasonic waves, Properties, Cavitation soldering and cleaning, Ultrasonic Doppler Blood flow meter

Classification of sound, characteristics of musical sound, Weber- Fechner law, Absorption coefficient and its determination, Factors affecting acoustics of building and their remedies.

Unit II Lasers & Fiber optics **12**

Principle of spontaneous and stimulated emission, Einstein theory of stimulated emission, Population inversion, Pumping mechanism, Types of Lasers, CO_2, Nd-YAG and Semiconductor laser, Applications: welding, heat treatment, cutting and holography.

Principle of fiber optics, Preparation, Crucible-crucible technique, Classification based on materials, refractive index profile, Applications: Fiber optic communication, Temperature sensor and Endoscope.

Unit III Crystal physics **12**

Single crystalline, polycrystalline and amorphous materials – single crystals, unit cell, crystal systems, Bravais lattices, directions and planes in a crystal, Miller indices – inter-planar distance - coordination number and packing factor for SC, BCC, FCC and HCP structures- crystal imperfections: point defects, line defect ,growth of single crystals: Czochralski growth technique**.**

Unit IV Quantum physics **12**

Introduction to Quantum theory, Dual nature of matter and radiation, de Broglie wave length, Uncertainty principle, Schrödinger wave equation, Particle in one dimensional box, Electron microscope, Scanning electron microscope (SEM), Scanning Transmission Electron Microscope (STEM).

Unit V Vacuum & Nano science **12**

Importance of vacuum in industries, Pumping speed and throughput, Types of pumps, Working principle and construction of Rotary pump, Diffusion pump, Measurement of vacuum using Pirani and Penning Gauges.

Dimensionality and size dependence, Fabrication methods: Top down process (Lithographic process) and Bottom up process (Physical vapour deposition) Carbon Nanotubes (CNT), Types and Properties, Fabrication of CNT -Laser ablation method, Applications: CNT field effect transistor, Fuel cells, Organic light emitting diode (OLED).

Total Hours : 60

References

1.Bhattacharya D.K&T.Poonam(2015). Engineering Physics, Oxford University Press,

2. ***M.N Avadhanulu , P G Kshirsagar & TVS Arun Murthy (2018) A Textbook of Engineering Physics,***S. Chand Publishing.

3.V RajendranEngineering Physics, Tata Mcgraw Hill Publishing Co Ltd

4. S.O. Pillai (2011).Solid State Physics *New Age International (P) Limited, Publishers*

5. S. Jaya Kumar (**2009). *Materials Science***. R.K. Publishers, ***Coimbatore***

6. G. SenthilKumar(2011). Engineering Physics. Chennai Revised Edition. VRP Publisher

7. **S. Jayakumar (2007).*Engineering PhysicsFirst Edition, RK Publishers, Coimbatore***

Course Outcomes:

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

CO1: Identify the basic concepts of Physics applied in Engineering.

CO2: Discuss the theory and demonstrate the methods involved in Engineering Physics.

CO3: Apply the theoretical ideas of various processes and techniques of physics in Engineering and Technology.

CO, PO MAPPING

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	M	M	-	-	M	L	-	M	-	-	L
CO2	H	M	-	-	-	M	L	-	M	-	-	L
CO3	H	M	M	-	-	M	L	-	M	-	-	L

Physics Practicals

(Common to all branches)

Semester I/ II **Hours of Instruction/week:3P**

21BESP02 **No. of credits: 1.5**

Objective

CLO1: To impart experimental skills on potentially important experiments needed for Engineering.

List of Experiments (Any 10)

1. LASER- Wavelength & Particle size determination
2. Ultrasonic Interferometer-Determination of compressibility of a liquids
3. Melde's apparatus- Frequency of the vibrator
4. Spectrometer- wavelength determination –Grating (Simulation Experiment).
5. Torsional Pendulum-Rigidity modulus of wire and moment of inertia of disc.
6. Non Uniform bending – Determination of Young's Modulus.
7. LCR Bridge –Dielectric constant of solids
8. Four Probe Apparatus-Bandgap of a semiconductor
9. Hysteresis curve tracer - Coercivity and Retentivity
10. Solar cell-V-I characteristics
11. Spectrometer- Determination of dispersive power of the prism.
12. Fiber optics – Numerical aperture

Course Outcomes:

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

CO1:Conduct experiments and interpret the results.

CO2: Verify the knowledge gained in theory with practical results.

CO, PO MAPPING

POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**
CO1	H	H	-	M		M	-	-	M	-	-	M
CO2	H	H	-	M	-	M	-	-	M	-	-	M

Basic Electrical and Electronics Engineering

Semester I **Hours of Instruction/week:3L+1Tu**

21BEES01 No.of credits:4

Objective:

CLO1: To provide a comprehensive idea for engineering students about AC and DC circuit analysis, working principles of basic machines in electrical engineering and their applications in various fields.

CLO2: To understand the working principle of electronic devices and circuits.

Unit I Basics of Circuit Analysis **12**

Ohm's Law- Kirchoff's Laws- DC circuits-AC Circuits (in series and parallel)- Meshand Nodal analysis using Matrix method, Thevenin's and Norton's theorems-Superposition theorem-Reciprocity theorem – Maximum power transfer theorem.

Unit II Introduction to Single and three phases **12**

Single phase and three phase with applications, three phase balanced /unbalanced loads – current and voltage relationship in star/delta connection – phasor diagrams of voltage and current – power and power factor measurements in three phase circuits - Transient response of RL, RC and RLC circuits to DC excitation - Three phase power- measurement by two wattmeter methods.

Unit III Transformers **12**

Principle of operation, Mutual coupling, construction, EMF equation, power losses, efficiency, Transformers and their functions, OC and SC equivalent Circuits, Ideal and practical transformer, losses in transformers, Introduction to auto transformers, applications.

Unit IV Basics of Electronics **12**

Intrinsic semiconductors, Extrinsic semiconductors – P-type and N-type, P-N junction, VI Characteristics of PN junction diode, Zener effect, Zener diode, Zener diode Characteristics-Rectifier Circuits - Working principle and characteristics – Wave shaping examples- Introduction to BJT, JFET and MOSFET (Construction, working and characteristics).

Unit V Electrical Machines **12**

Protection and Devices: Switch Fuse Unit (SFU), MCB, ELCB, MCCB, Types of Wires and Cables, Earthing, Types of Batteries DC Machine & Induction Motor: DC Generator, DC Motor - Construction, working principle, EMF equation and its types (qualitative treatment only). Single Phase Induction Motor- Construction and working (qualitative treatment only).

Total Hours: 60

Reference Books:

1. ***R.K.Mehta&A.K.Mal"ProblemsandSolutionsofElectricalCircuitAnalysis"*** CBS Publishers, 2015
2. ***D.P.KothariandI.J.Nagrath,"BasicElectricalEngineering",*** TataMcGrawHill,2010.
3. ***E.Hughes, "Electrical and Electronics Technology",*** Pearson,2010.
4. ***JosephEdministerandMahmoodNahri,"ElectricCircuits",*** fifthEdition,TataMcGraw Hill New Delhi,2008.
5. ***V.K.Mehta,RohitMehta,"PrinciplesofElectricalMachines",*** S.Chand&companyLtd., Reprint 2006.
6. ***John Bird, "Electrical Circuit theory and technology"***, Routledge; 5th edition, 2013
7. ***Thomas L. Floyd, "Electronic Devices"***, 10th Edition, Pearson Education, 2018.

Course Outcomes:

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

CO1: Comprehendthebasicconceptsofelectricandmagneticcircuits

CO2: DifferentiatepropertiesandAnalyseACaswellasDCcircuitsandvariousmachines,

CO3: Understand the working principle of electronic devices such as diode, Zener diode, characteristics and working of current controlled and voltage-controlled devices

CO, PO MAPPING

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H	L									L
CO2	H	H	L									L
CO3	H	L	L			M	M					L

Programming for Problem Solving using C and Python

Semester I/ II **Hours of instruction/week: 3T+1Tu**

21BEES04 **No. of Credits: 4**

Objectives:

CLO1: Understand the basic knowledge in programming concepts and problem solving using C.

CLO2: Learn core Python scripting elements such as variables and flow control structures and develop simple applications.

Unit I C Programming Fundamentals **12**

Introduction to C programming – Fundamentals – Structure of a C program – Character set- Keywords- Data types and sizes - Constants- Variables – Expressions - Operators –Control statements - if - else statement- nested if statement- switch case – Looping Statements - while- do-while- for - nested control structures - break- continue- goto statement – Implementation of simple C programs on Control Structures.

Unit II Arrays and Strings **12**

Arrays: Introduction - Initialization – Declaration – One Dimensional and Two Dimensional Arrays. Strings: String Operations – String Arrays - Variable length arrays- Implementation of Concepts on Arrays and String handling.

Unit III Functions and Pointers **12**

Functions: Prototypes and Functions–Declaring- defining and accessing functions–Parameter passing methods –Recursion–Storage classes–auto- extern- static and register–Library functions. Pointers: Pointer concept–Declaration–Accessing variable through pointer–Initializing pointer variable–Pointers and Functions–Pointers and Arrays - Implementation of Concepts on Functions and Pointers- Structures and Union.

Unit IV Fundamentals of Python Programming **12**

Introduction : History - Features - Setting up path - Working with Python - Basic syntax - Variables and Data types - Operators - Conditional- Looping –Control statements. String Manipulation: Accessing Strings - Operations and String slices. Functions: Definition - Calling a Function - Types - Arguments - Global and Local variable.

Unit V Core Python Programming **12**

Lists: Introduction - Accessing list - Operations and Methods. Tuples: Accessing Tuples - Operations - Working - Functions and Methods. Dictionaries: Accessing values in Dictionaries - Properties - Functions. Modules: Importing Module - Packages - Compositions. Exception Handling: Exception and Exception handling.

Total hours: 60

Reference Books:

1. ***PradipDey- ManasGhosh (2013). Computer Fundamentals and Programming in C***.Second Edition**.** Oxford University Press**.**
2. ***Yashavant P. Kanetkar (2011).Let Us C.*** BPB Publications**.**
3. ***Allen B. Downey (2016).Think Python: How to Think Like a Computer Scientist***. 2nd edition.O'Reilly Publishers.
4. ***Guido van Rossum and Fred L. Drake Jr (2011). An Introduction to Python – Revised and updated for Python 3.2.*** Network Theory Ltd.
5. ***Ashok N. Kamthane (2007). Computer Programming.Pearson Education.***

6. ***Kernighan,B.W and Ritchie,D.M (2006). The C Programming language.***SecondEdition.Pearson Education**.**
7. ***Byron S Gottfried and Jitendar Kumar Chhabra (2011).Programming with C.***ThirdEdition.Tata McGraw Hill Publishing Company.

Course Outcomes:

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

CO1: Describe and use the data types, expressions, functions, control statements, strings in C and Python programming.

CO2: Write user defined functions and implement different Operations on arrays, strings, pointers and classes in python.

CO3: Identify and use suitable C and python programs to solve real life problems.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	P10	P11	P12
CO1	L	L	M	L	M	_	_	_	L	_	_	_
CO2	L	L	M	L	M	_	_	_	L	_	_	_
CO3	L	M	M	L	M	_	_	_	L	_	_	_

Engineering Graphics

(Common to all branches)

Semester I **Hours of Instruction /week: 1T+4P**

21BEES02 **No. of Credits: 3**

Course Learning Objective:

CLO1: The objective of this course is to develop the students in graphic skill for communication of concepts and ideas in Engineering.

Unit I Projection of Points, Lines and Surfaces 17

Introduction to letter practice, the principles, orthographic projection of points, Projection of straight lines located in the first quadrant only, determination of true length and true inclination, Projections of plane surfaces like polygonal lamina and circular lamina, located in first quadrant only.

Unit II Projection of Simple Solids 17

Projection of simple solids like prism, pyramid, and cylinder, Drawing views when the axis of the solid is inclined to one reference plane.

Unit III Sectioning of Solids 17

Sectioning of simple solids like prisms, pyramids, cylinder, cone and sphere. Obtaining sectional views and true shape when the axis of the solid is vertical and cutting plane inclined to one reference plane.

Unit IV Isometric, Perspective Projection and freehand sketching 17

Isometric projections, Isometric scale, Isometric views of simple solids, Free hand sketching techniques, sketching of orthographic views from given pictorial views of objects, including freehand dimensioning. Sketching pictorial views from given orthographic views. Perspective projections of solids.

Unit V Auto CAD 7

Introduction to drafting software, creation of simple geometric bodies using basic primitives (line, arc, circle) and editing the drawings. Practice in drawing orthographic projection

Total Hours: 75

Reference Books:

1. Venugopal.K (2008). Engineering Graphics. New Age International (P) Limited.
2. Natarajan K.V (2008).Engineering drawing and graphics. 17thEdition.Private Publisher, Chennai.
3. Bhatt.N.D (2011)"Engineering Drawing" Charotar Publishing House.
4. Kumar M.S (2007). Engineering Graphics. Ninth edition. D.D. Publications, Chennai.
5. Warren J, Luzadder and John.M.Duff (2007). Fundamentals of Engineering Drawing. Eleventh edition. PrenticeHall of India Pvt., Ltd.,
6. Gopalakrishnan K.R (2007). Engineering Drawing (Vol.I& II).Subhass Publications.
7. Bertoline and Wiebe (2007). Fundamentals of graphics Communication. Third edition.
8. DhananjayA.Jolhe (2008). Engineering Drawing with an introduction to AutoCAD. Tata McGraw Hill Publishing Company Limited.

Course Outcomes:

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

CO1: To draw orthographic projection of one dimensional, two dimensional and 3 dimensional objects.

CO2: To prepare isometric and perspective sections of simple solids

CO3: To demonstrate basic skills in computer aided drafting.

CO- PO Mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	H								L	H		
CO2	H								M	H		
CO3	H				H					H		

Basic Electrical Engineering Practicals

Semester I **Hours of Instruction/week:2P**
21BEES03 **No. of credits:1**

Objective:

CLO1:To make the students learn and use the basic electrical concepts in various Practical applications and machines.

List of Experiments:

Introduction and use of measuring instruments–voltmeter, ammeter, multi-meter, oscilloscope, resistors, capacitors and inductors.

1. Design a resistive circuit to derive the specified load voltage and load current from a DC power source.
2. Verification of Kirchhoff's laws.
3. Build and test the voltage across and the current through any element using appropriate circuit analysis techniques.
4. Verify a circuit topology having star/delta connected network.
5. Design an RL/RC circuit for a given time constant, determine its current/voltage response and analyze the step response and the source free response of your circuit with initial conditions.
6. Design a home wiring circuit with R, RL load and two-way switch.
7. Power measurements in three phase system by two wattmeter method.
8. Determination of efficiency of single-phase transformer by load test.
9. Determination of efficiency of single-phase induction motor by Load test.
10. Load test and No-load test on DC motor.
11. Speed control of DC shunt motor.

Total Hours: 30

Course Outcomes:

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

CO1: Analyze AC and DC circuits and verify networks theorem
CO2: Design and demonstrate wiring for various loads.
CO3: Test transformers and electrical machines

CO, PO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H	H	L					L			L
CO2	H	H	L	L					L			L
CO3	H	H	L	H		L			L	L		L

Programming for Problem Solving using C and Python Practicals

Semester I/II **Hours of instruction/week: 2P**

21BEES06 **No. of Credits: 1**

Objective:

CLO: To understand and gain knowledge on the basic concepts in C and Python Programming languages.

List of Experiments:

C Programs

1. Programs using conditional operator and if statement
2. Programs using Switch Case Statements
3. Programs using for- while and do while loops
4. Programs using Arrays
5. Programs using Functions and Recursive Functions
6. Programs using Structures
7. Programs using Pointers
8. Programs using Files

Python Programs

1. Basic Python programs for reading input from console.
2. Programs using built-in data types – Numeric, Sequences (String, List, Tuple), Set and Dictionary Operations and type conversions
3. Programs using Looping statements.
4. Programs using the Decision statements
5. Programs for math operations and random number generation
6. Programs using user-defined functions with different types of function arguments
7. Programs for Class declaration and Object creation
8. Programs for File manipulations.

Total Hours: 30

Reference Books:

1. ***Pradip Dey- Manas Ghosh (2013). Computer Fundamentals and Programming in C***.Second Edition**.** Oxford University Press**.**
2. ***Yashavant P. Kanetkar (2011).Let Us C.*** BPB Publications**.**
3. ***Allen B. Downey (2016).Think Python: How to Think Like a Computer Scientist***. 2nd edition.O'Reilly Publishers.
4. ***Guido van Rossum and Fred L. Drake Jr (2011). An Introduction to Python – Revised and updated for Python 3.2.*** Network Theory Ltd.
5. ***Ashok N. Kamthane (2007). Computer Programming. Pearson Education.***
6. ***Kernighan,B.W and Ritchie,D.M (2006). The C Programming language.*** Second Edition. Pearson Education**.**
7. ***Byron S Gottfried and Jitendar Kumar Chhabra (2011).Programming with C.***Third Edition. Tata McGraw Hill Publishing Company.

Course Outcomes:

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

CO1: Experiment the fundamental concepts, control statements and functions in C and Python programming.

CO2: Apply Structures, Union and File concepts in C Programming to provide solutions to solve real world applications.

CO3: Analyze a problem and use appropriate language in C and python programs to solve it.

CO-PO Mapping

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	P10	P11	P12
CO1	M	H	M	L	L	-	-	-	-	M	M	M
CO2	L	M	H	M	L	-	-	-	-	M	M	M
CO3	M	M	M	L	L	-	-	-	-	M	M	M

Environmental Science
(Common to all branches)

Semester I **Hours of Instruction /week: 3T**
21BEMC01

Objective:

CLO 1: To study the interrelationship between living organisms and environment and to help students understand the various environment problems that we face and develop possible solutions to them.

Unit I Environment, Ecosystems and Biodiversity **11**

Definition, scope and importance of environment – need for public awareness - concept of an ecosystem – structure and function of an ecosystem – producers, consumers and decomposers – energy flow in the ecosystem – ecological succession – food chains, food webs and ecological pyramids – Introduction, types, characteristic features, structure and function of the (a) forest ecosystem (b) grassland ecosystem (c) desert ecosystem (d) aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries) – Introduction to biodiversity-definition: genetic, species and ecosystem diversity – biogeographical classification of India – value of biodiversity: consumptive use, productive use, social, ethical, aesthetic and option values – Biodiversity at global, national and local levels – India as a mega-diversity nation – hot-spots of biodiversity – threats to biodiversity: habitat loss, poaching of wildlife, man-wildlife conflicts – endangered and endemic species of India – conservation of biodiversity: In-situ and ex-situ conservation of biodiversity.

Field study of common plants, insects, birds.

Field study of simple ecosystems – pond, river, hill slopes, etc.

Unit II Natural Resources **10**

Forest resources: Use and over-exploitation, deforestation, case studies- timber extraction, mining, dams and their effects on forests and tribal people – Water resources: Use and over-utilization of surface and ground water, floods, drought, conflicts over water, dams-benefits and problems – Mineral resources: Use and exploitation, environmental effects of extracting and using mineral resources, case studies – Food resources: World food problems, changes caused by agriculture and overgrazing, effects of modern agriculture, fertilizer-pesticide problems, water logging, salinity, case studies – Energy resources: Growing energy needs, renewable and non-renewable energy sources, use of alternate energy sources. Case studies – Land resources: Land as a resource, land degradation, man induced landslides, soil erosion and desertification – role of an individual in conservation of natural resources – Equitable use of resources for sustainable lifestyles.

Field study of local area to document environmental assets – river / forest / grassland / hill / mountain.

Unit III Environmental Pollution **9**

Definition – causes, effects and control measures of: (a) Air pollution (b) Water pollution (c) Soil pollution (d) Marine pollution (e) Noise pollution (f) Thermal pollution (g) Nuclear hazards– solid waste management: causes, effects and control measures of municipal solid wastes – role of an individual in prevention of pollution – pollution case studies–disaster management: floods, earthquake, cyclone and landslides.

Field study of local polluted site – Urban / Rural / Industrial / Agricultural.

Unit IV Social Issues And The Environment 9

From unsustainable to sustainable development – urban problems related to energy – water conservation, rain water harvesting, watershed management – resettlement and rehabilitation of people; its problems and concerns, case studies – role of non-governmental organization- environmental ethics: Issues and possible solutions – climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust, case studies. – wasteland reclamation – consumerism and waste products – environment protection act– Air (Prevention and Control of Pollution) act – Water (Prevention and control of Pollution) act – Wildlife protection act – Forest conservation act – enforcement machinery involved in environmental legislation- central and state pollution control boards- Public awareness.

Unit V Human Population and The Environment 6

Population growth, variation among nations – population explosion – family welfare programme – environment and human health – human rights – value education – HIV / AIDS – women and child welfare – role of information technology in environment and human health –Case studies.

TOTAL HOURS: 45

Reference Books:

1. ***Raman Sivakumar,"Introduction to Environmental science and Engineering",*** McGraw Hill Education,**ISBN 13: 9780070672802,**2009.
2. ***Gilbert M.Masters, 'Introduction to Environmental Engineering and Science'***, 3rd edition, Pearson Education, ISBN-13: 9780131481930,2008.
3. ***Benny Joseph, 'Environmental Science and Engineering'***, Tata McGraw-Hill, New Delhi,**ISBN-13 9789387432352,**2006.
4. ***R.K. Trivedi, 'Handbook of Environmental Laws, Rules, Guidelines, Compliances and Standards'***,Vol. I and II, Enviro Media.ISBN:8186421017
5. ***Dharmendra S. Sengar, 'Environmental law***', Prentice Hall of India Pvt. Ltd., New Delhi, **ISBN-13:** 978-8120330597, 2007.
6. ***Rajagopalan, R, 'Environmental Studies-From Crisis to Cure***', Oxford University Press,**ISBN:**9780199459759,2005 .

Course Outcomes::

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

CO1: Correlate the complex relationship between natural environment and human activities.

CO2: Predict the consequences of human actions on the web of life, global economy and Quality of life.

CO3: Identify suitable measures to solve environmental problems.

CO, PO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	P10	P11	P12
CO1	L	M	-	-	-	M	H	M	L	-	-	M
CO2	L	M	-	-	-	H	H	M	L	-	-	M
CO3	L	M	-	-	-	H	H	M	L	-	-	M

Professional English Practicals
(Common to all branches)

Semester II **Hours of instruction/week:0T+ 2P**
21BEHS02 **No.of credit: 1**

Objective:

CLO 1: To provide hands-on aural, oral, reading and writing practices to students

Exercises:

I Group Discussion **4**

GD strategies, initiating a discussion, persuasion skills, body language, ways of interrupting (non–offending), summarizing and concluding.

II Interview Skills **4**

Introducing oneself, listing one's aspirations and goals, systematically expressing one's achievement (academic as well as professional), listening keenly and gently manipulating the interviewer, e mail etiquette.

III Presentation Skills **5**

Business and technical presentation, technical articles (for journals and conferences), business etiquette.

IV Active Listening Practices **4**

Speech decoding, comprehending, types of conversation, formal and informal, listening to academic, business and technical speeches.

V Online Grammar Exercises **4**

Editing the passage, cloze exercises, jumbled sentences, tag question, usage of tenses, phrasal verbs, sentence patterns.

VI Vocabulary Enrichment **4**

Word formation, technical jargon, words often confused and misused, homophones.

VII Book Review **5**

Reading inspiring articles, inferring meanings, reading between the lines and beyond the lines, understanding implicit and explicit ideas.

Total Hours : 30

Reference Books :

1.***Aysha Viswamohan*(2008).*English for Technical Communication***. Tata McGraw Hill Publishing Co. Ltd, New Delhi.

2.***M. Ashref Rizvi (2005). Effective Technical Communication*.** Tata McGraw Hill Publishing Co. Ltd, New Delhi.

3.***Dr.K.Devadoss and P.Malathi(2008).Customize Yourself to Corporate Life*.** InderPublications,Coimbatore.

Course Outcomes:

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

CO 1: Analyze and acquire listening and speaking skills in both formal and informal contexts.

CO 2: Acquire English language skills at their own pace by using language lab components.

CO 3: Communicate their thoughts, opinions and ideas freely and naturally**.**

CO, PO Mapping

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	-	-	-	-	-	-	-	M	M	H	-	-
CO2	-	-	-	-	-	-	-	L	H	M	-	-
CO3	-	-	-	-	-	-	-	H	M	L	-	-

Laplace Transforms and Complex variables

(Common to all branches)

Semester II **Hours of Instruction/ week: 3T+1Tu**

21BESM02 **No. of Credits: 4**

Objectives:

CLO1: To enhance knowledge in Laplace transforms, vector calculus and its applications.

CLO2: To understand the concepts of complex integration and contour integration.

CLO3: To gain knowledge in creating and working with arrays and to explore the built – in functions for vector, matrix operations and integration.

Unit I Laplace Transform **12**

Laplace Transform, Definition and Sufficient conditions, Transforms of functions, properties of Laplace Transforms, Inverse transforms, Derivatives and integrals of transforms, Transforms of derivatives and integrals, Convolution theorem, Transform of periodic functions, Application to solution of linear ordinary differential equations up to second order with constant coefficients.

Unit II Analytic Functions **12**

Function of a complex variable, Analytic function, Necessary conditions, Cauchy – Riemann equations in Cartesian coordinates, Sufficient conditions (Proof not included), Properties of analytic function, Determination of harmonic conjugate by Milne – Thomson method, Conformal mapping, $w = z + a, az, \frac{1}{z}$

Unit III Complex Integration **12**

Statement and application of Cauchy's theorem and Cauchy's integral formula, Laurent's expansion, Singularities, Classification, Residues, Cauchy's residue theorem, Contour integration, Unit circle and semi-circular contours (excluding poles on real axis).

Unit IV Vector Calculus **12**

Gradient, divergence and curl, Green's, Gauss divergence and Stoke's theorems (without proof), Verification of the above theorems and evaluation of integrals using them.

Unit V Mathematical Solutions Using Software Tools **12**

Scripts and Functions, Software tools applied to operation with Vectors, Arrays and Complex Integrations.(Unit V is only for gaining knowledge in software applications and not included in theory exams)

Total hours –60

Text Books:

1. ***T.Veerarajan (*2016), *Engineering Mathematics (for semester I and II),*** updated 2nd Edition, Tata McGraw Hill Publishing Co.Ltd, New Delhi.
2. ***P.Kandaswamy, K.Thilagavathy and K.Gunavathy (2014), Engineering Mathematics,*** 10th Revised Edition, S. Chand & Co, New Delhi.

Reference Books:

1. ***E.Kreyszig (2014), Advanced Engineering Mathematics***, 8th Edition, John Wiley and Sons (Asia) Ltd, Singapore.
2. ***Dennis G. Zill and Michael R.Cullen (2012), Advanced Engineering Mathematics,*** 2nd Edition, CBS Publishers.

3. ***Srimanta Pal and Subhodh C Bhunia (2012), Engineering Mathematics,*** 9th Edition**,** John Wiley and Sons.
4. ***Dr. B. S. Grewal (2014), Higher Engineering Mathematics***, 43rd Edition, Khanna Publishers, New Delhi.
5. ***Jain R.K. and Iyengar S.R.K. (2007), Advanced Engineering Mathematics,*** 3rd Edition, Narosa Publications, New Delhi.
6. ***Sastry, S.S (2014), Engineering Mathematics", Vol. I & II,*** 4th Edition, PHI Learning Pvt. Ltd, New Delhi,.
7. Open Source Software tools.

Course Outcomes:

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

CO1: Recognise the need of Laplace transform techniques, Complex integrals and Vector calculus in engineering fields like computer science, biomedical, communication etc.

CO2: Apply the knowledge of Laplace transforms and Complex variables in solving complex engineering problems

CO3: Assess complex variables and evaluate complex integrals that arise in engineering fields

CO, PO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H	M	-	-	-	-	-	-	-	-	M
CO2	H	H	M	-	-	-	-	-	-	-	-	M
CO3	H	H	M	-	L	-	-	-	-	-	-	M

Engineering Chemistry

(Common to all branches)

Semester I/ II **Hours of Instruction/week:3T+1Tu**

21BESC01 **No. of credits: 4**

Objective:

CLO1 : To provide students with a background in important concepts and principles of Chemistry and use the knowledge gained to describe and solve real technological problems.

Unit I Water Technology **12**

Characteristics: Alkalinity, types of alkalinity and determination. Hardness: Types and estimation by EDTA method (problems). Boiler feed water, requirements, and disadvantages of using hard water in boilers. Internal conditioning: Phosphate, calgon and carbonate conditioning. External conditioning: Demineralization process. Domestic water treatment: Disinfection methods (Chlorination, ozonation, UV treatment). Desalination: Reverse osmosis.

Unit II Electrochemistry and corrosion **12**

Electrochemical cells: Electrode potential, Nernst equation (problems). Reference electrodes: Calomel electrode, glass electrode and measurement of pH, EMF, electrochemical series and its significance. Chemical and electrochemical corrosion: principle, mechanism, galvanic corrosion, differential aeration corrosion. Factors influencing corrosion .Corrosion control: Selection of materials and proper designing, sacrificial anode and impressed current cathodic protection methods, corrosion inhibitors.

chemical factors influencing adhesive action – bonding process of adhesives –phenol formaldehyde

Unit III Engineering Materials **12**

Refractory, classification, acidic, basic, and neutral refractory, Properties (refractoriness, refractoriness under load, dimensional stability, porosity, thermal spalling), manufacture of alumina, magnesite and zirconia bricks, Adhesives – adhesive action – development of adhesive strength – physical and resins, polyurethane, epoxy resins and urea formal dehyde. Lubricants, properties, viscosity index, flash and fire points, cloud and pour points, oilyness, aniline point, solid lubricants, graphite and molybdenum sulphide, semisolid lubricants, greases.

Unit IV Polymer Chemistry **12**

Introduction: Functionality-degree of polymerization. Classification of polymers- Natural and synthetic, thermoplastic and thermosetting. Types and mechanism of polymerization: addition (free radical, cationic, anionic), condensation and copolymerization. Properties of polymers: Tg, tacticity, molecular weight-weight average, number average and polydispersity index. Techniques of polymerization: Bulk, emulsion, solution and suspension. Conducting polymers, types, mechanism of conduction and Applications.

Unit V Photo chemistry and Spectroscopy **12**

Photochemistry: Laws of photochemistry-Grotthuss-Draper law, Stark-Einstein law and Lambert-Beer Law. Photo processes - fluorescence, phosphorescence, chemiluminescence and photo-sensitization. Spectroscopy: Electromagnetic spectrum-absorption of radiation-electronic, vibrational and rotational transitions. Width and intensities of spectral lines.

Estimation of concentration of a coloured solution by colorimetry, UV-Visible and IR spectroscopy- principles, instrumentation (Block diagram only) and applications.

Total Hours: 60

REFERENCE BOOKS:

1. Jain P. C. & Monika Jain., "Engineering Chemistry", Dhanpat Rai Publishing Company (P) Ltd, New Delhi, ISBN 13: 9788187433170, 2015.

2. ***Vairam S., Suba Ramesh., "Engineering Chemistry***", Wiley India Pvt Ltd., New Delhi.,ISBN 13: 9788126544752, 2013.

3. Shashi Chawla., "A Text Book of Engineering Chemistry", Dhanpat Rai & Co Pvt. Ltd. 3rd Edition, 10thReprint 2013

4. ***Dara S.S.,Umare S.S., 'Engineering Chemistry' ,*** **12th edition,** S.Chand&CompanyPvt.Ltd,NewDelhi.,ISBN : 81-219-0359-9, 2010

5. ***Palanna O.G, "Engineering Chemistry***", 2nd Edition, McGraw-Hill Education (India) Pvt. Ltd.,Chennai,**ISBN:9789352605774,** 2017

6. ***Kannan P., Ravikrishnan A., "Engineering Chemistry***", Sri Krishna Hitech Publishing Company Pvt. Ltd. Chennai, 2014.

Course Outcomes:

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

CO1: Identify chemistry principles related to engineering concepts.

CO2: Analyse scientifically various chemistry related problems in engineering field based on theoretical concepts, experimental procedures and mechanism.

CO3: Predict potential applications of chemical principles and knowledge acquired in order to become good engineers and innovators

CO, PO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	M	-	-	-	M	L	-	-	-	-	-
CO2	L	H	-	M	-	L	L	-	-	-	-	-
CO3	L	-	H	-	-	M	M	-	-	-	-	-

Chemistry Practicals

(Common to all branches)

Semester I/II **Hours of Instruction/week:3P**

21BESC02 **No. of credits: 1.5**

Objective

CLO1 : To impart experimental skills and hands on experience in the use of analytical equipment needed for engineering applications.

List of Experiments

1. Determination of total hardness of water by EDTA method.
2. Determination of DO content by Winkler's method.
3. Determination of alkalinity in a water sample.
4. Determination of chloride content of water sample by argentometric method.
5. Estimation of concentration of a coloured solution using colorimeter
6. **pHmetry**

To find out the strength of given hydrochloric acid by sodium hydroxide.

7. **Conductometry**

a. Estimation of strength of acids in a mixture of acids.

b. Estimation of Barium Chloride using Sodium Sulphate.

8. **Potentiometry**

Estimation of ferrous ionin the given solution.

9. **Viscometry**

Determination of molecular weight of a polymer

10. **Corrosion Experiment**

Weight Loss method.

11. **Spectrophotometry**

Estimation of iron content of water sample

(Any ten experiments)

Course Outcomes:

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

CO1 : Acquire skills in measuring, recording and analysing the results.

CO2 : Assess the quality of water through different tests.

CO3 : Develop skills in handling analytical instruments.

CO, PO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H	-	H	-	L	-	L	-	-	-	-
CO2	H	H	-	H	-	H	M	-	-	-	-	L
CO3	H	H	-	H	-	M	-	-	-	-	-	-

Workshop Practicals

Semester II **Hours of Instruction/Week: 1T + 4P**

21BEES05 **No. of Credits: 3**

Objectives:

CLO1: The course caters the needs of the practical application and to help in basic learning skills in Civil Engineering, Mechanical Engineering and Electronics Engineering.

PART A (CE)

PLUMBING WORK:

1. Connecting various basic pipe fittings like valves, taps, coupling, unions, reducers, elbows and other components which are commonly used in household.
2. Preparing plumbing line sketches for household.
3. Connecting pipes of different materials: Metal, plastic and flexible pipes used in household appliances.

WOOD WORK:

1.Sawing, 2. Planning and 3. Making joints like Lap Joint and T-Joint

WOOD WORK STUDY:

1.Studying joints in door panels and wooden furniture

PART B (ME)

1. Simple turning and facing operations using Lathe
2. Knurling and Grooving operations using Lathe
3. Preparation of square butt joint in Arc welding
4. Preparation of T-Joint using Arc Welding
5. Preparation of Lap Joint using Arc Welding

PART C (ECE)

1. Soldering simple electronic circuits
2. V-I Characteristics of PN Junction Diode
3. V-I Characteristics of Zener Diode
4. Design and verify the characteristics of Half and Full Wave Rectifier
5. House hold wiring–series and parallel connections with two switches
6. Staircase light wiring

Total Hours: 45

Examination Pattern:

The Examination is to be conducted for both parts AB **(OR)** parts AC **(OR)** parts BC allotting 1.5 hours for each part.

Course Outcomes:

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

CO1: Identify pipe fitting, prepare plumbing line sketch connect pipes of different materials in plumbing works and identify various joints and components in wooden doors and furniture's.

CO2: Operate lathe for various operations and prepare butt, T, Lap joints in Arc welding

CO3: Understand basic connections of wiring, and verify the characteristics of PN junction, Zener Diode and rectifiers.

CO, PO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H				M	M			M	M		H
CO2	H	H		H		H	M					L
CO3	H	L			M				M			

Constitution of India
(Common to all branches)

Semester II **Hours of Instruction/week: 2T**

21BEMC02

Objective:

CLO1: To know about making of Indian constitution, Rights & Duties, Organs of Governance, Local Administration, and Election Commission

Unit I: History of Making of the Indian Constitution **6**

History, Drafting Committee, (Composition & Working), Philosophy of the Indian constitution-Preamble Salient Features

Unit II Contours of Constitutional Rights & Duties **6**

Fundamental Rights, Right to Equality, Right to Freedom, Right against Exploitation, Right to Freedom of Religion, Cultural and Educational Rights, Right to Constitutional Remedies, Directive Principles of State Policy, Fundamental Duties.

Unit III Organs of Governance **6**

Parliament, Composition, Qualifications and Disqualifications, Powers and Functions, Executive President, Governor, Council of Ministers, Judiciary, Appointment and Transfer of Judges, Qualifications, Powers and Functions

Unit IV Local Administration **6**

District's Administration head: Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation, Panchayat raj: Introduction, PRI: ZilaPachayat.Elected officials and their roles, CEO ZilaPanchayat: Position and role Block level: Organizational Hierarchy (Different departments), Village level: Role of Elected and Appointed officials, Importance of grass root democracy

Unit V Election Commission **6**

Election Commission: Role and Functioning. Chief Election Commissioner and Election Commissioners, State Election Commission: Role and Functioning, Institute and Bodies for the welfare of SC/ST/OBC and women.

Total Hours: 45

Reference Books:

1. ***The Constitution of India, 1950*** *(Bare Act),* Government Publication.
2. ***Dr. S. N. Busi, Dr. B. R. Ambedkar framing of Indian Constitution****,* 1st Edition, 2015.
3. ***M. P. Jain, Indian Constitution Law****,* 7th Edn., Lexis Nexis, 2014.
4. ***D.D. Basu, Introduction to the Constitution of India***, Lexis Nexis, 2015.

Course Outcomes:

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

CO1: Comprehend the history of Indian Constitution and the various schedules under it.

CO2: Appreciate and discuss the basic components of Indian constitution, Constitutional rights and duties and various Organs of Governance

CO3: Participate in democratic processes

CO, PO Mapping

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	-	-	-	L	L	-	-	-	-
CO2	-	-	-	-	-	-	M	M	-	-	-	-
CO3	-	-	-	-	-	-	L	H	-	-	-	-

Fundamentals of Research

Semester II **Hours of instruction /week:2**

21BEUR01 **No. of credits:2**

Objectives

CLO1: To introduce the importance of research.

CLO2 :To impart knowledge on the methods of data collection and analysis

CLO3 :To give basic foundation of statistics.

CLO4 :To introduce the skill of report writing

Unit I Introduction to Research **5**

Definition – Significance of Research – Types of Research – Scope of Research – Defining the research problem – Steps in Research – importance of research problem – Research Objectives – Research Protocol – Course Outcomes: of research – Understanding concepts, constructs, variables.

Unit II Tools for Collection of Data 6

Methods of data collection – Primary and Secondary data collection methods, qualitative methods of data collection and survey methods of data collection-Most popular methods: Direct observation, Experiments and Survey-Population and sampling–Types of sampling.

Unit III Statistical Methods **5**

Basics of data analysis - Measurement Scales, Sources of error in measurement. Measures of central tendency (Mean, Median, Mode), Measures of dispersion (Range, Mean Deviation, Standard Deviation)-Diagrammatic and Graphical representation of Data.

Unit IV Inferential statistics **5**

Types of hypothesis- Testing of Hypothesis - Type I and Type II error- Testing the difference between means (Z &t-test), ANOVA and Chi square test (basics only)

Unit V Report Writing **6**

Reportgeneration–Reportwriting-Bibliography–ImportanceofResearchEthicsandIntegrity-Misconduct in research and consequences of misconduct

Practical session **3**

Identifying a problem and using appropriate statistical tools

Text Book:

1.KothariC.R(2016).,Research Methodology, Sultan Chand publications, New Delhi.

Reference Books:

1.Krishnaswami O.R,Ranganatham M (2016),Methodology of Research in Social science, Himalaya Publishing House, Delhi.

2. Paneerselvam.R (2016), Research methodology, PHIlearning, NewDelhi.

3.Deepak Chawla and Neena Sodhi (2016), Research Methodology, Vikas Publishing House, NewDelhi.

4. Gupta,S.P.(2007),Statistical Methods, Sultan Chand &Son Publications, NewDelhi.

II year Syllabus

Human Values and Medical Ethics

Semester III **Hours of Instruction/ week: 3T**
21BEHS03 **No. of credits: 3**

Objectives:

CLO1: To identify the core values that shapes the ethical behavior of a biomedical engineer.

CLO2: To create awareness on medical ethics and human values.

Unit I Human Values **9**

Morals, values and Ethics – Integrity – Work ethic – Service learning – Civic virtue – Respect for others – Living peacefully – Caring – Sharing – Honesty – Courage – Valuing time – Cooperation – Commitment – Empathy – Self-confidence – Character – Spirituality – Introduction to Yoga and meditation for professional excellence and stress management.

Unit II Introduction to Medical Ethics **9**

Modern cultures and its influence on Ethics, Concept of Medical Ethics and its decline in India.

Unit III Principles and Code of Conduct **9**

Major principles of medical ethics, Principles of medical ethics formulated by AMA, International Code of Medical Ethics, Code of Medical Ethics by ICMR, Duties and responsibilities of physician in general.

Unit IV Malpractices, Negligence and Insurance **9**

Introduction to different type of Malpractices, Medical negligence, Consumer protection act Common medical malpractice legal terms, Types of insurance, financing**,** installing a policy to payment of claims.

Unit V Confidentiality and Patient Rights **9**

Confidentiality of medical data, Rights of patients**,** Governmental regulations on ethics**,** Informed Consent.

Total Hours: 45

Reference Books:

1. ***Mike W. Martin and Roland Schinzinger***, "***Ethics in Engineering***", Tata McGraw Hill, New Delhi, 2003.
2. ***R.S. Naagarasan, "A Textbook on Professional Ethics and Human Values",***New Age International Publishers, New Delhi, 2006.
3. ***Govindarajan M, Natarajan S, Senthil Kumar V. S***, "***Engineering Ethics***", Prentice Hall of India, 2013.
4. ***Charles B. Fleddermann, "Engineering Ethics***", Pearson Prentice Hall, New Jersey, 2004.
5. ***Charles E. Harris, Michael S. Pritchard and Michael J. Rabins,*** "**Engineering Ethics – Concepts and Cases",** Cengage Learning, 2009.

Course Outcomes:

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

CO1: Understand human values.

CO2: Summarize medical ethics and code of conduct.

CO3: Discuss malpractices, confidentiality of medical data and patient rights.

CO, PO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H					M	L	H		H		
CO2	H					M	L	H		H		
CO3	H					M	L	H		H		

Transforms, Partial Differential Equations and Applications for Biomedical Engineering
(BMIE)

Semester III **Hours of Instruction/ week: 3T+1Tu**
21BESM03 **No. of Credits: 4**

Objectives:

CLO1: To impart analytical skills to the students in the areas of boundary value problems and transform techniques.

CLO2: To serve as a prerequisite for post graduate and specialized studies and research.

Unit I Fourier series **12**

Dirichlet's conditions, General Fourier series, Half Range Sine and Cosine series, Parseval's identity, Harmonic Analysis.

Unit II Fourier Transform **12**

The Infinite Fourier transform, sine and cosine transform properties, inversion theorem, convolution theorem, Parseval's identity. Application in biomedical signal processing.

Unit III Z – Transforms **12**

Definition and properties, inverse Z transforms, Definition, Properties, Simple Problems, Application of Z – Transforms in solving difference equations. Application in biomedical engineering.

Unit IV Partial Differential Equations **12**

Formation of Partial Differential equation by eliminating arbitrary constants and arbitrary functions, Solution of standard types of first order equations, Lagrange's equation, linear partial differential equation of second and higher order with constant coefficients.

Unit V Boundary Value Problems **12**

Classification of second order linear partial differential equations, Solutions of one – dimensional wave equation, one – dimensional heat equation, Steady state solution of two- dimensional heat equation, Fourier series solution in Cartesian coordinates.

Total hours: 60

Reference Books*:*

1. ***P.Kandasamy, K.Thilagavathy, and K.Gunavathy (2007), Engineering Mathematics,*** III semester, First edition, S. Chand & Co, New Delhi.
2. ***T.Veerarajan (2014), Transforms, Partial Differential Equations and Applications,*** Third Edition, Tata McGraw – Hill Publishing Company Limited, New Delhi.
3. ***E.Kreyzig (2014), Advanced Mathematics,*** (9^{th} Edition), John Wiley and Sons. (Asia) Pvt. Ltd, Singapore.

4. ***B.S.Grewal (2014), Higher Engineering Mathematics*** (43rd Edition), Khanna Publishers, Delhi**.**

Course Outcomes:

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

CO1: Develop Fourier series for periodic functions and apply it to solve boundary value problems.

CO2: Transform a function in the time domain to another function in the frequency domain through Fourier Transform and apply Z transform in solving difference equations.

CO3: Formulate and solve problems involving functions of several variables in terms of PDE.

CO, PO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H	M									M
CO2	H	H	M									M
CO3	H	H	M									M

Electron Devices and Circuits

Semester III **Hours of Instruction/ week: 3T**
21BEBS01 **No. of credits: 3**

Objectives:

CLO1: To familiarize with the basic electronic devices and their characteristics.

CLO2: To analyze amplifier and oscillator circuits.

Unit I PN Junction Devices **9**

PN junction diode - structure, operation and V-I characteristics, diffusion and transient capacitance. Rectifiers, Half Wave and Full Wave Rectifier. Display devices- LED, Laser diodes, Zener diode-characteristics- Zener Reverse characteristics, Zener as regulator.

Unit II Transistors **9**

BJT, JFET, MOSFET- structure, operation, characteristics and Biasing, UJT, Thyristor and IGBT - Structure and characteristics.

Unit III Amplifiers **9**

BJT small signal model, Analysis of CE, CB, CC amplifiers- Gain and frequency response. MOSFET small signal model. Analysis of CS and Source follower Gain and frequency response- High frequency analysis.

Unit IV Multistage Amplifiers and Differential amplifier **9**

Cascaded amplifier, Differential Amplifier-Common mode and Difference mode analysis. FET-input stages, Single tuned amplifiers-Gain and frequency response. Neutralization methods, power amplifiers types

Unit V Feedback Amplifiers and Oscillators **9**

Advantages of negative feedback, voltage / current, series, Shunt feedback, positive feedback, Condition for oscillations, phase shift, Wien Bridge, Hartley, Colpitts and Crystal oscillators.

Total Hours: 45

Reference books:

1. ***Boylestead L. Robert, Nashelsky Louis***, "***Electronic Devices and Circuit Theory***", Pearson Education India, New Delhi, 2012.
2. ***Sedra A. S., Smith K****.C.,* "***Microelectronic Circuits***", Oxford University Press, USA, 2008.
3. ***Jacob Millman, Christos C. Halkias*****, "*****Electronic Devices and Circuits*****",** Tata McGraw Hill, New Delhi, 2010.
4. ***Thomas L. Floyd, "Electronic Devices: Conventional Current Version"***, Pearson Education India, New Delhi, 2008.
5. ***David A. Bell, "Electronic Devices and Circuits",*** Prentice Hall of India, New Delhi, 2008.

Course Outcomes:

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

CO1: Explain the principles and structure of basic electronic devices.
CO2 Discuss the operation and VI Characteristics of electronic devices.
CO3 Analyze gain and frequency responses of amplifier.
CO4 Discuss feedback amplifiers, oscillators and its conditions.

CO, PO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H	M						M	M		
CO2	H	H	M	L					M	M		
CO3	H	H	M	L					H	M		
CO$	H	H							M	M		

Devices and Circuits Practicals

Semester III **Hours of Instruction/ week: 3P**
21BEBS02 **No. of credits: 1.5**

Objective:

CLO: To test the operating characteristics of basic semiconductor devices and circuits by performing simulation and experiments.

List of Experiments

1. Characteristics of PN Junction Diode
2. Zener diode characteristics & Voltage Regulator
3. Common Emitter input-output characteristics
4. Common Base input-output characteristics
5. FET characteristics
6. SCR characteristics
7. Clippers and Clampers
8. Half wave rectifier & Full wave rectifier
9. BJT as RC coupled amplifier
10. BJT as RC phase shift oscillator

II. Simulation and testing of the above experiments using Multisim software

Total Hours: 45

Course Outcomes:

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

CO1: Plot the characteristics of electronic devices to understand their behavior.

CO2: Design, construct and test amplifier and oscillator circuits and interpret the results.

CO3: Verify the theoretical concepts through simulation experiments.

CO, PO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H			M				M	M		
CO2	H	H	M	L	H				M	M		
CO3	H	H	M	L	H				M	M		

Signals and Systems

Semester III **Hours of Instruction/week: 4T**

21BEBS03 **No. of credits: 4**

Objectives:

CLO1: To discuss the basic properties of signals and systems.

CLO2: To analyze continuous time signals and systems in the Fourier and Laplace domain.

CLO3: To analyze discrete time signals and system in the Fourier and Z transform domain.

Unit I Classification of Signals and Systems **12**

Continuous time signals (CT signals) - Discrete time signals (DT signals) - Step, Ramp, Pulse, Impulse, Sinusoidal, Exponential, Classification of CT and DT signals - Periodic & Aperiodic signals, Deterministic & Random signals, Energy & Power signals - CT systems and DT systems- Classification of systems – Static & Dynamic, Linear & Nonlinear, Time-variant & Time- invariant, Causal & Non-causal, Stable & Unstable.

Unit II Analysis of Continuous Time Signals **12**

Fourier series analysis - spectrum of Continuous Time (CT) signals - Fourier and Laplace Transforms in CT Signal Analysis - Properties.

Unit III Linear Time Invariant- Continuous Time Systems
12

Differential Equation-Block diagram representation-impulse response, convolution integrals- Fourier and Laplace transforms in Analysis of CT systems.

Unit IV Analysis of Discrete Time Signals **12**

Baseband Sampling - DTFT – Properties of DTFT - Z Transform – Properties of Z Transform.

Unit V Linear Time Invariant-Discrete Time Systems **12**

Difference Equations - Block diagram representation-Impulse response - Convolution sum - Discrete. Fourier and Z Transform Analysis of Recursive & Non-Recursive systems.

Total Hours: 60

Reference Books:

1. ***Allan V. Oppenheim, S. Wilsky and S. H. Nawab,* "*Signals and Systems*",** Pearson, 2007.
2. ***B. P. Lathi,* "*Principles of Linear Systems and Signals*"**, Second Edition, Oxford, 2009.
3. ***R. E. Zeimer, W. H. Tranter and R. D. Fannin*, "*Signals & Systems - Continuous and Discrete*",** Pearson, 2009.
4. **John Alan Stuller, "An Introduction to Signals and Systems",** *Thomson, 2007.*

5. ***M. J. Roberts, "Signals & Systems Analysis using Transform Methods & MATLAB"***, Tata McGraw Hill, 2017.

Course Outcomes:

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

- **CO1:** Classify and analyze the properties of CT and DT signals and systems.
- **CO2:** Represent CT and DT systems in the Frequency domain using Fourier analysis tools like CTFT and DTFT.
- **CO3:** Analyze CT and DT systems using Laplace transforms and Z transforms.
- **CO4:** Discuss the effects of signal sampling and convolution of systems.

CO, PO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	M			L							
CO2	H	M			M							
CO3	H	M			M							
CO4	H	M			L							

Human Anatomy and Physiology

Semester III **Hours of Instruction/ week: 3T**
21BEBC01 **No. of credits: 3**

Objectives:

CLO1: To identify all the organelles of an animal cell and their function.

CLO2: To acquire the basic knowledge of anatomical features and physiology of various human body systems.

Unit I Study of Cellular System **9**

Cell: Structure and organelles, Functions of each component in the cell. Cell membrane, transport across membrane, origin of cell membrane potential (Nernst and Goldman and Katz equations), Action potential.

Unit II Hematological System **9**

Blood composition, functions of blood, functions of RBC. WBC types and their functions. Blood groups, importance of blood groups, identification of blood groups. Blood flow factors regulating blood flow such as viscosity, radius, density, etc (Fahreus-lindqvist effect, Poiseuille's Law).

Unit III Renal and Respiratory System **9**

Structure of Kidney and nephron. Mechanism of Urine formation and acid base regulation, Dialysis. Components of respiratory system. Oxygen and carbon dioxide transport.

Unit IV Cardiac System **9**

Structure of heart, Circulatory of blood in Heart, Properties of Cardiac muscle, Cardiac muscle and pacemaker potential, cardiac cycle, ECG, Heart sound, volume and pressure changes and regulation of heart rate.

Unit V Nervous, Reproductive and Digestive System **9**

Structure of a Neuron, Synaptic conduction, Conduction of action potential in neuron, Parts of brain cortical localization of functions EEG. Simple reflexes, withdrawal reflexes. Autonomic nervous system and its functions, Human Reproductive System: Male and Female reproductive system. Organization of GI system, Digestion and absorption – Movement of GI tract.

Total Hours: 45

Reference Books:

1. ***Elaine N. Marie, "Essential of Human Anatomy and Physiology",*** 8th edition. Pearson Education, New Delhi, 2007.
2. ***F. Ganong, "Review of Medical Physiology",*** Second Edition. Mc Graw Hill, New Delhi, 2000.
3. ***Prof. A. K. Jain, "Text Book of Physiology",*** Third edition, Volume I and II, Avichal Publishing Company, New Delhi, 2005.

Courses Outcomes:

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

CO1: Summarize the basic structure and functions of cell.
CO2: Explain the fundamental principles of mechanics in hematological systems.
CO3: Discuss the physiological functions and regulations of various human body systems.
CO4: Describe the anatomical position and structures of various human body systems.

CO, PO MAPPING

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H								H		
CO2	H	H								M		
CO3	H	H								H		
CO4	H	H								H		

Biomedical Sensors and Measurement Devices

Semester III **Hours of Instruction/ week: 3T**
21BEBC02 **No. of credits: 3**

Objectives:

CLO1: To understand the purpose of measurement, methods and the errors associated with the measurements.

CLO2: To know the principle of transduction, design and construction of different transducers and to familiarize with measurement and display devices.

Unit I Concepts of Measurement **9**

General Measuring System, Standard Inputs, Characteristics, Static & Dynamic Characteristics of Measuring Instruments, Errors in Measurements, Signals & Noises, Units & Standards, Calibration of Instruments.

Unit II Transducers **9**

Resistive Transducers: Strain Gauge: Gauge factor, sensing elements, configuration, biomedical applications; strain gauge as displacement & pressure transducers, RTD materials & range, Characteristics, thermistor characteristics, biomedical applications of Temperature sensors Capacitive transducer, Inductive transducer, LVDT, Active type: Thermocouple, characteristics, Optical transducer.

Unit III Photoelectric and Piezoelectric sensors **9**

Phototube, scintillation counter, Photo Multiplier Tube (PMT), photovoltaic, Photo conductive cells, photo diodes, phototransistor, comparison of photoelectric transducers, spectrophotometric applications of photo electric transducers. Piezoelectric active transducer and biomedical applications as pressure & Ultrasound transducer, Construction and design of photoelectric and piezoelectric sensors.

Unit IV Signal Conditioning and Signal Analyzer **9**

AC and DC Bridges, wheat stone bridge, Kelvin, Maxwell, Hay, Schering, Concepts of filters, Pre-amplifier, impedance matching circuits, isolation amplifier. Spectrum analyzer.

Unit V Display Devices **9**

Digital voltmeter, Multi meter, 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. Demonstration of the display and recording devices.

Total Hours: 45

Reference Books:

1. ***Albert Helfrick and Cooper W.D. "Modern Electronic Instrumentation and Measuring Techniques",*** Prentice Hall of India**.**2007**.**
2. ***Sawhney.A.K. "Electrical and Electronic Measurements and Instrumentation",*** Dhanpat Rai and Sons, 2005.
3. ***John G. Webster, "Medical Instrumentation Application and Design"***, 4th edition, John Wiley and Sons, New York, 2009.
4. ***Richard S. C "Cobbold Transducers for biomedical measurements: principles and application",*** *New York, Wiley 2017.*
5. ***Jacob Fraden, "Handbook of Modern Sensors", Third edition****, San Diego, California, 2010*

Course Outcomes:

Upon completion of this course, the students should be able to:

CO1: Recall the characteristics of measuring instruments, transducers, photoelectric, piezoelectric sensors and display devices.

CO2: Describe the working principle of transducers, sensors, AC, DC bridges and display devices.

CO3: Use AC and DC bridges for relevant parameter measurement and employ the sensors, recording and display devices for biomedical applications.

CO4 Design the photoelectric and piezoelectric sensors.

CO, PO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H									H		
CO2	H								H	H		
CO3	H								H	H		
CO4	H			H								

Biomedical Sensors and Measurement Practicals

Semester III **Hours of Instruction/ week: 3P**
21BEBC03 **No. of credits: 1.5**

Objectives:

CLO1: To test the working of biosensors and transducers.

CLO2: To find the value of unknown resistance, capacitance using various bridges.

List of Experiments

1. To determine the value of unknown resistance using Wheatstone bridge
2. To determine the value of unknown capacitance using Schering's bridge
3. To determine the value of unknown capacitance using Wein's bridge oscillator
4. To determine the value of unknown capacitance using Desauty's bridge
5. To measure the low resistance using Kelvin's double bridge
6. To find the value of unknown inductance using a Maxwell's inductance bridge
7. Verify the characteristics of strain gauge
8. Verify the characteristics of flow transducer
9. Verify the characteristics of piezoelectric transducer
10. Plot the characteristics curve of Thermocouple, Thermistor and RTD
11. Verify the characteristics of Load cell
12. Verify the characteristics of Opto-coupler
13. Verify the characteristics of photoelectric transducer
14. Verify the characteristics of LVDT
15. To determine pH of common substances using pH meter
16. To measure torque of a rotating shaft using torque measurement trainer kit.
17. Testing of ECG equipment using ESA
18. Testing of Infusion pump using Infusion analyzer

Total Hours: 45

Course Outcomes:

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

CO1: Determine the values of unknown resistance, capacitance and inductance using various bridges.

CO2: Demonstrate the working and plot the characteristic curves of strain gauge, Load cell and opto- coupler.

CO3: Analyse the characteristics of thermocouple, thermistor, RTD, piezoelectric and photoelectric transducers and test the ECG equipment and Infusion pump.

CO, PO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H			H					H		
CO2	H	H			H					H		
CO3	H	H			H					H		

Consumer Affairs

(Non-Credit Mandatory Course)

Semester III **Hours of Instruction/week: 3T**

21BEMC03

Objectives:

CLO1: To familiarize with the rights and responsibilities of a consumer, the social frame work of consumer rights and legal framework of protecting consumer rights.

CLO2: To understand the procedure of redress of consumer complaints, and the role of different agencies in establishing product and service standards.

Unit I Conceptual Framework **9**

Consumer and Markets: Concept of Consumer, Nature of markets: Liberalization and Globalization of markets with special reference to Indian Consumer Markets, E-Commerce with reference to Indian Market. Concept of Price in Retail and Wholesale, Maximum Retail Price (MRP), Fair Price, GST, labeling and packaging along with relevant laws, Legal Metrology.

Experiencing and Voicing Dissatisfaction: Consumer buying process, Consumer Satisfaction/dissatisfaction-Grievances-complaint, Consumer Complaining Behaviour: Alternatives available to Dissatisfied Consumers; Complaint Handling Process: ISO 10000 suite

Unit II The Consumer Protection Law in India **9**

Objectives and Basic Concepts: Consumer rights and UN Guidelines on consumer protection, Consumer goods, defect in goods, spurious goods and services, service, deficiency in service, unfair trade practice, and restrictive trade practice.

Organizational set-up under the Consumer Protection Act: Advisory Bodies: Consumer Protection Councils at the Central, State and District Levels; Adjudicatory Bodies: District Forums, State Commissions, National Commission: Their Composition, Powers, and Jurisdiction (Pecuniary and Territorial), Role of Supreme Court under the CPA with important case law.

Unit III Grievance Re-dressal Mechanism under the Indian Consumer Protection Law 9

Who can file a complaint? Grounds of filing a complaint; Limitation period; Procedure for filing and hearing of a complaint; Disposal of cases, Relief/Remedy available; Temporary Injunction, Enforcement of order, Appeal, frivolous and vexatious complaints; Offences and penalties.

Leading Cases decided under Consumer Protection law by Supreme Court/National Commission: Medical Negligence; Banking; Insurance; Housing & Real Estate; Electricity and Telecom Services; Education; Defective Products; Unfair Trade Practices.

Unit IV Role of Industry Regulators in Consumer Protection **9**

I. Banking: RBI and Banking Ombudsman

II. Insurance: IRDA and Insurance Ombudsman

III. Telecommunication: TRAI
IV. Food Products: FSSAI
V. Electricity Supply: Electricity Regulatory Commission
VI. Real Estate Regulatory Authority

Unit V Contemporary Issues in Consumer Affairs **9**

Consumer Movement in India: Evolution of Consumer Movement in India. Formation of consumer organizations and their role in consumer protection. Misleading Advertisements and sustainable consumption. National Consumer Helpline, Comparative Product testing, Sustainable consumption and energy ratings.

Quality and Standardization: Voluntary and Mandatory standards; Role of BIS, Indian Standards Mark (1S1), Ag- mark, Hallmarking. Licensing and Surveillance; Role of International Standards: 1SO an Overview

Note: Unit 2 and 3 refers to the Consumer Protection Act, 1986. Any change in law would be added appropriately after the new law is notified.

Total hours: 45

Reference Books:

1. ***Khanna, Sri Ram, Savita Hanspal, Sheetal Kapoor, and H.K. Awasthi. (2007) "Consumer Affairs"***, University Press.
2. ***Choudharv, Ram Naresh Prasad (2005) "Consumer Protection Law Provisions and Procedure",*** Deep and Deep Publications Pvt. Ltd.
3. ***G. Ganesan and M. Sumathy. (2012) "Globalisation and Consumerism: Issues and Challenges"***, Regal Publications
4. ***Suresh Misra and Sapna Chadah (2012) "Consumer Protection in India: Issues and concerns"***, IIPA, New Delhi
5. ***Rajyalaxrni Rao (2012), "Consumer is King",*** Universal Law Publishing Company

Course Outcomes:

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

CO1: Discuss the concepts of consumer, markets, relevant laws and grievances and familiarize with the consumer protection laws and objectives.

CO2: Apply Grievance Redressal Mechanism and contemporary issues in consumer affairs and knowledge of quality and standards under the Indian Consumer Protection Law and Case studies.

CO3: Comprehend the business firms' interface with consumers and the consumer related regulatory and business environment.

CO, PO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	M	M						L	L	L	L	
CO2	M	M						L	L	L	L	
CO3	M	M						L	L	L	L	

Biomedical Waste Management

Semester IV **Hours of Instruction/ week: 3T**
21BEHS07 **No. of credits: 3**

Objectives:

CLO1: To ensure safe practices and proper management of different types of medical waste, in order to safeguard the patient, community and the environment.

CLO2: To be aware of cross infections through biomedical wastes and bioethics for handling the hospital generated wastes.

Unit I Introduction & Waste Segregation **9**

General Introduction, Definition of Biomedical Waste, General and Hazardous health care waste – color Coding and types of containers for disposal of medical waste, Segregation, Collection & Disposal.

Unit II Types of Biomedical Waste **9**

Infectious waste, Genotoxic waste, Waste Sharps – Categories, Categorization and composition of biomedical waste. Liquid Biomedical Waste - Radioactive wastes, Metals, Chemicals & drugs

Unit III Hospital Generated Waste **9**

Human Blood and Blood Products, pathological wastes, Contaminated sharps, Contaminated animal carcasses, body parts, and bedding Basic information about infection, Infectious agents on organizations spread of infection, Basic information about Hospital acquired infection.

Unit IV Types of Waste Disposal **9**

Disinfections unit container for Autoclaving, Sharp waste containers for storage & transportation, autoclaving, Incineration, Plasma Pyrolysis /Gasification systems, Composting.

Unit V Bioethics and Recent Trends **9**

Modern Technology for handling Biomedical Wastes – Monitoring & Controlling of Cross Infections, Protective Devices – Bioethics and Handling of Waste Management.

Total Hours: 45

Reference Books:

1. ***Singh Anantpreet, Kaur Sukhjit, "Biomedical Waste Disposal"***, Jaypee Brothers Publishers, 2012.
2. ***Prof. Dr. Mahendra Pal, "The Complete Book on Waste Treatment Technologies"***, Niir Project Consultancy Services, 2015
3. ***Sujata Sanjay Pawar, "Legal Perspective on Biomedical Waste Management",*** Create Space Independent Publishing Platform, 2016
4. ***Peter A. Reinhardt, "Infectious and Medical Waste Management"*** CRC Press, 1st edition 2018.

Course Outcomes:

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

- **CO1:** Illustrate the segregation and disposal of biomedical wastes.
- **CO2:** Comprehend the cross infections through hospital generated wastes and its prevention.
- **CO3:** Explain the awareness and seriousness in handling biomedical waste.

CO, PO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H					H			M	L		H
CO2	H					H			M	L		H
CO3	H				M	H		H	M	L		H

Medical Biochemistry

Semester IV **Hours of Instruction/Week: 3T**
21BEBC04 **No. of Credits: 3**

Objective:

CLO: To study the biochemical reactions in human body and selected analytical techniques for assessment of the biochemical parameters of diagnostic importance.

Unit I Introduction to Biochemistry: Chemistry and Significance of Biomolecules 9

Carbohydrates, Definition, Classification, Biomedical importance, Diabetes, Blood sugar analysis, Glucose Tolerance Tests, Lipids, Definition, Classification, Essential fatty acids and cholesterol and their clinical significance.

Unit II Proteins and their Separation 9

Proteins, Composition, Physical and Chemical Properties, Classification, Enzymes and Isoenzymes, Biomedical importance, Separation and Purification of proteins by HPLC, Ion Exchange and Column Chromatography, Electrophoretic Separation of Plasma Proteins.

Unit III Vitamins 9

Vitamins, Classification, Functions and Deficiency symptoms of fat soluble and water-soluble vitamins, Hypervitaminosis of A, D, E and K Radio isotopes: Radio isotopes in medicine, Diagnostic and therapeutic uses.

Unit IV Clinical Diagnostics 9

Liver function tests, Renal function tests, Gastric function tests, Thyroid function tests, Blood and Urine analysis, Urolithiasis, Regulation of Water and Electrolyte balance, Acid -Base balance, Normal Values of Biochemical Parameters.

Unit V Analytical Techniques 9

Principle, Instrumentation and Applications of Spectrophotometry-with special reference to UV visible, Atomic Absorption and Flame Emission Spectrophotometry, Fluorimetry, Ultra centrifugation and Immunoassays (RIA and ELISA), Automation in Clinical Laboratory.

Total Hours: 45

Reference Books:

1. ***MN Chatterjea and Rana Shinde, "Text Book of Medical Biochemistry"***, 8th Edition, Jaypee Brothers Medical Publishers, New Delhi- 2,2012.
2. ***Donold Voet, Judith, G.Voet and Charlotte W. Pratt "Principles of Biochemistry",*** 4th Edition, John Wiley and Sons, New Delhi, 2012.

3. ***Ranjana Chawla, "Practical Clinical Biochemistry Methods and Interpretations",*** 4th Edition, Jaypee Brothers Medical Publishers, New Delhi, 2014.
4. ***Carl A. Burtis and David E Brunsz Tietz, "Fundamentals of Clinical Chemistry and Molecular Diagnostics"***. 7th Edition, Elsevier Saunders, USA edition, Saunders, 2015.
5. ***Harold Varley, "Practical Clinical Biochemistry***", 6th edition, CBS, 2006.

Course Outcomes:

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

CO1: Explain the nature of biomolecules in human body.
CO2: Identify the biomedical importance of biomolecules in human physiology and pathology.
CO3: Evaluation methods of biomolecules in normal and abnormal/diseased conditions.

CO, PO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	M				M						
CO2	H	M		L		M						
CO3	H	M		L		M				L		

Biomaterials

Semester IV **Hours of Instruction/week: 3 T**
21BEBC05 **No. of credits: 3**

Objectives:

CLO1: To acquire basic knowledge about biomaterials and its mechanical properties.

CLO2: To gain knowledge about the interactions of biological molecules and cells with biomaterials.

Unit I Structure of Bio-Materials **9**

Definition and classification of Bio-materials, mechanical properties, Visco-elasticity, elasticity of non- Hookean materials. Biocompatibility**:** Wound healing process, body response to implants, blood compatibility. Biodegradable materials.

Unit II Mechanical Properties of Biomaterials **9**

Structure, Property relationship of biological material, Strength & Strengthening mechanism.

Unit III Metallic Implant Materials **9**

Stainless steels, carbon, based alloys, Ti-based alloys, Medical applications, deterioration of metallic Implant materials.

Ceramic and Polymeric Implant Materials: Aluminum oxides, hydroxyapatite, Glass ceramic, carbons, polymerization, poly olefins, polyamides acrylic polymers, rubbers. High strength thermoplastics, medical applications. Deterioration of polymers.

Unit IV Soft Tissue and Hard Tissue Replacement Implants **9**

Sutures, surgical tapes, adhesive, percutaneous and skin implants, maxillo, facial augmentation, blood Interfacing implants. Internal fracture fixation devices, jointer placements, dental implants. Scaffolds for tissue engineering.

Unit V Artificial Heart, Lung & Kidney Devices **9**

Use of patient's lung for gas exchange, the ideal heart lung device. Comparisons of natural and artificial lungs, Basic types of oxygenators, temperature maintenance, and gas flow rate requirements for artificial lungs. Basic methods of artificial waste removal, Hemodialysis, modeling of the patient, artificial kidney system, Drug delivery carriers.

Total Hours: 45

Reference Books:

1. ***J. S.Temenoff, "Biomaterials",*** Dorling Kindersley Pvt. Ltd, 2009.

2. ***Sujata,V.Bha, "Biomaterials" S***pringer, Netherland, 2019.
3. ***Joyce, Y.Wong, Joseph D. Bronzino, "Biomaterials",*** CRC press, 2012.
4. ***Ratner B D, Hoffmann A S, Schoen F J, Lemons J E. "Biomaterials science: An introduction to materials in medicine", Academic Press, 2004.***

Course Outcomes:

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

CO1: Describe the characteristics, structure and classification with mechanical properties of biomaterials.

CO2: Identify materials for design of implants in hard tissue, soft tissue and organ replacement.

CO3: Explain about principle, working and maintenance of devices in the application of implant, replacements and artificial organs.

CO, PO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H								M	M		H
CO2	H		H						M	M		H
CO3	H				L				M	M		H

Control Systems

Semester IV **Hours of Instruction/week: 4T**

21BEBC06 **No. of credits: 4**

Objectives:

CLO1: To understand the concepts of design and analysis of control systems.

CLO2: To analyze the stability of the control systems and state space representation.

Unit I Systems and their Representation **12**

Basic elements in control systems, Open and closed loop system, Methods of analysis of Physical systems, Electrical analogy of physical systems, AC and DC servomotor, Transfer function and block diagram, Reduction techniques for block diagram, Signal flow graph.

Unit II Time Response **12**

Time domain specifications, Types of test inputs, I and II order system responses, Error coefficients, generalized error series, Steady state error.

Unit III Frequency Response **12**

Determination of closed loop response from open loop response, Bode plot, Nichol's chart, Polar plot.

Unit IV Stability of Control Systems **12**

Characteristic equation, Location of roots in S, plane for stability, Routh Hurwitz criterion, Root locus techniques, Construction, Gain margin and phase margin, Nyquist stability criterion.

Unit V State Space Analysis **12**

State Space representation of SISO and MIMO systems using physical variables, Phase variables and canonical variables, State transition matrix, Solution of state equations. Transfer function from state model and Transfer matrix.

Total Hours: 60

Reference Books:

1. ***NagarthI.J. and Gopal. M. X, "Control Systems Engineering",*** New age International Publishers, 8th Edition 2008.
2. ***Katsukiko Ogata, "Modern Control Engineering,*** Prentice Hall of India Ltd, *5th Edition* 2013.
3. ***Benjamin C. Kuo, "Automatic Control Systems",*** Wiley and Sons Pvt. Ltd, 2012.

Course Outcomes:

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

CO1: Discuss the basic concepts of control systems and determine the mathematical modeling of control systems.

CO2: Compute the time, frequency response and transfer function of the open loop and closed loop systems.

CO3: Design a control system to satisfy dynamic performance specifications using root-locus, and state-space techniques.

CO4: Analyze control systems for stability and steady-state performance.

CO, PO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	M										
CO2	H	M							M			
CO3	H	M			M				M	M		
CO4	H	M			M				M	M		

Pathology and Microbiology

Semester IV **Hours of Instruction/week: 3T**

21BEBC07 **No. of credits: 3**

Objectives:

CLO1: To gain knowledge on the structural and functional aspects of living organisms.

CLO2: To learn about the cause, mechanism and diagnosis methods of pathological disease.

Unit I Cell Physiology **9**

Normal cell structure, Cell degeneration and regeneration, Inflammations. Neoplasia, Classification, Difference between benign and malignant tumors, Etiology of tumors, spread of tumors.

Unit II Tissue Processing Techniques **9**

Tissue processing, Histokinates Block making. Microtome and knives. Cryostat, frozen section. Basic stain and special stains (fat, iron stains)

Unit III Infections and Diseases **9**

Infection and immunity, Serodiagnosis of infections, Diseases, Diseases produced by bacteria, Diseases produced by viruses, Diseases produced by fungi.

Unit IV Study of Bacterial Cell **9**

Physiology of a bacterial cell, growth and identification of bacteria, observation of cultures. Microscope, Light Microscopy, Phase contrast microscopy, Electron microscopy.

Unit V Control of Diseases and Infections **9**

Disinfection, Sterilization: heat, filtration, chemicals and radiation, Immunization programs: Vaccination, Immunological tolerance, Regulation of the immune response, Infectious disease epidemics: Origin and spread, Population characteristics, infecting agent, Approaches to Control infectious diseases, Infectious diseases in hospitals, Infectious disease control network.

Total Hours: 45

Reference Books:

1. ***Harsh Mohan, "A Text book of Pathology, Jaypee Brothers"***, Medical Publishers (P) Ltd, 8th Edition. 2018.
2. ***Eugene, W. Nester, C. Evans Roberts, Marth at Nester. Microbiology-A Human Perspective.*** Mc Graw Hill Higher Education, 2019.
3. ***Robbins, Cotran and Kumar, "Pathologic Basis of Diseases".*** Elsevier India, 2018.
4. ***Ananthanarayanan.R & Jayaram Panicker. C.K. 'Text Book of Microbiology".*** Orient Longman Ltd, Chennai, 2017.

Course Outcomes:

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

CO1: Recall the structural and functional aspects of living organism and analyze the pathology of disease caused by various organisms.

CO2: Explain the etiology of tumors, spread of tumors and summarize the different tissue processing techniques.

CO3: Discuss the microscopic techniques and serological techniques used for identification and growth of pathogenic organisms.

CO4: Describe the various sterilization procedures and gain knowledge on immunization programs.

CO, PO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H						M					
CO2	H									M		
CO3	H						M			M		
CO4	H						M			M		

Analog and Digital ICs

Semester IV **Hours of Instruction/week: 3T**
21BEBC08 **No. of credits: 3**

Objectives:

CLO1: To familiarize with the basic methods for designing digital circuits.

CLO2: To discuss operational amplifiers, filters and signal generators.

Unit I Number Systems and Logic Gates **9**

Decimal, Binary, Octal and Hexadecimal Numbers. -Conversion between these number systems. - Complements r's and (r-1)'s complements. - subtraction using complements – Encoding numbers and characters using Binary digits. –Binary coded Decimal – Gray code Binary to Gary code conversion –ASCII Code. Logic gates – Truth tables – NOT, AND, OR, NOR, NAND, XOR, XNOR - Boolean Laws and theorems – Solving Boolean expressions, Truth Tables and Logic circuits – The Karnaugh Map – half adder, full adder, Multiplexers and Demultiplexers - Decoders and encoders.

Unit II Registers and Counters **9**

Flip Flops – RS, D, T, JK Flip Flops – Characteristic equations, exciting tables – JK Master-Slave flip flop – Universal shift register. Design of modulo-N counters – counter design using state diagram.

Unit III Operational Amplifiers **9**

The characteristics of Ideal Operation – slew rate, offset voltage, bias current, CMRR, bandwidth - equivalent circuit of an op-Amp – virtual ground concept – Linear applications of op-amp – inverting and non-inverting amplifier, summing, subtracting, averaging amplifier - voltage to current converter – current to voltage converter – Differential amplifiers – differentiator and integrator. Nonlinear applications – comparator -Schmitt Triggers – Precision Diode Half wave and full wave rectifiers – Average detectors – peak detector-Instrumentation amplifier, Buffer in op-amp.

Unit IV Active Filters and Signal Generator **9**

Active filters (first and second order) – Low pass, high pass, band pass filters, band reject filters (notch filters). Oscillators - RC Phase shift and Wein-bridge. Waveform generators - Square, triangular and saw tooth.

Unit V Timer, PLL, A/D and D/A Converters **9**

555 Timer (internal diagram) and its applications – monostable multivibrator, astable multivibrator. Phase locked Loop (565 - block diagram approach) and its application, frequency multiplication, Frequency translation, voltage to frequency and frequency to voltage converters. DAC – Binary weighted DAC and R-2R DAC. ADC – single slope and dual slope ADCs, successive approximation ADC-Sample and hold circuit.

Total Hours: 45

Reference Books:

1. ***M. Morris Mano***, "***Digital Logic and Computer design"***, 3rd Edition, Prentice Hall, 2010
2. ***Ramakant A. Gayakwad, "Op-AMP and Linear ICs***", 4th Edition, Prentice Hall, 2015.
3. ***Robert B.Northrop, "Analysis and Application of Analog Electronic Circuits to Biomedical Instrumentation***", CRC Press, 2004.
4. ***Sergio Franco, "Design with Operational Amplifiers and analog Integrated circuits"***, McGraw- Hills, 2003.
5. ***Millman J and Halkias C. "Integrated Electronics***", TMH, 2007.

Course Outcomes:

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

CO1: Recall number systems, logic gates and construct basic sequential circuits using universal gates.

CO2: Discuss the characteristics of Flip-flops, Op-amp and design of Counters.

CO3: Analyze linear and nonlinear applications of Op-amp and concepts of filter.

CO4: Design applications using Timer, ADC, DAC and PLL.

CO, PO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H	H									
CO2	H	H	H		H							
CO3	H	H	M						M	M		M
CO4	H	H							M	M		

Integrated Circuits Practicals

Semester IV **Hours of Instruction/week: 3P**

21BEBC09 **No. of credits: 1.5**

Objectives:

CLO1: To design and implement, combinational and sequential logic circuits using gates.

CLO2: To demonstrate simple digital systems for various applications.

List of Experiments:

1. Study of logic gates, Half adder and Full adder
2. Encoder and Decoder
3. Code converters
4. Multiplexer and demultiplexer using digital ICs
5. Design of mod-N counter
6. Inverting, non-inverting amplifier
7. Differential amplifier
8. Integrator and Differentiator
9. Active filter –LPF and HPF
10. Schmitt trigger
11. RC phase shift oscillator, Wein bridge oscillator
12. Multivibrator using IC555 Timer

Total Hours: 45

Course Outcomes:

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

CO1: Design and implement combinational and synchronous sequential circuits using universal gates.

CO2: Construct and test the circuits using operational amplifiers and timer.

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H	H	L	L				M			
CO2	H	H	H	L	L				M			

Virtual Instrumentation Practicals

Semester IV **Hours of Instruction/week: 3P**

21BEBC10 **No. of credits: 1.5**

Objectives:

CLO1: To implement Virtual Instruments using LabVIEW.

CLO2: To analyze biomedical signals using graphical programming tools**.**

List of Experiments:

1. Getting Started with LabVIEW, Basic operations, controls and Indicators
2. Simple programming structures and Timing Issues
3. LabVIEW -Programming Structure, Sub VIs, Clusters & Traffic Light Controller
4. Multiplexer and demultiplexer using digital ICs
5. Design of Virtual Instruments like Function Generator, Oscilloscope, Spectrum analyzer
6. Data Acquisition using Virtual instrumentation from temperature Sensor
7. Communication via RS232/ Serial Port
8. Implementation of Phase Shift Oscillator using NI ELVIS
9. Computerized data logging of ECG signal and find the heart beat rate using LabVIEW
10. Integration of m files in LabVIEW
11. Acquisition of PPG Signal using NI ELVIS

Total Hours: 45

Course Outcomes:

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

CO1: Design and implement virtual instruments.

CO2: Construct virtual instruments for the analysis of biomedical signals using graphical programming tools**.**

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H	H	L	L				M			
CO2	H	H	H	L	L				M			

III year Syllabus

Analog and Digital Communication

Semester V **Hours of Instruction/week: 3T**
21BEBC11 **No. of credits: 3**

Objectives:

CLO1: To learn and compare analog and digital communication techniques.
CLO2: To familiarize with source and error control coding and gain knowledge on multi-user radio communication.

Unit I Analog Communication **9**

Noise: Source of Noise - External Noise- Internal Noise - Noise Calculation. Introduction to Communication Systems: Modulation – Types - Need for Modulation. Theory of Amplitude Modulation- Evolution and Description of SSB Techniques - Theory of Frequency and Phase Modulation –Comparison of various Analog Communication System (AM – FM – PM).

Unit II Digital Communication **9**

Amplitude Shift Keying (ASK) – Frequency Shift Keying (FSK) Minimum Shift Keying (MSK) –Phase Shift Keying (PSK) – BPSK – QPSK – 8 PSK – 16 PSK - Quadrature Amplitude Modulation (QAM) – 8QAM – 16 QAM – Bandwidth Efficiency– Comparison of various Digital Communication System (ASK– FSK – PSK – QAM).

Unit III Data and Pulse Communication **9**

History of Data Communication - Standards Organizations for Data Communication- Data Communication Circuits - Data Communication Codes - Error Detection and Correction Techniques - Data communication Hardware - serial and parallel interfaces. Pulse Communication**:** Pulse Amplitude Modulation (PAM) – Pulse Time Modulation (PTM) – Pulse Code Modulation (PCM) - Comparison of various Pulse Communication System (PAM – PTM – PCM)

Unit IV Source and Error Control Coding **9**

Entropy Source encoding theorem, Shannon Fano coding, Huffman coding, mutual information, channel capacity, channel coding theorem, Error Control Coding, linear block codes, cyclic codes, convolution codes, Viterbi decoding algorithm.

Unit V Multi-User Radio Communication **9**

Advanced Mobile Phone System (AMPS) - Global System for Mobile Communications (GSM) – Code Division Multiple Access (CDMA) – Cellular Concept and Frequency Reuse - Channel Assignment and Hand off - Overview of Multiple Access Schemes - Satellite Communication - Bluetooth

Total Hours: 45

Reference Books:

1. ***Wayne Tomasi, "Advanced Electronic Communication Systems"***, 6th Edition, Pearson Education, 2015.
2. ***Simon Haykin, "Communication Systems"***, 5th Edition, John Wiley & Sons, 2009
3. ***Rappaport T.S, "Wireless Communications: Principles and Practice"***, 2nd Edition, Pearson Education, 2010
4. ***H.Taub, D L Schilling and G Saha, "Principles of Communication"***, 4th Edition, Pearson Education, 2017
5. ***B. P.Lathi, "Modern Analog and Digital Communication Systems"***, 3rd Edition, Oxford University Press, 2007

Course Outcomes:

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

CO1: Discuss the concepts of sources noise, analog, digital, data and pulse communication techniques.

CO2: Compare the techniques underlying in analog, digital, data and pulse communication.

CO3: Analyze source and error control coding and apply multi-user radio communication.

CO, PO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H											L
CO2	H	M	M		H							L
CO3	H	M	M									L

Medical Diagnostic Equipment

Semester V **Hours of instruction/week: 3T**
21BEBC12 **No. of credits: 3**

Objectives:

- **CLO1:** To acquire knowledge on principle, working and application of diagnostic equipment.
- **CLO2:** To be able to differentiate an appropriate diagnostic equipment usage for various testimonies.

Unit I Cardiac Equipment **9**

ECG; continuous monitoring systems for pulse rate, temperature, B.P. Respiration, Arrhythmia monitor; B.P. monitor, Blood flow and cardiac output, Measurement, Plethysmography, Oximetry, Treadmill (Stress ECG).

Unit II Electro-physiological Equipment **9**

EMG, EEG, EOG, ERG. Audiometer, Different modes and assessments.

Unit III Clinical Equipment - I **9**

UV, Visible and IR Spectrophotometers, Flame Photometers, Electrolyte analysis using sensitive electrodes, pH meter, principle and applications. Densitometer and Electrophoresis apparatus.

Unit IV Clinical Equipment -II **9**

Principles and applications of oil, gas and liquid chromatographs, Mass Spectrometry, Flow Cytometry, Radio immune assay and ELISA techniques, Blood gas analyzers, Blood cell counters.

Unit V Optical Equipment **9**

Various types of Endoscopes, Fiber optic, Fluid optic, Integral Camera. Electron Microscope, Transmission and Reflection.

Total Hours: 45

Reference Books:

1. ***Khandpur, R.S. "Handbook of Biomedical Instrumentation",*** Third Edition, McGraw-Hill, 2014.
2. ***Geddas, L.A. & Baker, L.E., "Principles of Applied Biomedical Instrumentation",*** Third Edition. John Wiley & Sons, 2016.

Course Outcomes:

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

- **CO1:** Describe the principle behind Cardiac, Electro-physiological, Clinical and Optical Equipment.
- **CO2:** Illustrate the working, and differentiate between the diagnostic equipment.
- **CO3:** Identify the advantages and disadvantages of diagnostic applications.
- **CO4:** Design circuits, modify and identify the malfunctioning accessories in the equipment.

CO, PO MAPPING

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H						M	H				
CO2	H						M	H				
CO3	H	M					M	H				
CO4	H	M	M	M	M		M	H		M		M

Medical Therapeutic Equipment

Semester V **Hours of Instruction/ week: 4T**
21BEBC13 **No. of credits: 4**

Objectives:

CLO1: To familiarize the principle and working of therapeutic equipment.
CLO2: To familiarize the testing and therapeutic applications.

Unit I Cardiac Equipment **12**

External and Implantable pacemakers, Programmable pacemakers, Power sources, Design of encapsulation and leads, Pacing system analyzers. Cardiac Defibrillators, Basic principles and comparison of different Defibrillators, Energy requirements, Synchronous operation, Implantable Defibrillators, Defibrillator analyzers.

Unit II Respiratory Equipment **12**

Principles of constant pressure and constant volume ventilators, Basic principles of electromechanical, Pneumatic and electronic ventilators, Nebulizer, Ventilator testing.

Unit III Electro therapy Equipment-I **12**

Electro diagnosis, Electrotherapy, Electrodes, Stimulators for Nerve and Muscle, Stimulator for pain relief, Interferential current therapy, Spinal cord stimulator, Functional Electrical Stimulation.

Unit IV Electrotherapy Equipment-II **12**

High frequency heat therapy, Principle, Shortwave diathermy, Microwave diathermy, Ultrasonic therapy, Lithotripsy, Therapeutic IR radiation, Therapeutic UV lamps.

Unit V Therapeutic Lasers **12**

Basic principles of Biomedical LASERS: Applications of lasers in medicine, CO_2 laser, He-Ne laser, Nd-YAG and Ruby laser.

Total Hours: 60

Reference Books:

1. ***Khandpur,R.S, "Handbook of Biomedical Instrumentation",*** Third Edition, McGraw Hill Education (India) Private Limited, 2014.
2. ***John G. Webster, Amit J. Nimunkar, "Medical Instrumentation, Application and Design",*** Fifth Edition. Wiley &sons, Inc., New York, 2020.
3. ***Joseph J. Carr, John M. Brown, "Introduction to Biomedical Equipment Technology",*** Sixth edition. Pearson Education Inc., New Delhi, 2011
4. ***Leslie Cromwell, Fred J.Weibell & Erich, A.Pfeiffer, "Biomedical Instrumentation and Measurements",*** Second Edition. Pearson India, 2015.
5. ***Val Robertson, Alex Ward, John Low & Ann Reed, "Electrotherapy Explained, Principles and Practice",*** Fourth Edition. Butterworth Heinemann Ltd, Elsevier, 2008.

Courses Outcomes:

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

- **CO1:** Understand the underlying principles of cardiac, respiratory, electrotherapy equipment and laser.
- **CO2:** Describe the working and differentiate between the cardiac, respiratory, electrotherapy equipment and laser.
- **CO3:** Identify the advantages and disadvantages of the application of cardiac, respiratory, electrotherapy equipment and laser.
- **CO4:** Apply the acquired knowledge of principle and working to design circuits, troubleshooting and testing of equipment.

CO, PO MAPPING

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H						M	H				
CO2	H						M	H				
CO3	H	M					M	H				
CO4	H	M	M	M	M		M	H		M		M

Biomechanics

Semester V **Hours of Instruction/week: 3T**
21BEBC14 **No. of credits: 3**

Objectives:

CLO1: To acquire knowledge on fundamental concepts of biomechanics
CLO2: To analyze mechanics of physiological systems and related applications

Unit I Principles of Mechanics **9**

Free-body diagrams and equilibrium, Linear/Angular Kinematics/Kinetics.

Bio fluidics: Biofluid mechanics, Flow properties of blood, Rheology of blood in micro vessels, Measurement/Estimation of In-vivo elasticity of blood vessels. Structures, properties of mechanics of soft and hard tissues (bones, cartilage, muscles, tendon and ligaments).

Unit II Application of Finite Element Analysis **9**

Introduction to FEA, Implementation in Biomechanical Engineering, Biomechanical Engineering Analytical models, definition of stress and strain, Soft tissue mechanics-modeling and material properties.

Unit III Cardiac Mechanics **9**

Cardio vascular system, Mechanical properties of blood vessels: arteries, arterioles, capillaries, veins, Pulse wave velocities in arteries, prosthetic heart valves & replacements.

Unit IV Orthopaedic Mechanics **9**

Mechanical properties of cartilage, Diffusion properties of articular cartilage, Mechanical properties of bone, Skeletal joints, types of joints, Lubrication of joints.

Unit V Orthopaedic Applications **9**

Human locomotion: Gait cycle-parameterization and analysis. Chemistry of normal locomotion, above knee, below knee prosthesis, Foot braces, Multitask exoskeletal walking devices for paraplegics. Biomechanical analysis of scoliotics pine, Use of ISIS.

Total Hours: 45

Reference books:

1. ***Dhanjoo N. Ghista, "Applied Biomedical Engineering Mechanics",*** CRC Press, 2008.
2. ***Y.C Fung, "Biomechanics-mechanical Properties of Living Tissues",*** Second Edition, 2013.
3. ***Susan J.Hall, "Basic Biomechanics", Mc Graw Hill Education,*** Seventh Edition, 2015.
4. ***Duane Knudson, "Fundamentals of Biomechanics", Springer***, Second Edition, 2007.

Course Outcomes:

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

CO1: Recall the basic principle of mechanics underlying in cardiac and orthopedics mechanics.

CO2: Illustrate the biocompatibility role with implants and replacements.

CO3: Summarize the cardiac mechanics, orthopedic mechanics and its applications confined to human.

CO, PO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	L					L					H
CO2	H		H	L		M			M			H
CO3	H							M	H	M		H

Diagnostic and Therapeutic Equipment Practicals

Semester V **Hours of Instruction/week: 3P**
21BEBC15 **No. of credits: 1.5**

Objectives:

CLO1: To demonstrate recording and analysis of different Bio potentials.

CLO2: To examine different therapeutic modalities.

List of Experiments:

1. To measure the blood pressure levels using Sphygmomanometer.
2. Acquisition of ECG signals using 3 channel ECG machine.
3. To record the 12 channel ECG signals using Page writer.
4. To record the oxygen saturation in blood using Pulse Oximeter.
5. To plot the human auditory response using Digital Audiometer.
6. Acquisition of heart sounds using Phonocardiograph.
7. Study and analysis of functioning and safety aspects of Surgical Diathermy.
8. To perform the operation of Drug Delivery Device.
9. To acquire vital parameters from Real time Patient Monitoring System.
10. To perform the sterilization using Autoclave.

Total Hours: 45

Course Outcomes:

Upon completion of this course, students will be able to:

CO1: Measure different bioelectrical signals using various methods.

CO2: Operate sphygmomanometer, phonocardiograph, audiometer and monitor the physiological parameters.

CO3: Demonstrate surgical diathermy, autoclave and drug delivery system.

CO, PO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H				H	M						H
CO2	H				H	M			M	M		H
CO3	H				H	M			M	M		H

Digital Signal Processing for Biomedical Engineering

Semester V **Hours of Instruction/week: 4T**
21BEBC16 **No. of credits: 4**

Objectives:

CLO1: To familiarize the student with bio signal processing algorithm and time series analysis for automated diagnosis of diseases.

CLO2: To gain knowledge on bio signal recognition and time frequency analysis

Unit I Bio signal and Spectral Characteristics **12**

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 **12**

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 Wavelet Detection **12**

Filtering, LMS adaptive filter, adaptive noise canceling 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 **12**

Signal classification and recognition, Statistical signal classification, linear discriminant 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 **12**

Time frequency representation, spectrogram, Wigner distribution, Time-scale representation, scalogram, Data reduction techniques, ECG data compression, ECG characterization, Feature extraction- Wavelet packets, Multivariate component analysis- PCA, ICA

Total Hours: 60

Reference Books:

1. ***Rangaraj M. Rangayyan, "Biomedical Signal Analysis-A case study approach***", Wiley- Interscience/IEEE Press, 2002.
2. ***Willis J. Tompkins, "Biomedical Digital Signal Processing"***, Prentice Hall of India, New Delhi, 2003.
3. ***Raghuveer M. Rao and Ajith S. Bopardikar, "Wavelets Transform, Introduction to theory and its applications"***, Pearson Education, India 2000.
4. ***D.C.Reddy, "Biomedical Signal Processing, Principles and Techniques***", TMH, New Delhi, 2005.
5. ***GariD. Clifford, Francisco Azuaje and Patrick E.McSharry, "Advanced Methods and Tech for ECG Data Analysis",*** *ARTECH House, Boston,2006.*

Course Outcomes:

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

CO1: Discuss the concepts of bio signals and its spectral/frequency representation.

CO2: Describe biological parameters, filtering techniques, classification and recognition algorithms.

CO3: Apply filtering and data reduction techniques on ECG signal.

CO4: Analyze bio signals with time/frequency domain representation.

CO, PO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H											
CO2	H	M			M				M	M		L
CO3	H	M			M				M	M		L

Digital Signal Processing Practicals

Semester V **Hours of Instruction/week: 3P**
21BEBC17 **No. of credits: 1.5**

Objectives:

CLO1: To understand the handling of discrete signals using MATLAB.

CLO2: Analyze the spectral parameter of window functions and design various filters.

List of Experiments:

1. Introduction to MATLAB, I Basic array manipulations and graphics, 2D and 3D plots
2. Introduction to MATLAB, II Loop structures and basic programming concepts
3. Generation of signals, noises and the effect of sampling
4. Discrete time system analysis, Impulse, step and frequency responses
5. Transforms, Z-transform and Fourier transform
6. Convolution and correlation
7. Fast Fourier Transform and efficiency computation
8. IIR filter design, all types
9. FIR filter design, all types
10. Power spectrum of ECG signal
11. QRS detection algorithm
12. ST segment analysis
13. Arrhythmia monitor
14. Audio spectrum analysis can be related to heart sound
15. EEG analysis

Total Hours: 45

Course Outcomes:

Upon completion of this course, students will be able to:

CO1: Understand signal generation and implement transforms using MATLAB.

CO2: Perform biosiganl analysis using MATLAB.

CO3: Design IIR and FIR low pass, high pass, band pass and band stop filters.

CO, PO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H				H	M						H
CO2	H				H	M			M	M		H
CO3	H				H	M			M	M		H

Radiology and Nuclear Medicine

Semester VI **Hours of Instruction/week: 3T**

21BEBC18 **No. of credits: 3**

Objectives:

CLO1: To learn the principle operation of X-ray and its uses in imaging.

CLO2: To discuss the radiation therapy techniques and radiation safety.

Unit I X-Ray Equipment **9**

Nature of X-rays, X-Ray absorption, Tissue contrast. Quality of X, rays, X, Ray Equipment (Block Diagram), X-Ray Tube, the collimator, Bucky Grid, power supply, Digital Radiography, discrete digital detectors, storage phosphor and film scanning, X-ray Image Intensifier tubes, Fluoroscopy, Digital Fluoroscopy, Computed Tomography

Unit II Nuclear Medicine **9**

Basic characteristic and units of radioactivity, ionization chamber, GM tubes, Gas filled detectors, scintillation detectors, semiconductor detectors, Liquid scintillation counter, Statistical aspects of nuclear medicine.

Unit III Nuclear Medicine Imaging System **9**

Rectilinear scanners, Scintillation Camera, principle of operation, collimator, photomultiplier tube, Pulse height Analyzer, computerized multi crystal Gamma camera, Principles of PET and SPECT.

Unit IV Radiation Therapy **9**

Principles of Radiation Therapy, Radio therapy treatment planning Dose in Radiotherapy, Mega voltage therapy, Intensity modulated Radiation therapy, Brachytherapy, Radiotherapy using radio isotopes

Unit V Radiobiology and Radiological Protection **9**

Radiation sensitivity of biological materials, Evidence on radiobiological damage from cell survival curve, Radiation effects on humans, Maximum permissible dose equivalent limits, Hazard from ingested radioactivity, substances, ICRP regulations, Quality factor and sievert, Principles of radiological protection, personnel dosimetry.

Total periods: 45

Reference Books:

1. ***Dendy, P.P & Heaton, B, "Physics for Radiologists. Third Edition. Charles C.***" Thomas Publisher S.A., 2012.
2. ***Khan, F.M, "Physics for Radiation Therapy***", Williams & Wilkins, 2010.
3. ***Gopal B. Saha., "Physics and Radiobiology of Nuclear Medicine***", 2006.
4. ***Penelope J.Allis, Roberts Obefipsm, "Farr's Physics for Medical Imaging",*** Ferry Williams, 2008.

Course Outcomes:

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

CO1: Recall the characteristics of radioactivity and working of X-ray equipment.

CO2: Discuss the working principle of radiation based imaging systems and radiation detectors.

CO3: Understand the principle of radiation therapy, treatment plans and dosimetry.

CO4: Summarize the principles of radiological protection and ICRP regulations.

CO, PO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H											
CO2	H											
CO3	H	M							M	M		
CO4	H	M				M	M		M	M		M

ICU and Operation Theatre Equipment

Semester VI **Hours of Instruction/week: 4T**
21BEBC19 **No. of credits: 4**

Objectives:

CLO1: To acquire knowledge on equipment used in surgeries, extracorporeal devices used in critical care.

CLO2: To discuss the importance of patient safety against electrical hazard.

Unit I ICU Equipment **12**

Suction apparatus, Types of Sterilization: Chemical, Radiation, Gaseous and Steam for small and larger units. Automated drug delivery systems, Infusion pumps, components, implantable infusion systems, closed loop control, Microprocessor based infusion pump, Programme controlled insulin dosing device.

Unit II Critical Care Equipment **12**

Hemodialysis Machine, diseases of the kidney, Artificial kidney, Different types of Dialyzers, Performance analysis, Membranes, Machine controls and measurements. Heart Lung Machine, types of oxygenators, peristaltic pumps, Incubators.

Unit III Operation Theatre Equipment **12**

Principle of surgical diathermy, Electrosurgical techniques, Surgical diathermy machine, Automated electrosurgical systems, Electrodes, Safety aspects. Anesthesia machine, Gas supply system and delivery system, Vapour delivery system.

Unit IV Centralized Systems **12**

Centralized Oxygen, Nitrogen, Air supply & Suction. Centralized Air Conditioning, Operation Theatre table, special features, accessories, surgical positions, line diagrams & Surgical lighting, Dome type ceiling fixed surgical spotlight.

Unit V Patient Safety **12**

Patient electrical safety, Electric shock hazards, Natural protective mechanisms against electricity, Leakage currents, Types, leakage current measurement, Inspection of grounding and patient isolation, Hazards in operation rooms, ICCU and IMCUs, Optocouplers and Pulse transformers.

Total Hours: 60

Reference Books:

1. ***Khandpur, R.S., "Hand book of Biomedical Instrumentation",*** Third Edition**.** McGraw Hill Education (India) Private Limited, 2014.
2. ***John G. Webster, Amit J. Nimunkar, "Medical Instrumentation, Application and Design",*** Fifth Edition. Wiley & sons, Inc., New York, 2020.

3. ***G.D. Kunders, S.Gopinath, Asoka Katakam***, "***Hospitals: Facilities, Planning, Design and Management"***, Tata McGraw Hill Publishing Company, Ltd., New Delhi. 2004.
4. ***S.K.Venkata Ram, "Bio-Medical Electronics & Instrumentation",*** Galgotia Publications Pvt, New Delhi. 2000.
5. ***Joseph L. Du Bovy, "Introduction to Biomedical Electronics",*** McGraw Hill Co, 2003.

Course Outcomes:

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

CO1: Understand the principle of equipment in ICU, Critical care and OT.
CO2: Explain the working of equipment in ICU, Critical care and OT.
CO3: Discuss the concepts of centralized systems OT table and OT lights in a hospital.
CO4: Recollect the safety aspects to be incorporated in the design of medical equipment.

CO, PO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H					M						
CO2	H					M	M					
CO3	H					M	M					
CO4	H	M				M	M		M	M		M

Microprocessor and Microcontrollers

Semester VI **Hours of Instruction/week: 3T**
21BEBC20 **No. of credits: 3**

Objectives:

CLO1: To familiarize with the architecture and function of Microprocessors and Microcontroller.

CLO2: To solve real world problems in an efficient manner and emphasis on architecture, programming and system design used in various day to day gadgets.

Unit I 8086 Microprocessor **9**

Introduction to 8086 – Microprocessor architecture – Addressing modes - Instruction set and assembler directives – Assembly language programming – Modular Programming - Linking and Relocation - Stacks - Procedures – Macros – Interrupts and interrupt service routines – Byte and String Manipulation.

Unit II 8051 Microcontroller **9**

Architecture of 8051 – Special Function Registers (SFRs) - I/O Pins Ports and Circuits - Programming 8051 Timers - Serial Port Programming - Interrupts Programming - Instruction set - Addressing modes - Assembly language programming.

Unit III I/O Interfacing **9**

LCD & Keyboard Interfacing - ADC, DAC & Sensor Interfacing - Stepper Motor and Waveform generation, Serial communication interface, Traffic Light control.

Unit IV High Performance RISC Architecture – ARM **9**

Organization of CPU – Bus architecture –Memory management unit - ARM instruction set- Thumb Instruction set- addressing modes – Programming the ARM processor.

Unit V ARM Application Development **9**

Peripheral Interface – Application of ARM Processor - Caches – Memory protection Units – Memory Management units – Future ARM Technologies.

Total Hours: 45

Reference Books:

1. ***Yu-Cheng Liu, Glenn A.Gibson***, "***Microcomputer Systems: The 8086 / 8088 Family - Architecture, Programming and Design***", Second Edition, Prentice Hall of India, 2007.
2. ***Mohamed Ali Mazidi, Janice Gillispie Mazidi, Rolin Mc Kinlay,"The 8051 Microcontroller and Embedded Systems: Using Assembly and C",*** Second Edition, Pearson Education, 2011.

3. ***Doughlas V.Hall***, "***Microprocessors and Interfacing, Programming and Hardware",*** TMH, 2012
4. ***William Hohl, "ARM Assembly Language: Fundamentals and Techniques",*** Allite Boo***ks,*** 2014.

Course Outcomes:

Upon completion of this course, students will be able to:

- **CO1:** Interpret the architecture, instruction set, memory organization and addressing modes of the microprocessor, microcontrollers and ARM Processor.
- **CO2:** Apply the knowledge of microprocessor, microcontroller and ARM for implementing assembly language programming.
- **CO3:** Discuss the hardware interfacing peripheral devices.
- **CO4:** Develop applications using microprocessor, microcontrollers and ARM Processor.

CO, PO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	M								L		L
CO2	H	H								L		L
CO3	H	M	M	L	M				M	M		M
CO4	H	H	H	H	M				M	M	L	H

Microprocessor and Microcontroller Practicals

Semester V **Hours of Instruction/week: 3P**
21BEBC21 **No. of credits: 1.5**

Objective:

CLO1: To develop assembly level programs and practice the basic operations of the microprocessors and microcontrollers.

CLO2: To provide solid foundation on interfacing the external devices to the processor according to the user requirements to create novel products and solutions for the real time problems.

List of Experiments:

8086 Programs using kits

1. Basic arithmetic and Logical operations
2. Move a data block without overlap
3. Code conversion, decimal arithmetic and matrix operations
4. Floating point operations, string manipulations, sorting and searching
5. Counters and Time Delay

Peripherals and Interfacing Experiments

6. Traffic light control
7. Stepper motor control
8. Key board and Display
9. Serial interface and Parallel interface

8051 Experiments using kits

1. Basic arithmetic and Logical operations
2. Find 2's complement of a number
3. BCD to ASCII conversion

Total Hours: 45

Course Outcomes:

Upon completion of this course, students will be able to:

CO1: Implement the basic programming for Arithmetic and Logical operations in 8086 microprocessor and 8051 microcontrollers.

CO2: Interface different I/O devices with processor.

CO, PO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	M	M	M					M	M		
CO2	H	M	M						M	M		L

Digital Image Processing

Semester VI **Hours of Instruction/week: 4T**
21BEBC22 **No. of credits: 4**

Objectives:

CLO1: Be exposed to image processing fundamentals and techniques.

CLO2: Be familiar with image compression, segmentation and representation algorithms to solve image processing problems.

Unit I: Fundamentals of Image Processing **12**

Introduction – Steps in Digital Image Processing – Components – Elements of Visual Perception – Image Sensing and Acquisition – Image Sampling and Quantization – Relationships between pixels - color models.

Unit II: Image Enhancement and Restoration **12**

Spatial Domain: Gray level transformations – Histogram processing – Basics of Spatial Filtering– Smoothing and Sharpening Spatial Filtering

Frequency Domain: 2D DFT – Smoothing and Sharpening frequency domain filters – Ideal, Butterworth and Gaussian filters.

Restoration: Noise models, Restoration using inverse filtering and Wiener filtering

Unit III:Image Compression **12**

Types of redundancy, Fidelity criteria, Lossless compression – Run length coding, Huffman coding, Bit-plane coding, Arithmetic coding. Introduction to DCT, Wavelet transform. Lossy compression – DCT based compression, Wavelet based compression. Image and Video Compression Standards.

Unit IV: Image Segmentation **12**

Image Segmentation: Point Detections, Line detection, Edge Detection - First order. Derivative –Prewitt and Sobel. Second order derivative – LoG, DoG, Canny. Edge linking, Hough Transform, Thresholding – Global, Adaptive. Otsu's Method.

Region Growing, Region Splitting and Merging. Morphological Operations.

Unit V: Representationand Description **12**

Representation – Chain codes, Polygonal approximation, Signatures. Boundary Descriptors – Shape numbers, Fourier Descriptors, Statistical moments. Regional Descriptors – Topological, Texture.Principal Components for Description.

Total Hours: 60

Reference books:

1. ***Rafael C.Gonzalez, Richard E Woods, "Digital Image Processing",*** III ed., Pearson Education 2008.
2. ***William K. Pratt, "Digital Image Processing",*** John Wiley 2001.

3. ***JayaramanS, Veerakumar.T, Esakkirajan. S.,"Digital Image Processing"*** Tata Mc Graw Hill Pub. Co., Ltd., 2009
4. ***A. K. Jain, "Fundamentals of Digital Image Processing",*** Prentice Hall of India New Delhi, 2009.
5. ***Chanda Dutta Magumdar, "Digital Image Processing and Applications",*** Prentice Hall of India, 2000.

Course Outcomes:

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

CO1: Discuss digital image fundamentals.
CO2: Apply image enhancement and restoration techniques.
CO3: Interpret image compression and segmentation techniques.
CO4: Represent features of images.

CO, PO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	M										
CO2	H	M										
CO3	H	M		H	H				M	M		
CO4	H	M		H	H				M	M		H

Digital Image Processing Practicals

Semester VI **Hours of Instruction/ week: 3P**
21BEBC23 **No. of credits: 1.5**

Objectives:

CLO1: To perform the basic operations on images.

CLO2: To design and implement algorithms for the real time image processing Systems / applications.

List of Experiments

1. Point Processing techniques
2. Spatial domain Filtering
3. Histogram Processing
4. Frequency Domain Filtering (Plotting 2D-DFT, Low pass and High Pass- Ideal Butterworth and Gaussian Filters)
5. Segmentation - Gradient operators
6. Transforms - DCT and DWT
7. Image compression techniques
8. A mini project based on medical image processing

Total Hours: 45

Course Outcomes:

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

CO1: Perform enhancing operations on the image using spatial filters and frequency domain filters.

CO2: Implement the algorithms for segmentation and compression.

CO3: Apply image processing technique to solve real health care problems.

CO, PO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H			H	L				H		
CO2	H	H	M	M	H					H	M	M
CO3	H	H		M	H		L			H		

IV year Syllabus

Hospital Management

Semester VII **Hours of Instruction/week: 3T**
21BEHS13 **No. of credits: 3**

Objectives:

CLO1: To acquire knowledge on hospital systems and equipment management.

CLO2: To learn and explore various information management systems and relative supportive services in hospitals.

Unit I Classification of Hospital Systems **9**

Classification of hospital systems-Role of Administrator-Primary Health Center. Hospital Services- Organization of Outpatient, inpatient, supportive, casualty & emergency service systems.

Unit II Planning of Service Departments **9**

Ancillary services-laboratory services, physiotherapy, occupational therapy, blood transfusion services, radio diagnosis, hospital pharmacy, nursing services, dietary services, transport services, communication services. Supportive Services -Electrical System- Generator standby power-Air conditioning system-Water supply and sanitary system- Firefighting equipment –Alarm system -Housekeeping and maintenance services.

Unit III Hospital Information Systems **9**

Hospital information system and management- Admission/Discharge records of patients, patient billing, maintenance of patients' record - Functional characteristics of HIS-Infection control in hospitals- Pest control, hospital waste management-Lighting in hospital.

Unit IV Clinical Engineering Systems **9**

Need for a biomedical equipment consultant - Purchase of Biomedical Equipment-Justification, planning specification, budgeting, tendering, evaluation, selection, installation, commissioning, and acceptance. Maintenance of equipment- In-house and contract, various types of contracts, PM & CM- TQM applications-Types of Biomedical equipment.

Unit V Overview of the International Regulatory Framework for Medical Devices **9**

Medical device regulatory and technology assessment agencies, Role of the regulatory profession and professional, Medical device lifecycle, Medical Devices, Invitro, diagnostic and active implantable medical devices directives, ASEAN medical device directives, ISO, IEC, ASTM standards for medical devices.

Total Periods: 45

Reference Books:

1. ***Goyal R.C, "Hospital Administration and Human Resource Managemen***t", PHI, 4th Edition, 2006.
2. ***Kunders G.D, "Hospitals – Facilities Planning and Management",*** 5th Edition, New Delhi, 2007.
3. ***Lele R.D, "Computer in Medicine",*** Tata McGraw-Hill, New Delhi, 2005.
4. ***Goel.S.L and R.Kumar, "Hospital Administration& Management",*** Deep &Deep Publications, New Delhi, 1999.
5. ***Val Theiz, "Medical Device regulatory practices: An international Perspective"***, pan Stanford, 2015.

Course Outcomes:

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

CO1: Discuss the role of hospital system and hospital information system.

CO2: Explain the importance of supportive services.

CO3: Explain the engineers role in medical device maintenance and the medical ethics followed in hospital.

CO, PO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H								M	M		
CO2	H								M	M		
CO3	H								M	M		

Medical Imaging Techniques

Semester VII **Hours of Instruction/week: 3T**
21BEBC25 **No. of credits: 3**

Objectives:

CLO1: To gain knowledge on ionizing imaging modalities and the techniques involved in medical imaging.

CLO2: To acquire knowledge on non-ionizing imaging modalities and the techniques involved in medical imaging.

Unit I Radiographic Imaging **9**

Point spread, Line spread and Modulation Transfer Function. Beer lamberts law for projection of radiography, Details of radio graphics and fluoroscopic images in X-ray systems, Screen, film and image intensifier systems, Picture Storage and archiving systems in Medical imaging, Digital Radiography, Principles of Digital Subtraction Angiography.

Unit II X-Ray Computed Tomography **9**

Basic principle, Evolution of CT machines, Acquisition, Processing, Reconstruction, Viewing and storage systems. Gantry Geometry, Patient dose in CT scanner.

Unit III Nuclear Medical Imaging Systems **9**

Radio-isotopes, Physics of radioactivity, Radiation detectors, Pulse height analyzers, Uptake monitoring equipment, Rectilinear scanner, Gamma Camera, Emission Computed Tomography, PET scanner, Principle, Data acquisition, Basic physics and instrumentation of medical images in SPECT with its characteristics.

Unit IV Ultrasonic Imaging System **9**

Diagnostic Ultrasound, Physics of Ultrasonic waves, Principles of A-Mode, B-Mode, M-Mode, Real time Ultrasonic (B-Scan) imaging systems, Requirements, Multi-element Linear array scanners, Digital scan converters, Biological effects of ultrasound and its requirements.

Unit V Magnetic Resonance Imaging System **9**

Principles of NMR imaging system, Image acquisition in MRI, T1, T2, Proton density weighted images, Artifacts in imaging, Pulse sequences, conventional, fast acquisition, image reconstruction techniques, Basic NMR components, Biological effects of MRI and Advantages. Basic physics and instrumentation of medical images in FMRI with its characteristics.

Total Hours: 45

Reference Books:

1. ***Khandpur.R.S. "Handbook of Biomedical Instrumentation",*** Third edition Tata Mc Graw Hill Pub. Co., Ltd, 2014.
2. ***John Ball and Tony Price, "Chesney's Radiographic Imaging", Blackwell*** Science Limited, U.K, 6th edition 2019.
3. ***Farr, "The Physics of Medical Imaging",*** Adem Hilger, Bristol & Philadelphia, 2007.
4. ***Joseph Bronzino, "The Physics of Medical Imaging",*** Second edition, 2005.

Course Outcomes:

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

CO1: Discuss the principles of radiographic, nuclear medical, ultrasonic, magnetic resonance imaging systems.

CO2: Describe the instrumentation and working of CT, Ultrasound, MRI, nuclear medical imaging systems.

CO3: Explain the image reconstruction, picture storage, biological effects of imaging systems and its applications.

CO, PO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	L				H	H					L
CO2	H					H	H					L
CO3	H					H	H					L

Special Medical Equipment Practicals

Semester VII **Hours of Instruction/week: 3P**

21BEBC26 **No. of credits: 1.5**

Objectives:

CLO1: To demonstrate the principle and working of life supporting devices.

CLO2: To learn the maintenance procedure of medical equipment

List of Experiments:

1. To study and demonstrate the working of TENS & Ultrasound Therapy Unit.
2. Acquisition of blood flow graph using PC based Vascular Doppler.
3. To study and demonstrate the working of Baby Incubator.
4. To study and demonstrate the working of Radiant heat warmer & Phototherapy.
5. Recording of lung flow, volume and capacities graph using PC based Spirometer.
6. To study and demonstrate the working of Respiratory Ventilator.
7. To study the working of Ultrasound Scanner.
8. To demonstrate the working of Defibrillator.
9. Study of Heart lung machine.
10. To demonstrate the working of Video Endoscopy system.

Total Hours: 45

Course Outcomes:

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

CO1: Demonstrate the working of Medical diagnostic equipment.

CO2: Demonstrate the working of Medical therapeutic equipment and the maintenance procedure of medical equipment.

CO, PO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H				M					M		M
CO2	H	M			M				M	M		M

Hospital Internship

Semester VII **Hours of Instruction/ week: 3P**

21BEBC27 **No. of credits: 1.5**

Objectives:

CLO1: To acquire skills with respect to diagnosis and assessment of the diseases.

CLO2: To learn the professional ethical issues followed in hospital.

Course Outcomes:

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

CO1: State the ethics followed in hospitals.

CO2: Develop the technical and professional skills required for hospital environment.

CO3: Study and analyze the infection control and safety management in hospitals and practice in servicing of equipment.

15 days of internship at multi-specialty hospitals

Total Hours: 45

CO, PO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H							H				
CO2	H	M			M				M	M		
CO3	H	M			M	H	H		M	M		M

Medical Physics

PEI- Semester V **Hours of Instruction/week: 3T**
21BEBE01 **No. of credits: 3**

Objectives:

CLO1: To understand the effects of radiation and how isotopes are produced.

CLO2: To acquire knowledge about the principle and working of Radiation Detection and dosimeters.

Unit I Non-Ionizing Radiation and its Medical Application **9**

Overview of non-ionizing radiation effects-Low Frequency Effects- Higher frequency effects. Thermography, application. Ultrasound Transducer - Interaction of Ultrasound with matter; Cavitation Conditions for reflection, Transmission-Scanning systems, Artifacts- Ultrasound- Doppler-Double Doppler shift Clinical Applications.

Unit II Principles of Radioactive Nuclides **9**

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 radio nuclides, Cyclotron produced Radionuclide-Reactor produced Radio-nuclide-fission and electron Capture reaction, radionuclide Generator-Milking process (Technetium generator).

Unit III Interaction of Radiation with Matter **9**

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.

Unit IV Principles of Radiation Detection and Dosimeters **9**

Principles of radiation detection, Properties of dosimeters, Theory of gas filled detectors, Ionization Chamber, Proportional chamber, G.M. Counter, Film dosimetry, luminescence dosimetry, scintillation detectors, Radiation detection instruments, Area survey meters, Personal Radiation monitoring device, Film badge, TLD, OSLD.

Unit V Basic Radiation Quantities **9**

Introduction-exposure-Inverse square law-KERMA-Kerma and absorbed dose -stopping power - relationship between the dosimetric quantities - Bremsstrahlung radiation, Bragg's curve- concept of LD 50- Stochastic and Non-stochastic effects, Different radiation Unit, Roentgen, gray, Sievert.

Total Hours: 45

Reference Books:

1. ***John R Cameron, James G Skofronick "Medical Physics",*** John-Wiley & Sons, 2018.
2. ***W. J. Meredith and J.B. Massey "Fundamental Physics of Radiology",*** Varghese Publishing house, 2013.
3. ***P. Uma Devi, A. Nagarathnam , B S Satish Rao , "Introduction to Radiation Biology", B.I Chur Chill Livingstone Pvt Ltd, 2005.***
4. ***S.Webb, "The Physics of Medical Imaging",*** Taylor and Francis, 2012.
5. ***J.P.Woodcock, "Ultrasonic, Medical Physics Handbook series"*** 1, Adam Hilger, Bristol, 2002.

Course Outcomes:

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

CO1: Understand the effects of ionizing and non-ionizing radiation.

CO2: Discuss the interaction of radiation and ultrasound with matter and its clinical applications.

CO3: Explain the principles of production of radionuclides, radiation dosimetry and radiation detection.

CO, PO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H								M	M		
CO2	H								M	M		
CO3	H								M	M		

Medical Optics

PEI - Semester V **Hours of Instruction/week: 3T**
21BEBE02 **No. of credits: 3**

Objectives:

CLO1: To study about the optical properties of the tissues and the principle behind the photonics.

CLO2: To understand and employ the applications of laser in diagnosis and therapy.

Unit I Optical Properties of the Tissues **9**

Refraction, Scattering, Absorption, Light transport inside the tissue, Tissue properties, Laser Characteristics as applied to medicine and biology-Laser tissue Interaction- Chemical- Thermal- Electromechanical, Photo ablative processes.

Unit II Instrumentation in Photonics **9**

Instrumentation for absorption, Scattering and emission measurements, excitation light sources, high pressure arc lamp, LEDs, Lasers, Optical filters, - optical detectors - Time resolved and phase resolved detectors.

Unit III Surgical Applications of Lasers **9**

Lasers in ophthalmology- Dermatology, Dentistry-Urology-Otolaryngology- Tissue welding.

Unit IV Non-Thermal Diagnostic Applications **9**

Optical coherence tomography, Elastography, Laser Induced Fluorescence (LIF)-Imaging, FLIM Raman Spectroscopy and Imaging, FLIM, Holographic and speckle application of lasers in biology and medicine.

Unit V Therapeutic Applications **9**

Phototherapy, Photodynamic therapy (PDT) - Principle and mechanism - Oncological and non- oncological applications of PDT - Bio stimulation effect, applications-Laser Safety Procedures.

Total Hours: 45

Reference Books:

1. ***Markolf H. Niemz, "Laser-Tissue Interaction Fundamentals and Applications", Springer, 2019.***
2. ***Paras N. Prasad, "Introduction to Bio photonics"***, A. John Wiley and sons, Inc. Publications, 2003.
3. ***Tuan Vo Dinh, "Biomedical photonics"***, *Handbook*, CRC Press LLC, 2003.

4. ***Mark E. Brezinski, "Optical Coherence Tomography: Principles and Applications"***, Academic Press, 2006.
5. ***R. Splinter and B.A. Hooper, "An Introduction to Biomedical Optics"***, Taylor and Francis, 2007.

Course Outcomes:

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

CO1: Outline the fundamentals of optical properties of tissues, photonic instruments and laser.

CO2: Explain laser tissue interaction process and employ the surgical, diagnostic and therapeutic applications of laser.

CO3: Describe the principle and mechanism of photonic instruments, non-thermal diagnostic applications and therapeutic applications.

CO, PO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H								H	H		
CO2	H								H	H		
CO3	H								H	H		

Neural Engineering

PEI- Semester V **Hours of Instruction/ week: 3T**
21BEBE03 **No. of credits: 3**

Objectives:

CLO1: To be familiar with the nervous system development.

CLO2: To be exposed to neuronal diseases and disorders and familiarize with nerve reconstruction and repairing

Unit I Basics of Neuron Structure and Functions **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. Alzheimer‘s, Parkinson‘s 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 Hours: 45

Reference Books:

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.

3. ***Mathews G.G., "Neurobiology"***, 2nd edition, Blackwell Science, UK, 2000.
4. ***Malcom Carpenter, "Textbooks of Neuroanatomy"***, Mc. Graw hill Edition, 1996.

Course Outcomes:

Upon completion of this course, the students should be able to:

CO1: Explain the basic structure and functions of human nervous system.
CO2: Understand diseases and degeneration related to nervous system.
CO3: Analyze visualization and radiological assessment of nervous system.
CO4 Apply neural tissue engineering for rehabilitation.

CO, PO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H								H	H		
CO2	H								H	H		
CO3	H								H	H		
CO4	H	M							H	H		

Cell and Tissue Engineering

PEI- Semester VI **Hours of Instruction/week: 3T**
21BEBE04 **No. of credits: 3**

Objectives:

CLO1: To understand the physio-biological functions of cells and tissues, their interaction with biomaterials.

CLO2: To acquire knowledge about Stem cells and Tissue Engineering Application.

Unit I Fundamentals of Cell Mechanism **9**

Structure and functions of cells, cell membrane, transport across membrane, cell potential, cell growth & cycle, cell adhesion and migration, cellular interaction- cell-cell and cell-matrix, cell transplantation.

Unit II Basic Tissue Engineering **9**

Introduction to Tissue Engineering, structure and organization of tissue, development of tissue- Tissue exchange and diffusion of simple metabolites, Tissue Equivalent - Wound Healing Process - Biocompatibility and toxicity assessment.

Unit III Biomaterials in Tissue Engineering **9**

Definition, Biological vs Non-biological materials, Extra Cellular Matrix, Collagen, Chitin & Degradable and Non-degradable materials, Polymer, Ceramics and Metals, Cell interaction with different materials, Scaffolds - Control releaser agents in Tissue Engineering, Cell interaction with suspension and gels, Tissue response to implants.

Unit IV Stem Cells in Tissue Engineering **9**

Introduction of Stem cells, Hemopoietic Stem cells, Embryonic Stem cells, Adult stem cells, Cancer Stem cells, Cord Blood cells, Induced Pluripotent Stem cells, Stem cell identification, Surface markers & FACS analysis, Differentiation, Dedifferentiation and Immortalization - Application of stem cells in tissue Engineering.

Unit V Tissue Engineering Application **9**

Synthetic components, Artificial organs, Joints and dental prostheses, Connective Tissue Engineering, Cardiovascular Tissue Engineering, Neural Tissue Engineering, Cell and Drug Delivery systems.

Total Hours: 45

Reference Books:

1. ***Robert P Lanza, Robert Langer and Joseph Vacanti, "Principles of tissue engineering***", Academic Press, California, 2013.
2. ***Cecie Starr, Ralph Taggart, "Cell biology and genetics",*** Brooks/Cole Publishers, California, volume 1 2015.
3. ***Bruce Alberts, et.al. "Molecular Biology of the Cell"***, Garland Science Publications, New York, 2016.

4. ***Yoshito Ikada, "Tissue engineering: Fundamentals and applications***", Elsevier Ltd, UK, 2006.

Course Outcomes:

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

- **CO1:** Recall the basic concepts of cell mechanism and importance of stem cells in tissue engineering.
- **CO2:** Discuss the physio-biological functions of cells and tissue in wound healing mechanism.
- **CO3:** Compare the properties of degradable and non-degradable biomaterials.
- **CO4:** Describe the importance of bioengineered scaffolds and in tissue engineering applications.

CO, PO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H								H	H		
CO2	H								H	H		
CO3	H								H	H		
CO4	H	M							H	H		

Rehabilitation Engineering

PEI- Semester VI **Hours of Instruction/week: 3T**
21BEBE05 **No. of credits: 3**

Objectives:

CLO1: To understand the technology used to improve the quality of life of individuals with disabilities.

CLO2: To design the wheel chair, sensory rehabilitation aid and motor rehabilitation aid.

UNIT I Introduction to Rehabilitation **9**

Definition – Concept of Rehabilitation: Types of Physical Impairments, Principles of Assistive Technology Assessment, Principles of Rehabilitation Engineering - Key Engineering Principles– Key Ergonomic Principles– Engineering Concepts in Sensory & Motor rehabilitation.

UNIT II Orthotics & Prosthetics in Rehabilitation **9**

Types of orthosis - FO,AFO,KAFO,HKAFO and prosthesis, Partial Foot Prostheses - Foot-ankle assembly– Trans femoral Prostheses– Prosthetic Hand– Advance and automated prosthetics and orthosis– Externally powered and Controlled orthotics & prosthetics – FES system– Restoration of Hand function– Restoration of standing and walking.

UNIT III Mobility Aids **9**

Electronic Travel Appliances (ETA) : Path Sounder, Laser Cane, Ultrasonic Torch, Sonic Guide, Light Probes, Nottingham Obstacle Sensors, Electro cortical Prosthesis, Polarized Ultrasonic Travel aids.Materials used for wheel chairs– Type of Wheel Chairs– design of wheel Chair– Walking frames– Parallel bars– Rollators– Quadripods– Tripods & walking sticks– Crutches.

UNIT IV Auditory And Speech Assist Devices **9**

Types of deafness – hearing aids – application of DSP in hearing aids – Cochlear implants – Voice synthesizer – speech trainer.

UNIT V Sensory Augmentation And Substitutions **9**

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

Total Hours: 45

Reference Books:

1. ***Bronzino J.D, "The Biomedical Engineering handbook",*** fourth Edition. Vol. II, CRC press, Boca Raton, 2018.
2. ***Rory Cooper Douglas, A. Hobson. "An Introduction to Rehabilitation Engineering",*** CRC Press, 2008.

3. Horia, Hicholi, TeodorescuL., Lakme C Jain, "Intelligent Systems and Technologies in Rehabilitation Engineering", 3rd Edition, CRC Press, 2006.

Course Outcomes:

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

CO1: Understand the key terminologies used by the rehabilitation team.

CO2: Identify the use of the orthopedic prosthetics and orthotics in rehabilitation.

CO3: Illustrate the various assist devices for different disabilities of the body.

CO4: Interpret augmented, substitute assistive devices for visually impaired persons.

CO, PO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H		H			H			M			
CO2		L	M	M								L
CO3	H					H						
CO4					M			M		M		M

Modeling of Physiological Systems

PEI- Semester VI **Hours of Instruction/week: 3T**
21BEBE06 **No. of credits: 3**

Objectives:

CLO1: To provide basic ideas related to modeling techniques of physiological systems.

CLO2: To gain knowledge on parameters involved in the physiological system and to model the physiological system.

Unit I Basics of Physiological Systems **9**

Systems Analysis, examples of physiological control systems, differences between engineering and physiological control systems. Generalized system properties, mathematical approach, electrical analogs, linear models, Lung mechanics, Muscle mechanics, distributed parameter versus lumped parameter models, static analysis, regulation of cardiac output, blood glucose regulation, chemical regulation of ventilation, electrical model of neural control mechanism.

Unit II Circulatory System **9**

Physical, chemical and rheological properties of blood, problems associated with extracorporeal blood flow, dynamics of circulatory system.

Unit III Thermal Regulatory System **9**

Parameters involved, Control system model etc. Biochemistry of digestion, types of heat loss from body, models of heat transfer between subsystem of human body like skin core, etc and systems like within body, body- environment, etc.

Unit IV Ultra Filtration System **9**

Transport through cells and tubules, diffusion, facilitated diffusion and active transport, methods of waste removal, counter current model of urine formation in nephron, Modeling Henle's loop.

Unit V Respiratory System **9**

Modelling oxygen uptake by RBC and pulmonary capillaries, Mass balancing by lungs, Gas transport mechanisms of lungs, oxygen and carbon dioxide transport in blood and tissues.

Total Hours: 45

Reference Books:

1. ***David O. Cooney, "Biomedical Engineering Principles",*** Marcel Decker Pub. Co, 2017.
2. ***Michael C. K. Kho, "Physiological Control Systems",*** Prentice Hall of India, 2018.

3. ***John Enderly, Susan Blanchard, Joseph Bronzino, "Introduction to Biomedical Engineering",*** Second Edition, Academic Press Series in Biomedical Engineering, 2005.

Course Outcomes:

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

CO1: Recall the basics and parametric aspects of physiological systems.

CO2: Compare the engineering models of physiological systems with its biological functions.

CO3: Discuss the rheological properties of blood/blood cells and gas transport mechanism.

CO4: Apply modeling techniques in renal and pulmonary functions that influences waste removal/ oxygen transport respectively.

CO, PO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	M								M		
CO2	H	M			M				M			
CO3									M	M		
CO4							M	H				

Telemedicine

PEI- Semester VI **Hours of Instruction/week: 3T**

21BEBE07 **No. of credits: 3**

Objectives:

CLO1: To Learn the key principles for telemedicine and health and understand telemedical technology.

CLO2: To know telemedical standards, mobile telemedicine and it applications.

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 Type of Information & 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**

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

Total Hours: 45

Reference Books:

1. ***Khandpur R S, "TELEMEDICINE– Technology and Applications"***, PHI Learning Pvt Ltd., 2017.
2. ***Norris A C***, "***Essentials of Telemedicine and Telecare"***, John Wiley, New York, 2002.
3. ***H K Huang, "PACS and Imaging Informatics: Basic Principles and Applications"*** Wiley, New Jersey, 2010.

Course Outcomes:

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

CO1: Discuss the basic principle and technology underlying in the telemedicine.

CO2: Explain protocols behind encryption techniques for secure transmission of data.

CO3: Apply telehealth technologies in various fields of healthcare with its ethical and legal aspects.

CO, PO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	M								L		H
CO2	H	M	M						H	M		
CO3	H		M			H			H			

BioMEMS and Nanotechnology

PEI- Semester VI **Hours of Instruction/week: 3T**

21BEBE08 **No. of credits: 3**

Objectives:

CLO1: To gain knowledge on the principles and fabrication techniques of BioMEMS.

CLO2: To acquire knowledge on applications of MEMS and Nanotechnology in Medicine.

Unit I Introduction to MEMS & Nanotechnology **9**

Introduction to BioMEMS and Nanotechnology, Development of MEMS technology- Comparison of microsystems and microelectronics – Materials for MEMS-Smart Materials and Structures – Applications of MEMS.

Unit II Micro and Nanofabrication Techniques **9**

Nanotechnology, Bottom up and top down methods of synthesis - Self-assembly-lithography techniques, etching – Ion implantation, surface micromachining - LIGA process - CVD technique.

Unit III MEMS Sensors and Actuators **9**

Sensing and Actuation – Piezo resistive and Capacitive sensing - Electrostatic actuation - Pressure sensors - Accelerometers, Gyroscopes - Interfacing with Sensors and Actuators-Nanopore sensors – magnetic sensors, Thermal sensors and actuators.

Unit IV Micro-Opto Electromechanical Systems & Microfluidics **9**

Fundamental principle of MOEMS Technology - Light Modulators, Beam splitter, Micro-lens, Micro-mirrors - Digital Micro-mirror Device, Light detectors - Important Consideration on Micro-scale fluid, Properties of fluid - Fluid Actuation Methods, Micro-pumps - Typical Micro-fluidic Channel, Micro-fluid Dispenser.

Unit V Applications of MEMS and Nanotechnology in Medicine **9**

Biochip - Micro Total Analysis Systems detection and measurement methods - DNA sensor - Drug delivery system, Ampero-metric Biosensor - Multi-analyte measurement, Micro-dialysis - Monitoring of Glucose & Lactate with a micro-dialysis probe, Ammonia Monitoring - Electronic Nose, Biomolecular sensing for cancer diagnostics using carbon nanotubes, Carbon nanotube biosensors, Magnetic nanoparticles for MR Imaging, Nano-devices in biomedical applications.

Total Hours: 45

Reference Books:

1. ***Steven s Saliterman, "Fundamentals of Biomems and Medical Microdevices***", Spie press, USA, 2006.
2. ***Desai, Sangeeta Bhatia, "Biomedical Nanotechnology*****: Therapeutic Micro Nanotechnology"** – VOL 3, Springer, New York, 2006.
3. ***Tai Ran Hsu, "MEMS and Microsystems design and manufacture"***, Tata McGraw Hill Publishing Company, New Delhi, 2017.
4. ***Stephen D Senturia, "Microsystem Design"***, Springer, New Delhi, 2011.
5. ***Chang Liu, "Foundations of MEMS***", Pearson Education International, New Jersey, USA, 2006.

Course Outcomes:

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

CO1: Describe the fundamental principle of MEMS, MOEMS, Microfluidics and fabrication techniques of micro and nanotechnology.

CO2: Explain the working of MEMS sensors, actuators, MOEMS and Microfluidics and its types.

CO3: Discuss about the recent applications of MEMS and nanotechnology in medicine.

CO, PO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H								H	H		
CO2	H								H	H		
CO3	H								H	H		

Advanced Bioanalytical and Therapeutic Techniques

PEI- Semester VI **Hours of Instruction/week: 3T**

21BEBE09 **No. of credits: 3**

Objectives:

CLO1: To acquire knowledge on the bio analytical and therapeutic techniques.

CLO2: To familiarize with gene therapy and Nanotherapeutics.

Unit I Analytical Techniques **9**

Principle, instrumentation and application of electrophoresis - SDS, native gel. UV and IR spectroscopy and its application. Spectrophotometry, fluorimetry, principle, instrumentation and application in medical sciences.

Unit II Enzymes as a Diagnostic Tool **9**

Isoenzymes and their significance in diagnosis, enzyme pattern in health and diseased condition, lipase, amylase, ALP, ACP, SGOT, SGPT, LDH & CPK. Techniques in screening isoenzymes. Biosensors - enzyme based, antibody based, DNA based and optical biosensor. Blotting techniques. Automation in clinical laboratory.

Unit III Radio Isotopic Techniques **9**

Types of radioisotopes, units of measurements, methods in measuring radioactivity, G.M liquid scintillation counter application in diagnosis (RIA & ELISA), autoradiography, biological hazards, safety measures in handling isotopes, disposal of labeled compounds and radio dosimetry.

Unit IV Gene Therapy **9**

Central concept of gene therapy, basic molecular mechanism of gene transfer, human genome project, prerequisite of human gene therapy, biological basis of gene therapy strategies, vehicles for gene transfer, gene transfer methods, clinical gene therapy studies, gene therapy for hereditary disease, gene therapy for cancer, gene therapy for HIV. Ethical issues in human gene therapy.

Unit V Nanotherapeutics **9**

Nanoparticles as carriers in drug delivery - design, manufacture and Physiochemical properties, transport across biological barriers, nanotechnology in Cancer therapy, bone treatment, nano particles for oral vaccination and skin disease. Types of nanoparticles-half-life. Fate of nano particles.

Total Hours: 45

Reference Books:

1. ***Douglas A, "Principles of Instrumental Analysis"***, Skoog Brooks Cole publisher 7th edition 2017.
2. ***Keith Wilson & John Walker, "Practical Biochemistry, Principles and Techniques"***, Oxford University Press 7th edition 2010.
3. ***Harvey Lodish W. H, "Molecular Cell Biology"***, Freeman publisher 8th Edition 2016.
4. ***G. Louis Hornyak, John J. Moore, Harry F. Tibbals and Joydeep Dutta, "Fundamentals of Nanotechnology"***, CRC press, 1st edition 2008.
5. ***Gabor L. Hornyak, Joydeep Dutta, H.F. Tibbals, Anil Rao, "Introduction to Nano Science"***, CRC press 2008.

Course Outcomes:

Upon completion of this course, the students should be able to:

CO1: State the principle, working and application of analytical instruments and recall the concepts in analytical biochemistry.

CO2: Analyse the significance of enzymes as a diagnostic tool and understand the ethical issues in human gene therapy.

CO3: Explain the concept, methods of radio-isotopic techniques and immunoassay.

CO4: Discuss about the concepts of nano-therapeutics in drug delivery.

CO, PO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H								H	H		
CO2	H								H	H		
CO3	H								H	H		
CO4	H								H	H		

Medical Device Regulations

PEI- Semester VII **Hours of Instruction/ week: 3T**
21BEBE10 **No. of credits: 3**

Objectives:

CLO1: To understand the medical device classes and regulatory efforts and to familiarize the national and international medical device regulations and standards.

CLO2: To know about the patents and intellectual property rights.

Unit I Definition of Testing **9**

Parsing test requirements, test protocol, test methodology, purpose of the test, failure definition, determining sample size and test length, types of testing. Analysis of test data- failure rate, mean time between failure, reliability, confidence level, confidence limits, minimum life, graphical analysis. Reliability and liability- negligence, strict liability, breach of warranty, defects, plaintiff's conduct, defendant's conduct, defendant related issues, manufacturers and physicians responsibilities, accident reconstruction and forensics.

Unit II Food and Drug Administration **9**

History of device regulation, device classification, registration and listing, 510(k) process, declaration of conformance to a recognized standard, PMA application, investigational device exemptions, good laboratory practices, good manufacturing practices, human factors, design control, FDA and software classification, FDA inspection, advice on dealing with the FDA regulations and standards- definition of medical device, MDD, United States Domestic Standards, rest of the world standards.

Unit III Indian Medical Device Rules and Regulations **9**

Indian medical device rules and regulations-2017, licensing patents, copyrights and trade secrets, trademarks. Manufacturing and quality control- GMP regulations, design for manufacturability, design for assembly, manufacturing process.

Unit IV Miscellaneous Issues **9**

Learning from failure, design for failure, design for convenience, universal design, design for assembly, prevention through design, design for the environment, poka-yoke, product life issues, product testing issues. Product safety and legal issues, accident reconstruction and forensics, biomechanics and traffic-accident investigations. professional issues, BME – related professional societies, standards setting groups, professional engineering licensure, rules of professional conduct, codes of ethics, forensics and consulting, continuing education.

Unit V Design of Case studies **9**

Multidetector brain scanning system development, testing of anesthetists, apnea detection system, cancer clinic charting, EKG analysis techniques & module.

Total Hours: 45

Reference Books:

1. ***Seeram Ramakrishna, "Medical Devices Regulations, Standards and Practices''***, WoodHead Publishing series in Biomaterials UK, 2015.
2. ***Val Theisz., "Medical Device Regulatory Practices, An International Perspective"***, CRC Press, 2016.

Course Outcomes:

Upon completion of this course, the students should be able to:

CO1: Understand the basic concepts of medical device regulations and define the purpose and types of testing.

CO2: Discuss the FDA regulations and standards, and global policies on medical device regulations.

CO3: Inspect and investigate national and international device regulation standards.

CO4: Analyze the way design concepts are imbibed in practical scenarios.

CO, PO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	M								M		
CO2	H	M			M				M			
CO3									M	M		
CO4							M	H				

Electromagnetic Interference and Compatibility

PEI- Semester VII **Hours of Instruction/ week: 3T**
21BEBE11 **No. of credits: 3**

Objectives:

CLO1: To introduce the basic concepts of Electromagnetic Interference.

CLO2: To teach the importance of Electromagnetic Compatible designs.

CLO3: To explain the existing standards for Electromagnetic Compatibility**.**

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 Standards and Regulation **9**

Units of EMI; National and International EMI Standardizing Organizations – IEC, ANSI, FCC, CISPR, BIS, CENELEC; FCC standards; EN Emission and Susceptibility standards and specifications; MIL461E Standards.

Unit V Test Methods and Instrumentation **9**

EMI test sites - Open area site; TEM cell; Shielded chamber; Shielded Anechoic chamber; EMI test receivers; Spectrum Analyzer; Transient EMI Test wave Simulators; EMI coupling Networks - Line impedance Stabilization Networks; Feed through capacitors; Antennas and factors; Current probes and calibration factor; MIL-STD test methods; Civilian STD Test methods, Government policies.

Total Hours: 45

Reference Books:

1. ***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. ***Don R.J.White Consultant Incorporate, "Handbook of EMI/EMC"***, Vol I-V, 1988

4. ***Bemhard Keiser, "Principles of Electromagnetic Compatibility"***, 3rd Edition, Artech house, Norwood, 1987
5. ***C.R. Paul, "Introduction to Electromagnetic Compatibility"***, John wiley & sons Inc. 2006.

Course Outcomes:

Upon completion of this course, the students should be able to:

CO1: Identify the various types and mechanisms of Electromagnetic Interference
CO2: Propose a suitable EMI mitigation technique
CO3: Describe the various EMC Standards and methods to measure them

CO, PO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H	H									
CO2	H	H	H									
CO3	H	H	H		M				H			L

Robotics and Automation in Medicine

PEI- Semester VII **Hours of Instruction/week: 3T**
21BEBE12 **No. of credits: 3**

Objectives:

CLO1: To understand the basic mechanism of robotic subsystems

CLO2: To gain knowledge on design, analysis and working principle of robotics in medical field.

Unit I Introduction of Robotics **9**

Introduction to Robotics and its history, Overview of robot subsystems, Degrees of freedom, configurations and concept of workspace, Automation, Mechanisms and movements, Dynamic stabilization- Applications of robotics in medicine

Unit II Actuators and Grippers **9**

Pneumatic and hydraulic actuators, Stepper motor control circuits, End effectors, Various types of Grippers, Design consideration in vacuum and other methods of gripping, PD and PID feedback actuator models

Unit III Manipulators & Basic Kinematics **9**

Construction of Manipulators, Manipulator Dynamic and Force Control, Electronic and pneumatic manipulator, Forward Kinematic Problems, Inverse Kinematic Problems, Solutions of Inverse Kinematic problems

Unit IV Power Sources and Sensors **9**

Sensors and controllers, Internal and external sensors, position, velocity and acceleration sensors, Proximity sensors, force sensors, laser range finder, variable speed arrangements, Path determination - Machinery vision, Ranging, Laser- Acoustic, Magnetic fiber optic and Tactile sensor

Unit V Robotics in Medicine **9**

Da Vinci Surgical System, Image guided robotic systems for focal ultrasound based surgical applications, System concept for robotic Tele-surgical system for off-pump CABG surgery, Urologic applications, Cardiac surgery, Neuro-surgery, Pediatric-, and General- Surgery, Gynecologic Surgery, General Surgery and Nano robotics.

Total Hours: 45

Reference Books:

1. ***Nagrath and Mittal, "Robotics and Control***", Tata McGraw-Hill, 2018.
2. ***Reza N.Jazar, Theory of Applied Robotics Kinematics, Dynamics and Control***, Springer, First Indian Reprint 2016.
3. ***Spong and Vidhyasagar, "Robot Dynamics and Control***", John Wiley and Sons, First edition, 2015.

4. ***Jacob Rosen, Blake Hannaford & Richard M Satava, "Surgical Robotics: System Applications & Visions"***, Springer 2011.
5. ***Constantinos Mavroidis, Antoine Ferreira, "Nanorobotics: Current approaches and Techniques"***, Springer 2011.

Course Outcomes:

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

CO1: Outline the basic concept of robotics and discuss the sensors, actuators, manipulators.

CO2: Explain the working principle underlying in sensors, actuators, manipulators with power source in robotics.

CO3: Discuss the applications of robotic systems in medical field.

CO, PO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H								H	H		
CO2	H								H	H		
CO3	H	M							H	H		

Object Oriented Programming with C++

PE II –Semester V **Hours of Instruction/week: 3T**
21BEBE21 **No. of credits: 3**

Prerequisite:

Programming and Problem Solving

Objectives:

CLO1: Develop programming skills of students, using object oriented programming concepts.

CLO2: Apply the major object-oriented concepts to implement object oriented programs in C++, encapsulation, inheritance and polymorphism, stream I/O, templates and operator overloading.

Unit I Introduction to Object Oriented Programming **9**

Basic concepts and benefits of OOP – Elements of Object Oriented Programming Language – Advantages and Application of OOP - C++ fundamentals – Data types, Operators and Expressions, Control flow, Arrays, Structure and Functions.

Unit II Classes and Objects **9**

Classes and Objects – Passing objects as arguments – returning objects – Friend functions – Static data and member functions - Constructors –Parameterized constructor – Destructor- Copy contractor- Array of Objects – pointer to object members.

Unit III Operator Overloading **9**

Function overloading – Unary operator overloading – binary operator overloading – Data Conversion- Overloading with Friend Functions.

Unit IV Inheritance and Polymorphism **9**

Derived class and base class-derived class constructor - types of inheritance-virtual function-polymorphism.

Unit V Streams and Files **9**

C++ streams – console streams – console stream classes - formatted and unformatted console I/O operations – Manipulators File streams classes - File modes - File pointers and Manipulations - File I/O – Exception handling.

Total Hours: 45

References:

1. ***Balagurusamy (2011). Object Oriented Programming with C++.*** 5th Edition. Tata McGraw Hill.
2. ***Ravichandran (2011). Programming with C++.*** Tata McGraw Hill.
3. ***Bjarne StrousTrup (2013). The C++ Programming Language.*** 4th Edition. Addison-Wesley.

Course Outcomes:

At the end of the course, students will be able to:

CO1: Demonstrate ability to implement one or more patterns involving realization of the concepts of Object Oriented Programming

CO2: Apply object oriented programming concepts to develop solutions to problems demonstrating usage of control structures, modularity, I/O and other standard language constructs.

CO3: Develop solutions to problems demonstrating usage of encapsulation, inheritance and polymorphism, stream I/O, templates and operator overloading.

CO, PO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	M	H	H	L	M							L
CO2	M	H	H	M	M						M	M
CO3	M	H	H	H	H						M	H

Soft Computing

PE II –Semester V **Hours of Instruction/week: 3T**
21BEBE22 **No. of credits: 3**

Objectives:

CLO1: To expose the students to various types of soft computing techniques.

CLO2: To familiarize with genetic algorithm and applications of soft computing techniques.

Unit I Introduction **9**

Artificial neural network: Introduction, characteristics- learning methods - taxonomy - Evolution of neural networks – basic models-important technologies-applications. Fuzzy logic: Introduction - crisp sets- fuzzy sets - crisp relations and fuzzy relations: cartesian product of relation-classical relation, fuzzy relations, tolerance and equivalence relations, non-iterative fuzzy sets. Genetic algorithm-Introduction - biological background - traditional optimization and search techniques - Genetic basic concepts.

Unit II Neural Networks **9**

McCulloch-Pitts neuron-linear separability- hebb network-supervised learning network: perceptron networks-adaptive linear neuron, multiple adaptive linear neuron, BPN,RBF, TDNN- associative memory network: auto-associative memory network, hetero-associative memory network, BAM, Hopfield networks, iterative auto associative memory network & iterative associative memory network - unsupervised learning networks: Kohonen self-organizing feature maps, LVQ - CP networks, ART network.

Unit III Fuzzy Logic **9**

Membership functions: features, fuzzification, and methods of membership value assignments- Defuzzification: lambda cuts - methods – fuzzy arithmetic and fuzzy measures: fuzzy arithmetic - extension principle - fuzzy measures - measures of fuzziness –fuzzy integrals- fuzzy rule base and approximate reasoning: truth values and tables, fuzzy propositions, formation of rules-decomposition of rules, aggregation of fuzzy rules, fuzzy reasoning- fuzzy inference systems-overview of fuzzy expert system-fuzzy decision making.

Unit IV Genetic Algorithm **9**

Genetic algorithm and search space-general genetic algorithm-operators-Generational cycle-stopping condition-constraints-classification-genetic programming–multilevel optimization – real life problem- advances in GA.

Unit V Hybrid Soft Computing Techniques & Applications **9**

Neuro-fuzzy hybrid systems - genetic neuro hybrid systems - genetic fuzzy hybrid and fuzzy genetic hybrid systems - simplified fuzzy ARTMAP - Applications: A fusion approach of multispectral images with SAR, optimization of traveling salesman problem using genetic algorithm approach, soft computing-based hybrid fuzzy controllers.

Total Hours: 45

Reference Books:

1. ***J.S.R.Jang, C.T. Sun and E.Mizutani, "Neuro-Fuzzy and Soft Computing***", PHI / Pearson Education2009.
2. ***S.N.Sivanandam and S.N.Deepa, "Principles of Soft Computing***", Wiley India Pvt Ltd, 2011.
3. ***S.Rajasekaran and G.A.Vijayalakshmi Pai, "Neural Networks, Fuzzy Logic and Genetic Algorithm: Synthesis & Applications***", Prentice-Hall of India Pvt. Ltd., 2006.
4. ***George J. Klir, Ute St. Clair, Bo Yuan, "Fuzzy Set Theory: Foundations and Applications***" Prentice Hall, 2007.
5. ***David E. Goldberg, "Genetic Algorithm in Search Optimization and Machine Learning***" Pearson Education India,2013.

Course Outcomes:

Upon completion of this course, the student should be able to:

CO1: Recall neural network architectures, fuzzy sets and concept of genetic algorithms.

CO2: Describe various neural networks.

CO3: Discuss fuzzy inference and fuzzy expert systems.

CO4: Elaborate on the concepts of genetic algorithm and applications of soft computing techniques.

CO, PO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	M	M									
CO2	H	M	M								M	
CO3	H	M			M							
CO4	H	M		M		M			M		H	

Speech Processing

PE II –Semester V **Hours of Instruction/week: 3T**

21BEBE23 **No. of credits: 3**

Objectives:

CLO1: To acquire knowledge on speech analysis and different speech modeling procedures.

CLO2: To be familiarize with speech Recognition and Speech Synthesis Methods and its application.

Unit I Basic Concepts **9**

Speech Fundamentals: Articulatory Phonetics, Production and Classification of Speech Sounds; Acoustic Phonetics, Acoustics of speech production; Review of Digital Signal Processing concepts; Short-Time Fourier Transform, Filter-Bank and LPC Methods.

Unit II Speech Analysis **9**

Features, Feature Extraction and Pattern Comparison Techniques: Speech distortion measures, mathematical and perceptual, Log, Spectral Distance, Cepstral Distances, Weighted Cepstral Distances and Filtering, Likelihood Distortions, Spectral Distortion using a Warped Frequency Scale, LPC, PLP and MFCC Coefficients, Time Alignment and Normalization, Dynamic Time Warping, Multiple Time, Alignment Paths.

Unit III Speech Modeling **9**

Hidden Markov Models: Markov Processes, HMMs, Evaluation, Optimal State Sequence, Viterbi Search, Baum-Welch Parameter Re-estimation, Implementation issues.

Unit IV Speech Recognition **9**

Large Vocabulary Continuous Speech Recognition: Architecture of a large vocabulary continuous speech recognition system, acoustics and language models, n-grams, context dependent sub-word units; Applications and present status.

Unit V Speech Synthesis **9**

Text-to-Speech Synthesis: Concatenative and waveform synthesis methods, sub-word units for TTS, intelligibility and naturalness, role of prosody, Applications and present status.

Total Hours: 45

Reference Books:

1. ***Lawrence Rabiner and Biing-Hwang Juang, "Fundamentals of Speech Recognition"***, Pearson Education, 2003.
2. ***Daniel Jurafsky and James H Martin, "Speech and Language Processing, An Introduction to Natural Language Processing",*** Computational Linguistics, and Speech Recognition‖, Pearson Education, 2019.

3. ***Thomas F Quatieri, "Discrete-Time Speech Signal Processing, Principles and Practice"***, Pearson Education, 2004.
4. ***Claudio Becchetti and Lucio Prina Ricotti, "Speech Recognition"***, John Wiley and Sons, 2008.
5. ***Ben Gold and Nelson Morgan, "Speech and audio signal processing, Processing and Perception of Speech and Music"***, Wiley- India Edition, 2006 Edition.

Course Outcomes:

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

CO1: Describe the concept of speech production mechanism and speech signal processing.

CO2: Design algorithms for extracting parameters from the speech signal and implement speech modeling techniques.

CO3: Discuss simple pattern recognition applications of speech processing and reproduce the concepts of speech synthesis and its applications.

CO, PO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H											
CO2	H	M			M				M	M		
CO3	H								M	M		

Embedded Systems

PE II –Semester VI **Hours of Instruction/week: 3T**

21BEBE24 **No. of credits: 3**

Objectives:

CLO1: To understand the concepts of embedded system design and analysis.

CLO2: To learn and analyze the various embedded development strategies.

Unit I Introduction to Embedded Systems **9**

Introduction to Embedded Systems – The build process for embedded systems- Structural units in Embedded processor, selection of processor & memory devices- DMA – Memory management methods- Timer and Counting devices, Watchdog Timer, Real Time Clock, In circuit emulator, Target Hardware Debugging.

Unit II Embedded Networking **9**

Embedded Networking: Introduction, I/O Device Ports & Buses– Serial Bus communication protocols - RS232 standard – RS422 – RS485 - CAN Bus -Serial Peripheral Interface (SPI) – Inter Integrated Circuits (I^2C) –need for device drivers.

Unit III Embedded Firmware Development Environment **9**

Embedded Product Development Life Cycle- objectives, different phases of EDLC, Modelling of EDLC; issues in Hardware-software Co-design, Data Flow Graph, state machine model, Sequential Program Model, concurrent Model, object-oriented Model.

Unit IV RTOS Based Embedded System Design **9**

Introduction to basic concepts of RTOS- Task, process & threads, interrupt routines in RTOS, Multiprocessing and Multitasking, Preemptive and non-preemptive scheduling, Task communication- shared memory, message passing-, Inter process Communication – synchronization between processes-semaphores, Mailbox, pipes, priority inversion, priority inheritance, comparison of Real time Operating systems: Vx Works, µC/OS-II, RT Linux.

Unit V Case Studies of Embedded Systems **9**

Case study of embedded system like Automatic Chocolate Vending Machine, Mobile Phone, Digital camera, washing machine, smart card, ECG recorder.

Total periods: 45

Reference books:

1. ***Rajkamal, "Embedded System- Architecture, Programming, Design"***, McGraw-Hill, 2013.
2. ***Peckol, "Embedded system Design",*** John Wiley & Sons, 2010.
3. ***Lyla B Das, "Embedded Systems-An Integrated Approach",*** Pearson, 2013.
4. ***Shibu. K.V, "Introduction to Embedded Systems",*** Tata McGraw Hill, 2012.
5. ***Elicia White," Making Embedded Systems",*** O' Reilly Series, SPD, 2011.

Course Outcomes:

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

CO1: Discuss the basic concepts of embedded system, networking, firmware development environment and RTOS.

CO2: Explain the embedded processor, communication protocols and product development.

CO3: Elaborate on RTOS based embedded system design and perform case studies on embedded systems.

CO, PO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H										
CO2	H	H										
CO3	H	H	M		M				M	M		M

Medical Data Analytics

PE II –Semester VI **Hours of Instruction/week: 3T**

21BEBE25 **No. of credits: 3**

Objectives:

CLO1: To learn about data analytics and different statistical tools related to medical data applications.

CLO2: To understand and apply the algorithms in health care applications.

Unit I Introduction to Healthcare Data **9**

Typical problems of data analysis, descriptive statistics, predictive modeling, health surveys - measure of disease risk and association, standardization of data - Introduction to spreadsheet - importing, coding and manipulating data, writing formulas and linking tables, pivot tables, what-if analysis and data displays.

Unit II Introduction to Statistical Learning **9**

Probability - Bayes Rule - types of distributions - estimation of unknown function, prediction accuracy and model interpretability, supervised versus unsupervised learning, regression versus classification, modeling data, principles of guesstimation.

Unit III Algorithms for Regression **9**

Linear regression, ridge regression, the lasso, logistic regression, linear discriminant analysis- case studies.

Unit IV Algorithms for Classification **9**

K-nearest neighbors - splines - generalized additive models, tree-based methods - support vector machines, Random forests, case studies.

Unit V Computational Tools **9**

Introduction to R Package: Basic commands, Graphics, indexing data, loading data, time series analysis, graphical multivariate analysis - analytics in clinical trials- predicting the medical devices life cycle- predicting deterioration of patient's condition using EMR.

Total Hours: 45

Reference Books:

1. ***Gareth James, Daniela Witten, Trevor Hastie and Robert Tibshirani, "An Introduction to Statistical Learning"***, Springer, 2014.
2. ***Trevor Strome, "Healthcare Analytics for Quality and Performance Improvement"***, Hoboken: John Wiley & Sons Inc.,2013.
3. ***Victor A. Bloomfield, "Using R for Numerical Analysis in Science and Engineering"***, Chapman & Hall, CRC,2014.
4. ***Sarah Stowell, "Instant R: An Introduction to R for Statistical Analysis"***, Jotunheim Publishing, 2012.

5. ***Philipp K. Janet, "Data Analysis with Open Source Tools A hands-on guide for programmers and data scientists"***, O'Reilly Media, 2010.

Course Outcomes:

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

CO1: Outline the basics of health care data, statistical methods, computational tools, data modelling, supervised and unsupervised learning.

CO2: Apply and compare the regression and classification algorithms.

CO3: Use various data computational tools in health care.

CO, PO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	M			M				M	M		L
CO2	H	M			M				M	M		L
CO3	H					M						

Body Area Networks

PE II –Semester VI **Hours of Instruction/week: 3T**

21BEBE26 **No. of credits: 3**

Objectives:

CLO1: To acquire knowledge about Body Area Networks (BAN) and different hardware related to it.

CLO2: To understand and learn about Wireless communication and Network and applications of BAN.

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, BSN Architecture.

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 arrhythmias monitoring, Multi patient monitoring systems, Multichannel Neural recording, Gait analysis, Sports Medicine, Electronic pill.

Total Hours: 45

Reference Books:

1. ***Annalisa Bonfiglio, Danilo De Rossi, "Wearable Monitoring Systems***", Springer, 2014.
2. ***Sandeep K.S. Gupta, Tridib Mukherjee, Krishna Kumar Venkatasubramanian, "Body Area Networks Safety, Security, and Sustainability***," Cambridge University Press, 2013.

3. ***Zhang, Yuan-Ting, "Wearable Medical Sensors and Systems***", Springer, 2013.
4. ***Guang -Zhong Yang (Ed.), "Body Sensor Networks"***, Springer, 2006.
5. ***Mehmet R. Yuce, Jamil Y. Khan, "Wireless Body Area Networks Technology, Implementation, and applications",*** Pan Stanford Publishing Pte. Ltd, Singapore, 2012.

Course Outcomes:

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

CO1: Outline fundamental concepts of body area networks and discuss the hardware for BAN.

CO2: State the efficiency of communication and the security parameters.

CO3: Explain BAN for appropriate application in medicine and describe issues with BAN.

CO, PO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H								M	M		
CO2	H								M	M		
CO3	H	M							M	M		M

Telehealth Technology

PE II –Semester VI **Hours of Instruction/week: 3T**

21BEBE27 **No. of credits: 3**

Objectives:

CLO1: To Learn the key principles for telemedicine and health and understand telemedical technology

CLO2: To know telemedical standards, mobile telemedicine and it applications

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 Type of Information & 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**

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

Total Hours: 45

Reference Books:

1. ***Khandpur R S, "TELEMEDICINE– Technology and Applications"***, PHI Learning Pvt Ltd.,2017.
2. ***Norris A C***, "***Essentials of Telemedicine and Telecare"***, John Wiley, New York, 2002.
3. ***H K Huang, "PACS and Imaging Informatics: Basic Principles and Applications"*** Wiley, New Jersey, 2010.

Course Outcomes:

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

- **CO1:** Discuss the fundamentals of telemedicine, information and communication infrastructure.
- **CO2:** Summarize the ethical, legal aspects and PACS.
- **CO3:** Categorize the telemedical applications.

CO, PO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	M								L		H
CO2	H	M	M					M	H	M		
CO3	H		M			H			H			

Biometric Systems

PE II –Semester VI **Hours of Instruction/week: 3T**

21BEBE28 **No. of credits: 3**

Objectives:

CLO1: To understand the technologies and general principles of biometric systems.

CLO2: To gain knowledge about personal privacy and security implications of biometrics-based identification technology.

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 Fingerprint Technology **9**

History of finger print pattern recognition-General description of finger prints-finger print sensors, finger print enhancement, Feature Extraction- Ridge orientation, ridge frequency, finger print matching techniques- correlation based, Minutiae based, Ridge feature based, finger print classification, Applications of finger prints, 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, examples of multimodal biometric systems, Securing and trusting a biometric transaction, matching location, local host - authentication server, match on card (MOC).

Total Hours: 45

Reference Books:

1. ***S.Y. Kung, S.H. Lin, M.W., "Biometric Authentication: A Machine Learning Approach John Chirillo, Scott Blaul, "Implementing Biometric Security"*,** John Wiley, 2004.
2. ***Arun A. Ross, Karthik Nandakumar, A.K.Jain, "Hand book of Multibiometrics"***, Springer, New Delhi, 2006.
3. ***James Wayman& Anil Jain, "Biometric Systems- Technology Design and Performance Evaluation"***, Springer Verlag London Ltd, 2005, USA.
4. ***Paul Reid, "Biometrics for Network Security"***, Pearson Education, 2004.
5. ***Nalini K Ratha, Ruud Bolle, "Automatic fingerprint recognition system"***, Springer 2003.

Course Outcomes

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

CO1: Demonstrate the principles of biometric systems.

CO2: Develop fingerprint recognition technique.

CO3: Design face recognition, hand geometry and iris recognition systems.

CO4: Develop speech recognition and multimodal biometric systems.

CO, PO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H											
CO2		M		M					M			
CO3	H				M	M				M		
CO4			M			M	H					M

VLSI Design

PE II –Semester VI **Hours of Instruction/week: 3T**
21BEBE29 **No. of credits: 3**

Objectives:

CLO1: To understand the fundamentals of CMOS circuits, design and its characteristics.

CLO2: To analyze digital operations and testability of VLSI circuits.

Unit I MOS Transistor Theory **9**

The VLSI design process - Architectural design, Logical design, physical design, Layout styles, full custom, semicustom approaches. Basic electrical properties of MOS and CMOS circuits: Ids versus Vds relationships, Transconductance, pass transistor, nMOS inverter, Determination of pull up to pull down ratio for an nMOS inverter, CMOS inverter, MOS transistor circuit model.

Unit II VLSI Fabrication Technology and Design **9**

CMOS fabrication and Layout, CMOS technologies, P -Well process, N -Well process, Twin -tub process, MOS layers stick diagrams and Layout diagram, Layout design rules, Latch up in CMOS circuits, CMOS process enhancements, Technology – related CAD issues, Fabrication and packaging.

Unit III Subsystem Design **9**

Switch logic, pass transistor and transmission gates, Gate logic, inverter, Two input NAND gate, NOR gate, other forms of CMOS logic, Dynamic CMOS logic, Clocked CMOS logic, CMOS domino logic, simple combinational logic design examples, Parity generator, Multiplexers. Two phase clocking, Charge storage.

Unit IV Device Architectures **9**

CPLD – Max 4000, Max 7000, FPGA - Xilinx 4000, ACTEL ACT 01, 02 and 03. Comparison of CPLDs and FPGAs.

Unit V Introduction to VHDL **9**

Introduction, identifiers, data objects, data types, operators, behavioral modeling, data flow modeling, structural modeling, Examples: encoder, decoder, clock divider, multiplier, adder, multiplexer, parity generator and checker.

Total Hours: 45

Reference books:

1. ***J.Bhasker, "VHDL Primer",*** Pearson Education, New Delhi, Thirdedition,2004.
2. ***E. Eshranghian, D. A. Pucknell and S. Eshraghian***, "**Essentials of VLSI circuits and systems"**, PHI, 2005.
3. ***J.Sebastian Smith, "Application Specific Integrated Circuits",*** Pearson Education, Inc., 2002.

4. ***Neil H.E.Weste', David Harris And Ayan Banerjee,"CMOS VLSI Design, A circuits and systems perspective"***, (3/e), Pearson, 2006.

Course Outcomes:

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

CO1: Explain the basic CMOS circuits and the CMOS process technology.

CO2: Discuss the techniques of chip design using programmable devices.

CO3: Model the digital system using Hardware Description Language.

CO, PO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H										
CO2	H	H										
CO3	H	H	M		M				M	M		

Wearable Systems

PE II –Semester VII **Hours of Instruction/week:3T**

21BEBE30 **No. of credits:3**

Objectives:

CLO1: To learn about sensors and signal processing

CLO2: To acquire knowledge on wearable devices and its application

Unit I Sensors **9**

Need for wearable systems, Sensors for wearable systems-Inertia movement sensors, Respiration activity sensor, Inductive plethysmography, Impedance plethysmography, pneumography, Wearable ground reaction force sensor, GSR, Radiant thermal sensor, Wearable motion sensors, CMOS, Based Biosensors, E-Textiles, Bio compatibility.

Unit II Signal Processing **9**

Wearability issues-physical shape and placement of sensor, Technical challenges-sensor design, signal acquisition, Constraint on sampling frequency for reduced energy consumption, light weight signal processing, Rejection of irrelevant information, Data mining.

Unit III Energy Harvesting For Wearable Devices **9**

Solar cell, Vibration based, Thermal based, Human body as a heat source for power generation, Hybrid thermoelectric photovoltaic energy harvests, Thermopiles.

Unit IV 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 V Applications of Wearable Systems **9**

Medical Diagnostics, Medical Monitoring- Patients with chronic disease, Hospital patients, Elderly patients, Multi parameter monitoring, Neural recording, Gait analysis, Sports Medicine, Smart Fabrics.

Total Hours: 45

Reference Books:

1. ***Annalisa Bonfiglio, Danilo De Rossi, "Wearable Monitoring Systems***", Springer,2014.
2. ***Sandeep K.S. Gupta, Tridib Mukherjee, Krishna Kumar Venkatasubramanian,"Body Area Networks Safety, Security, and Sustainability***" Cambridge University Press,2013.
3. ***Hang,Yuan-Ting, "Wearable medical sensors andsystems***",Springer-2013.
4. ***Mehmet R. Yuce, Jamil Y.Khan, "Wireless Body Area Networks Technology, Implementation and Applications***", Pan Stanford Publishing Pvt. Ltd, Singapore,2012.
5. ***Guang-Zhong Yang (Ed.), "Body Sensor Networks***, "Springer,2006.

Course Outcomes:

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

- **CO1:** Choose appropriate sensors and signal processing techniques for wearable systems.
- **CO2:** Assess the energy requirement for a wearable system and analyse and experiment energy harvesting techniques for wearable systems.
- **CO3:** Appreciate the need for BAN and the challenges involved in the design of BAN.
- **CO4:** Design basic wearable systems for medical applications.

CO, PO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H								M	M		
CO2	H								M	M		
CO3	H	M							M	M		
CO4	H	M							M	M		

Medical Informatics

PE II –Semester VII **Hours of Instruction/week: 3T**

21BEBE31 **No. of credits: 3**

Objectives:

CLO1: To understand the theories and practices adopted in Hospital Information systems in the light of medical standards, medical data formats.

CLO2: To gain knowledge on Health informatics and recent Trends in Medical informatics.

Unit I Medical Informatics **9**

Introduction, Medical Informatics, Bioinformatics, Health Informatics, Structure of Medical Informatics Functional capabilities of Hospital Information System, On-line services and off, line services, History taking by computer, Dialogue with the computer

Unit II Medical Standards **9**

Evolution of Medical Standards, IEEE 11073, HL7, DICOM, IRMA, LOINC, HIPPA, Electronics Patient Records, Healthcare Standard Organizations, JCAHO (Join Commission on Accreditation of Healthcare Organization), JCIA (Joint Commission International Accreditation), Evidence Based Medicine, Bioethics.

Unit III Medical Data Storage and Automation **9**

Plug in Data Acquisition and Control Boards, Data Acquisition using Serial Interface, Medical Data formats, Signal, Image and Video Formats, Medical Databases, Automation in clinical laboratories, Intelligent Laboratory Information System, PACS, Datamining.

Unit IV Health Informatics **9**

Bioinformatics Databases, Bio-information technologies, Semantic web and Bioinformatics, Genome projects, Clinical informatics, Nursing informatics, Public health informatics, Education and Training.

Unit V Recent Trends in Medical Informatics **9**

Medical Expert Systems, Virtual reality applications in medicine, Virtual Environment, Surgical simulation, Radiation therapy and planning, Telemedicine, virtual Hospitals, Smart Medical Homes, Personalized e-health services, Biometrics, GRID and Cloud Computing in Medicine.

Total Hours: 45

Reference Books:

1. ***R.D.Lele, "Computers in medicine progress in medical informatics"***, Tata McGraw Hill Publishing computers Ltd, New Delhi, 2005.
2. ***Mohan Bansal, "Medical informatics"***, Tata McGraw Hill Publishing Computers Ltd, NewDelhi, 2003.
3. ***N.Mathivanan, "PC-Based Instrumentation***", Prentice Hall of India Pvt Ltd, New Delhi, 2007.

4. ***Orpita Bosu and Simminder Kaur Thukral, "Bioinformatics Databases, Tools and Algorithms"***, Oxford University press, New Delhi, 2007.
5. ***Yi, Ping Phoebe Chen, "Bioinformatics Technologies"***, Springer International Edition, NewDelhi,2007.

Course Outcomes:

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

CO1: Recall about health informatics and hospital information system.

CO2: State medical standards and explain about storage of medical data, databases used in health informatics and its functions.

CO3: Describe the recent trends in medical informatics.

CO, PO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H								M	M		
CO2	H								M	M		
CO3	H								M	M		

Internet Technology

PE II –Semester VII **Hours of Instruction/week: 3T**
21BEBE32 **No. of credits: 3**

Objectives:

CLO1: Examine the routing techniques and identify suitable routing procedures while developing real time applications.
CLO2 : Apply the concepts of web programming and core java concepts to design Static and Dynamic Web Pages

Unit I Internet Working With TCP/IP **9**

Review of network technologies - Internet addressing - Address resolution protocols (ARP/ RARP) - Routing IP data grams Reliable stream transport service (TCP) TCP/IP over ATM networks - Internet applications-E-mail – Telnet – FTP – NFS - Internet traffic management.

Unit II World Wide Web **9**

HTTP protocol - Web browsers Netscape - Internet explorer - Web site and web page design - HTM - XHTML – XML – CSS - Dynamic HTML - CGI.

Unit III Javascript Programming **9**

Introduction, Control statements, Functions, Arrays and Objects – Programming

Unit IV Java Programming **9**

Language features, Classes, Object and methods. Sub-classing and dynamic binding, Multithreading, Overview of class library, Object method serialization, Remote method invocation, Java Servelets and Javaserver pages.

Unit V Web Design and Databases **9**

Macromedia Dream Weaver, Web Servers, Databases – SQL, MYSQL, DBI and ADO.NET, Web design

Total Hours: 45

References:

1. ***Deitel (2011). Internet & World Wide Web***, Fourth Edition. Pearson International Education.
2. ***Paul J. Deitel, Harvey M. Deitel (2017). Java How to Program***. Pearson Education.
3. ***Herbert Schildt (2011). Java The Complete Reference.*** Eighth Edition, Tata Mc-graw Hill.
4. ***Achyut S. Godbole, Atul Kahate (2013), Web Technologies: TCP/IP, Web/Java Programming, and Cloud Computing. Third Edition.*** Tata Mc-Graw Hill.
5. ***E. Balagurusamy (2014). Programming with Java - A Premier.*** Third Edition. Tata McGraw Hill.
6. ***Douglas E.Comer (2013). Internetworking with TCP/IP***. Vol 1. Pearson Education.

Course Outcomes:
At the end of the course, students will be able to:

CO1: Identify and examine the characteristics of routing protocols.
CO2: Design web pages using static and dynamic HTML.
CO3: Build dynamic web pages using Client-side programming and explore the concepts of database connectivity and web services.

CO, PO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	M	M	H	H								
CO2	H	H	H	M	M	L					M	M
CO3	H	H	H	M	M	L					M	M

Open Elective

Diagnostic Instrumentation

Hours of Instruction/ week: 3T

21BEBO01 **No. of credits: 3**

Objectives:

CLO1: To acquire knowledge about various physiological measurements used in medical field.

CLO2: To be familiarize with the instruments used for measurement of physiological parameters.

Unit I Cardiovascular Diseases and Their Diagnosis **9**

Introduction on cardio vascular diseases-Phonocardiography, Blood pressure& Heart rate measurements, Blood flow measurements, Doppler, echocardiography, cartography, and other non-invasive techniques like treadmill and holter monitoring.

Unit II G. I. Tract Disorders and Their Diagnosis **9**

Laparoscopy, Cystoscopy, Upper G. I. Endoscopy, Colonoscopy, Sigmoidoscopy, Protoscopy, X RAY, barium meal studies, capsule endoscopy, ultra-sonography, cholecptography.

Unit III Auditory and Nervous Disorder Diagnosis **9**

EEG, SER, EMG, Scanning Techniques, AER, Audiometry.

Unit IV Electrocardiograph **9**

The ECG waveform, Block-diagram, Front panel, Controls, ECG Preamplifier, ECG recorders.

Unit V Instruments for Measurement of Physiological Parameters **9**

Electronic manometer, Electro-sphygmomanometer, Electronic stethoscope, Blood flow meter, Thermometer, Tonometer, Auto- refractro meter, Spiro meter, Audiometer.

Total Hours: 45

Reference Books:

1. ***Khandpur R.S, "Hand Book of Biomedical Instrumentation"***– Tata McGraw Hill publication, New Delhi 3rd edition 2014.
2. ***Webster J.G, "Medical Instrumentation application and design"***, Wiley, 5th edition 2020.
3. ***Joseph J Carr and John M Brown –"Introduction to Biomedical equipment Technology",*** Pearson Education 4th edition New Delhi 2001.
4. ***Leslie Cromwell, Fred Weibell J, Erich Pfeiffer. A, "Biomedical Instrumentation and Measurements"***, Prentice-Hall India, 2nd Edition, 1997.

Course Outcomes:
Upon completion of this course, the students will be able to:

CO1: Understand the physiology of biomedical systems.

CO2: Describe the disorders in physiological systems.

CO3: Discuss the operating principle of the instruments used to diagnose the disorders in cardiac care, G.I Track, auditory and nervous system.

CO, PO MAPPING

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H								M	M		
CO2	H				M				M	M		
CO3	H	M			M				M	M		