DHANALAKSHMI SRINIVASAN ENGINEERING COLLEGE

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

PERAMBALUR - 621212

REGULATIONS – 2020

CHOICE BASED CREDIT SYSTEM

CURRICULA AND SYLLABI

DEPARTMENT OF BIOMEDICAL ENGINEERING

(Applicable to the students admitted from the Academic year 2020 – 2021)

Discussed in 2nd BOS meeting Dated: 28.04.2021 / BME Ratified & Approved in Academic Council on 11.05.2021

DHANALAKSHMI SRINIVASAN ENGINEERING COLLEGE

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PERAMBALUR - 621212.

B.E. BIOMEDICAL ENGINEERING

REGULATIONS – 2020

CHOICE BASED CREDIT SYSTEM

COURSE MATRIX

SEMESTER I										
S. No.	Course Code	Name of the Subject	Category	Credit	L-T-P	Internal Assessment		End semester Examination		Minimum Passing Marks
						Max. Marks	Min. Marks	Max. Marks	Min. Marks	
1	U20HS101	Communicative English	HS	3	3-0-0	20 *	-	80	-	50
2	U20MA101	Engineering Mathematics	BS	4	3-1-0	20 *	-	80	-	50
3	U20PH101	Engineering Physics - I	BS	3	3-0-0	20 *	-	80	-	50
4	U20CY101	Engineering Chemistry	BS	3	3-0-0	20 *	-	80	-	50
5	U20GE101	C - Programming	ES	3	3-0-0	20 *	-	80	-	50
6	U20GE102	Engineering Graphics	ES	4	2-0-4	20 *	-	80	-	50
7	U20BS101	Physics and Chemistry Laboratory	BS	2	0-0-4	20	-	80	-	50
8	U20GE103	C - Programming Laboratory	ES	2	0-0-4	20	-	80	-	50
Total			-	24	-	-	-	-	-	-

HS	BS	ES	PC	PE	OE	EEC	TOTAL
3	12	9	19	-	-	-	24

*** Continuous Assessment (CA)**

SEMESTER II										
S. No.	**Course Code**	**Name of the Subject**	**Category**	**Credit**	**L-T-P**	**Internal Assessment**		**End semester Examination**		**Minimum Passing Marks**
						Max. Marks	**Min. Marks**	**Max. Marks**	**Min. Marks**	
1	U20HS201	Functional English	HS	3	3-0-0	20*	-	80	-	50
2	U20MA201	Advanced Calculus and Ordinary Differential Equation	BS	4	3-1-0	20*	-	80	-	50
3	U20PH201	Engineering Physics - II	BS	3	3-0-0	20*	-	80	-	50
4	U20GE201	Python Programming	ES	3	3-0-0	20*	-	80	-	50
5	U20BT201	Fundamentals of Biochemistry	PC	3	3-0-0	20*	-	80	-	50
6	U20BT202	Engineering Mechanics for Biomedical Engineers	ES	3	3-0-0	20*	-	80	-	50
7	U20GE203	Engineering Practices Laboratory	ES	2	0-0-4	20	-	80	-	50
8	U20BT203	Fundamentals of Biochemistry Laboratory	PC	2	0-0-4	20	-	80	-	50
9	U20GE204	Python Programming Laboratory	ES	2	0-0-4	20	-	80	-	50
Total			-	25	-	-	-	-	-	-

HS	**BS**	**ES**	**PC**	**PE**	**OE**	**EEC**	**TOTAL**
3	**7**	**10**	**5**	**-**	**-**	**-**	**25**

*** Continuous Assessment (CA)**

SEMESTER III										
S. No.	Course Code	Name of the Subject	Category	Credit	L-T-P	Internal Assessment		End semester Examination		Minimum Passing Marks
						Max. Marks	Min. Marks	Max. Marks	Min. Marks	
1	U20MA301	Transforms and Partial Differential Equations	BS	4	4-0-0	20*	-	80	-	50
2	U20BM301	Sensors and Transducers	PC	3	3-0-0	20*	-	80	-	50
3	U20BM302	Pathology and Microbiology	PC	3	3-0-0	20*	-	80	-	50
4	U20BM303	Signals and Systems	PC	4	4-0-0	20*	-	80	-	50
5	U20BM304	Anatomy and Human Physiology	PC	3	3-0-0	20*	-	80	-	50
6	U20BM305	Electronic Devices and Circuits	ES	3	3-0-0	20*	-	80	-	50
7	U20BM306	Pathology and Microbiology Laboratory	PC	2	0-0-4	20	-	80	-	50
8	U20BM307	Devices and Circuits Laboratory	ES	2	0-0-4	20	-	80	-	50
Total			-	24	-	-	-	-	-	-

HS	BS	ES	PC	PE	OE	EEC	TOTAL
-	4	5	15	-	-	-	24

*** Continuous Assessment (CA)**

SEMESTER IV										
S. No.	Course Code	Name of the Subject	Category	Credit	L-T-P	Internal Assessment		End semester Examination		Minimum Passing Marks
						Max. Marks	Min. Marks	Max. Marks	Min. Marks	
1	U20MA404	Probability and Statistics	BS	4	4-0-0	20*	-	80	-	50
2	U20BM401	Microprocessors and Microcontrollers	PC	3	3-0-0	20*	-	80	-	50
3	U20BM402	Digital and Integrated Circuits	PC	3	3-0-0	20*	-	80	-	50
4	U20BM403	Medical Physics	PC	3	3-0-0	20*	-	80	-	50
5	U20BM404	Bio Electric Physiology and Chemical Analysis	PC	3	3-0-0	20*	-	80	-	50
6	U20HS202	Environmental Science and Engineering	HS	3	3-0-0	20*	-	80	-	50
7	U20BM405	Microprocessors and Microcontrollers Laboratory	PC	2	0-0-4	20	-	80	-	50
8	U20BM406	Digital and Integrated Circuits Laboratory	PC	2	0-0-4	20	-	80	-	50
Total			-	23	-	-	-	-	-	-

HS	BS	ES	PC	PE	OE	EEC	TOTAL
3	**4**	**-**	**16**	**-**	**-**	**-**	**23**

*** Continuous Assessment (CA)**

SEMESTER V										
S. No.	Course Code	Name of the Subject	Category	Credit	L-T-P	Internal Assessment		End semester Examination		Minimum Passing Marks
						Max. Marks	Min. Marks	Max. Marks	Min. Marks	
1	U20BM501	Bio Signal Processing	PC	4	4-0-0	20*	-	80	-	50
2	U20BM502	Biomechanics	PC	3	3-0-0	20*	-	80	-	50
3	U20BM503	Biomedical Instrumentation	PC	3	3-0-0	20*	-	80	-	50
4	U20BM504	Clinical Management	PC	3	3-0-0	20*	-	80	-	50
5		Professional Elective-I	PE	3	3-0-0	20*	-	80	-	50
6		Open Elective-I	OE	3	3-0-0	20*	-	80	-	50
7	U20BM505	Professional Communication Laboratory	EEC	1	0-0-2	20	-	80	-	50
8	U20BM506	Biomedical Instrumentation Laboratory	PC	2	0-0-4	20	-	80	-	50
9	U20BM507	Bio Signal Processing Laboratory	PC	2	0-0-4	20	-	80	-	50
Total			-	24	-	-	-	-	-	-

S.No.	Professional Elective-I		Open Elective-I	
1	U20BM507	Physiological Modeling	U20OBM51	Biomedical Instrumentation
2	U20BM508	Biometric Systems	U20OBM52	Day-to-Day Biology
3	U20BM509	Bio MEMS	U20OBM53	Biometric Systems
4	U20BM510	Biomaterials	U20OBM54	Bioinformatics
5	U20BM511	Biophotonics and Laser in Medicine	U20OBM55	Introduction of Cell Biology

HS	BS	ES	PC	PE	OE	EEC	TOTAL
-	-	-	17	3	3	1	24

*** Continuous Assessment (CA)**

SEMESTER VI										
S. No.	Course Code	Name of the Subject	Category	Credit	L-T-P	Internal Assessment		End semester Examination		Minimum Passing Marks
						Max. Marks	Min. Marks	Max. Marks	Min. Marks	
1	U20BM601	Biocontrol Systems	PC	4	4-0-0	20*	-	80	-	50
2	U20BM602	Advanced Biomedical Instrumentation	PC	3	3-0-0	20*	-	80	-	50
3	U20BM603	Medical Imaging Techniques	PC	3	3-0-0	20*	-	80	-	50
4	U20BM604	Medical Image Processing	PC	3	3-0-0	20*	-	80	-	50
5		Professional Elective-II	PE	3	3-0-0	20*	-	80	-	50
6	U20BM605	Medical Image Processing Laboratory	PC	2	0-0-4	20	-	80	-	50
7	U20BM606	Advanced Biomedical Instrumentation Laboratory	PC	2	0-0-4	20	-	80	-	50
Total			-	20	-	-	-	-	-	-

S.No.	Professional Elective-II	
1	U20BM607	Development of Medical Devices
2	U20BM608	Rehabilitation Engineering
3	U20BM609	Nanotechnology in Medicine
4	U20BM610	Embedded Systems in Medical Devices
5	U20BM611	Machines in Emerging Biomedical Engineering

HS	BS	ES	PC	PE	OE	EEC	TOTAL
-	-	-	17	3	-	-	20

*** Continuous Assessment (CA)**

SEMESTER VII										
S. No.	Course Code	Name of the Subject	Category	Credit	L-T-P	Internal Assessment		End semester Examination		Minimum Passing Marks
						Max. Marks	Min. Marks	Max. Marks	Min. Marks	
1	U20BM701	Tele Health Technology	PC	3	3-0-0	20*	-	80	-	50
2	U20BM702	Artificial Intelligence in Healthcare	PC	3	3-0-0	20*	-	80	-	50
3	U20BM703	Medical Equipment Maintenance And Troubleshooting	PC	3	3-0-0	20*	-	80	-	50
4		Professional Elective-III	PE	3	3-0-0	20*	-	80	-	50
5		Open Elective-II	OE	3	3-0-0	20*	-	80	-	50
6	U20BM704	Hospital Training	EEC	2	0-0-4	20	-	80	-	50
7	U20BM705	Mini project	EEC	1	0-0-2	20	-	80	-	50
Total			-	18	-	-	-	-	-	-

S.No.	Professional Elective-III		Open Elective-II	
1	U20BM706	Brain Computer Interface and its Applications	U20OBM71	Tele Health Technology
2	U20BM707	Nuclear Imaging	U20OBM72	Virtual Instrumentation
3	U20BM708	Continuum Models in Biomedical Engineering	U20OBM73	Tissue Engineering
4	U20BM709	Neurophysiology and Neural Engineering	U20OBM74	Laser in Medicine
5	U20BM710	Medical Ethics and Standards	U20OBM75	Hospital Management

HS	BS	ES	PC	PE	OE	EEC	TOTAL
-	-	-	9	3	3	3	18

*** Continuous Assessment (CA)**

SEMESTER VIII										
S. No.	**Course Code**	**Name of the Subject**	**Category**	**Credit**	**L-T-P**	**Internal Assessment**		**End semester Examination**		**Minimum Passing Marks**
						Max. Marks	**Min. Marks**	**Max. Marks**	**Min. Marks**	
1	U20BM801	Human Assist Device and Implants	PC	3	3-0-0	20*	-	80	-	50
2		Professional Elective-IV	PE	3	3-0-0	20*	-	80	-	50
3	U20BM802	Project Work	EEC	6	0-0-12	20	-	80	-	50
Total			-	12	-	-	-	-	-	-

S.No.	**Professional Elective-IV**	
1	U20BM803	Artificial Organs and Implants
2	U20BM804	Medical Informatics
3	U20BM805	Home Medicare Technology
4	U20BM806	Body Area Networks and Mobile Healthcare
5	U20BM807	Regenerative Biology

HS	**BS**	**ES**	**PC**	**PE**	**OE**	**EEC**	**TOTAL**
-	**-**	**-**	**3**	**3**	**-**	**6**	**12**

*** Continuous Assessment (CA)**

TOTAL NUMBER OF CREDITS TO BE EARNED FOR AWARD OF THE DEGREE = 170

TOTAL COURSES & CREDITS-SEMESTER WISE

Semester	I	II	III	IV	V	VI	VII	VIII	TOTAL
No of Courses	8	9	8	8	8	7	7	3	58
Credits	24	25	24	23	24	20	18	12	170

SUMMARY

B.E. BIOMEDICAL ENGINEERING											
S. No.	Subject Area	Credits per Semester								Credit Total	Percentage %
		I	II	III	IV	V	VI	VII	VIII		
1	Humanities Sciences and Social Sciences	3	3	-	3	-	-	-	-	9	5.29
2	Basic Sciences	12	7	4	4	-	-	-	-	27	15.88
3	Engineering Sciences	9	10	5	-	-	-	-	-	24	14.12
4	Professional Core	-	5	15	16	17	17	9	3	82	48.24
5	Professional Electives	-	-	-	-	3	3	3	3	12	7.06
6	Open Electives	-	-	-	-	3	-	3	-	6	3.53
7	Employability Enhancement Courses	-	-	-	-	1	-	3	6	10	5.88
Total		24	25	24	23	24	20	18	12	170	100

SEMESTER I

U20HS101	**COMMUNICATIVE ENGLISH (COMMON TO ALL BRANCHES)**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Pre-requisite: Acquiring Basic grammar knowledge.

COURSE OBJECTIVES:

- To enable the engineering students to develop their basic communication skills in English for academic and social purposes.
- To equip the students with appropriate oral and written communication skills.
- To inculcate the skills of listening, reading and critical thinking.
- To integrate English Language learning with employability skills and training.
- To enhance the students' proficiency in reading skills enabling them meet the academic demands of their course.

UNIT I GENERAL INTRODUCTION **9**

Listening - Listening to conversations, Welcome Speeches, Lectures and description of equipment. Speaking - introducing one self - family and friends. Reading - Practice in skimming - scanning and predicting - Writing - completing sentences. Grammar - WH - Questions - asking and answering - Yes or No questions and Question Tag - Parts of Speech. Prefixes - Suffixes - Tense- Present, Past and Future Tense. Word formation.

UNIT II TECHNIQUES OF READING AND WRITING **9**

Reading - Purpose of reading-comprehension - re - reading- post reading - comprehension questions (multiple choice questions or short questions/open-ended questions). Writing - Free writing on any given topic (My favourite place / Hobbies / School life, etc.) - Autobiographical writing (writing about one's leisure time activities, hometown, etc.) - Listening - Situational Conversation, Telephonic Conversation. Speaking - Sharing information of a personal kind - greeting - Taking leave - Grammar - Adjectives, Prepositions, Conjunctions, Articles, Punctuations - Error correction, editing mistakes in grammar, vocabulary, spelling.

UNIT III GRAMMAR AND SKILL DEVELOPMENT **9**

Reading - Reading general contexts and interpreting graphical representations. Writing - understanding text structure - Use of reference words and discourse markers - Coherence - Jumbled Sentences Listening - listening to longer texts and filling up the table - Product description - narratives from different sources. Speaking - asking about routine actions and expressing opinions. Grammar-Past Tense - Kinds of noun, verb and adverb, Impersonal Passive voice.

UNIT IV READING AND LANGUAGE DEVELOPMENT **9**

Reading - Short reading passages for sentence matching exercises, Picking out specific information in a short text. Writing - Letter writing, informal or personal letters - e-mails - conventions of personal e-mail - Listening-listening to dialogues or conversations and completing exercises based on them. Speaking - Group Discussion - Grammar - Future tense, Synonyms - Antonyms - Phrasal verbs.

UNIT V WRITING SKILLS **9**

Reading - Intensive reading - Writing - Writing short essays - Dialogue Writing - Listening - listening to

talks - conversations - Speaking - Presenting welcome speech and vote of thank - Grammar - Modal verbs - Collocations - Single word substitutes.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Learners are able to

1. Speak clearly, effortlessly, confidently and appropriately.
2. Write coherently with acceptable accuracy, organizing ideas logically.
3. Listen and comprehend different discourses and genres of texts.
4. Read and comprehend different discourses and genres of texts.
5. Read and infer, analyze, predict, interpret and draw conclusions any printed text.

TEXT BOOKS:

1. Board of Editors Using English "A Course book for Undergraduate Engineers and Technologists". Orient Black Swan Limited, Hyderabad, 2015.
2. Richards, C. Jack. "Interchange Students'Book-2", New Delhi: CUP, 2015.

REFERENCES:

1. Bailey, Stephen. "Academic Writing: A practical guide for students". New York: Rutledge, 2011.
2. Raymond Murphy, Murphy's "English Grammar", Cambridge University Press 2004.
3. Meenakshi Raman, Sangeeta Sharma, "Technical Communication: English Skills for Engineers", Oxford University Press, 2009.
4. Dr.S.Sumant, "Technical English-I" Tata McGraw-Hill, New Delhi, 2001.
5. Essential English - E.Suresh Kumar, P. Sreehari, J. Savithri - Orient Blackswan 2011.

U20MA101	ENGINEERING MATHEMATICS (COMMON TO ALL BRANCHES)	L	T	P	C
		3	1	0	4

Prerequisite: Basic ideas of Matrices, Differentiation and Integration.

COURSE OBJECTIVES:

- To handle practical problems arising in the field of engineering.
- To achieve conceptual understanding and to retain the best traditions of traditional calculus.
- To provide the basic tools of calculus mainly for the purpose of modeling the engineering problems mathematically and obtaining solutions.
- To deal with topics such as single variable and multivariable Calculus.
- To play an important role in the understanding of science, engineering, economics and computer science, among other disciplines.

UNIT I EVALUATION AND APPLICATION OF MATRICES 12

Definition - Basic concepts of Matrices - Eigen values and Eigen vectors of a real matrix -Characteristic equation -Properties of Eigen values and Eigen vectors - Cayley - Hamilton theorem - Diagonalization of

matrices - Reduction of a quadratic form to canonical form by Orthogonal transformation - Nature of quadratic forms.

UNIT II DIFFERENTIAL CALCULUS 12

Limit of a function - Continuity - Derivatives - Differentiation Rules - Mean Value Theorem - Interval of increasing and decreasing functions - Maxima and Minima - Interval of concavity and convexity.

UNIT III MULTIVARIABLE CALCULUS 12

Limits and Continuity - Partial derivatives - Total derivative - Differentiation of implicit functions - Jacobian and properties -Taylor's series for functions of two variables -Maxima, Minima and saddle points - Method of Lagrange multipliers.

UNIT IV INTEGRAL CALCULUS 12

Definite Integrals and its properties - Fundamental theorem of Calculus - Techniques of integration for Indefinite Integrals using basic integration formulas -Integration by parts -Trigonometric Substitutions - Integration of Rational functions by Partial Fractions.

UNIT V MULTIPLE INTEGRAL AND THEIR APPLICATIONS 12

Double integrals - Change the order of integration - Polar Coordinates - Area - Change of variables - Triple integrals - Volume - Applications - Areas and Volumes.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

Learners are able to

1. Express large amounts of data and functions in an organized and concise form apart from diagonalizing matrices.
2. Solve maxima and minima problems using differentiation.
3. Apply functions of several variables to solve problems in engineering and technology.
4. Evaluate integrals by using Fundamental Theorem of Calculus.
5. Apply integration to compute multiple integrals, area, volume, integrals in polar coordinates, in addition to change the order and change of variables.

TEXT BOOKS:

1. Grewal B.S.,"Higher Engineering Mathematics", Khanna Publishers, New Delhi, 43rd Ed., 2014.
2. Veerarajan T, "Engineering Mathematics", Tata McGraw-Hill, New Delhi, 2011.

REFERENCES:

1. Bali N. P. and Manish Goyal, "Engineering Mathematics" (For Semester I) Third Edition, University Science Press, 2017.
2. Erwin Kreyszig, "Advanced Engineering Mathematics", 10th Edition, John Wiley & Sons,2014
3. Fritz John and Richard Courant, "Introduction to Calculus and Analysis" Springer, 1999.
4. James Stewart, "Calculus: Early Transcendental", Cengage Learning, 7th Edition, New Delhi, 2015.
5. Venkatraman M K, "Engineering Mathematics, Volume-I", Second edition, National Publishing Co, Chennai, 2003.

U20PH101	ENGINEERING PHYSICS - I (COMMON TO ALL BRANCHES)	L	T	P	C
		3	0	0	3

Pre-requisite: Adequate knowledge in basic and modern physics.

COURSE OBJECTIVES:

- To import knowledge in basic concepts of physics relevant to engineering applications.
- Capability to understand advanced topics in engineering.
- To acquire the knowledge of recent trends in LASER, Optical Fiber, and Ultrasonic.

UNIT I SOLID STATE PHYSICS 9

Lattice -unit cell -seven crystal systems -Bravai's lattices -lattice planes -Miller indices –derivation for inter-planar spacing in terms of Miller indices-calculation of number of atoms per unit cell , atomic radius, coordination number and packing factor for SC, BCC, FCC and HCP structures. X-ray diffraction: Bragg's law -diffraction methods: powder and Laue methods. Crystal Growth Techniques: melt growth technique (Bridgman and Czochralski techniques).

UNIT II ELASTICITY OF MATTER 9

Introduction- Elasticity - Plasticity–Hooke's law - relationship between three modulii of elasticity (qualitative) -stress –strain diagram -Poisson's ratio - factors affecting elasticity. Beam: Internal Bending moment -Cantilever: theory and experiment-Young's modulus: theory and experiment (uniform and non-uniform bending) -I-shaped girders-advantages and applications -twisting couple of a wire or cylinder -torsion pendulum - determination of moment of inertia of disc and rigidity modulus of cylindrical wire.

UNIT III ULTRASONICS AND ITS APPLICATIONS 9

Introduction-classification of sound- properties of infrasonics, audible and ultrasonics -production: magnetostriction and piezoelectric methods–detection of ultrasonic waves–determination of velocity of sound in liquid (Acoustic grating method). Applications: Engineering and medical field- Non-destructive testing: pulse echo system through transmission and reflection modes. Ultrasonic scanning methods-Sonogram.

UNIT IV MODERN PHYSICS 9

Black body radiation- Basic Laws -Planck's hypothesis and its radiation law: derivation -deduction of Wien's displacement law and Rayleigh Jean's law from Planck's law -Photons and its properties-Compton Effect –derivation –experimental verification. Photo Electric effect and its Laws -Einstein's Equation - Matter waves–de-Broglie hypothesis - de-Broglie wavelength-Schrodinger's time independent and time dependent wave equations -physical significance of the wave function. Application: particle in one dimensional box-normalization - degenerate and non-degenerate states.

UNIT V LASER AND OPTICAL FIBER 9

Laser: properties–population inversion-pumping methods –Einstein's coefficients-derivation. Types: He-Ne and semiconductor lasers (Homo and Hetero junction) –uses of LASER- Hologram -Construction and Reconstruction Process. Optical fiber: Structure-advantages of optical fibre-Principle and propagation of light through optical fiber–expressions for numerical aperture and acceptance angle–fabrication of optical fiber- types of optical fibers-fiber optical communication system -endoscope -Fiber optic sensors (Qualitative Study only).

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Learners are able to

1. Assess the elastic behavior of the materials and bending behavior of beam.
2. Acquire knowledge of NDT and applications of ultrasonics.
3. Know the development of modern physics and its applications.
4. Recognize the uses of laser and fiber optics.
5. Distinguish the different crystal systems, structural determination and synthesis of crystals.

TEXT BOOKS:

1. Marikani, “Engineering Physics”, PHI, New Delhi, 2013.
2. S. Vadivel & A. Pannerselvam, “Engineering Physics”, Jaitech Publications, 2015.

REFERENCES:

1. Selladurai, “Engineering Physics Part-I”, PHI learning private limited, New Delhi, 2010.
2. V.Rajendran, “Engineering Physics”, Tata McGraw-Hill. New Delhi.2011
3. P. K. Palanisamy “Engineering Physics”. Scitech Publications, 2011
4. Raymond A. Serway and John Jewett, Jr. , “Physics for Scientist and Engineer with modern Physics”, Mary Finch Publication, 9th edition,2014.
5. William T. Silfvast ,“Laser Fundamentals”, Second Edition, Cambridge University Press, 2008.

U20CY101	ENGINEERING CHEMISTRY (COMMON TO ALL BRANCHES)	L	T	P	C
		3	0	0	3

Pre-requisite: Basics of Ionisation, adsorption phenomenon kinetics, Light emission components.

COURSE OBJECTIVES:

- To make the students conversant with basics of polymer chemistry.
- To make the student acquire sound knowledge of second law of thermodynamics and second law based derivations of importance in engineering applications in all disciplines.
- To acquaint the student with concepts of important photo physical and photochemical processes and spectroscopy.
- To develop an understanding of the basic concepts of phase rule and its applications to single and two Component systems and appreciate the purpose and significance of alloys.

UNIT I BASICS OF POLYMER 9

Introduction: Classification of Polymers -Natural and Synthetic: Thermoplastic and Thermosetting Functionality -Degree of Polymerization. Types and mechanism of Polymerization: Addition, Condensation and Co-polymerization. Properties of Polymer - Techniques of Polymerization: Bulk, Emulsion, Solution and Suspension. Preparation, Properties and uses of Nylon6.6, and Epoxy resin.

UNIT II SURFACE CHEMISTRY AND CATALYSIS 9

Adsorption: Types of Adsorption -Adsorption of gases on solids -Adsorption of solute from solutions - Adsorption isotherms -Freundlich’s Adsorption Isotherm -Langmuir’s Adsorption Isotherm -Applications of

Adsorption on pollution abatement. Catalysis: Catalyst -Types of Catalysis -Criteria -Auto Catalysis - Catalytic Poisoning and Catalytic Promoters - Acid Base Catalysis -Enzyme Catalysis - Michaelis - Menten equation.

UNIT III CHEMICAL THERMODYNAMICS 9

Terminology of Thermodynamics - Second Law: Entropy - Entropy change for an ideal gas, Reversible and Irreversible Processes; Entropy of Phase Transitions; Clausius inequality. Free Energy and Work function: Helmholtz and Gibbs free energy functions - Criteria of Spontaneity: Gibbs - Helmholtz equation -Clausius - Clapeyron equation: Maxwell Relations - Van't Hoff Isotherm and Isochore.

UNIT IV PHOTO CHEMISTRY AND SPECTROSCOPY 9

Photo Chemistry: Laws of Photo Chemistry - Grotthuss-Draper law, Stark - Einstein Law and Lambert - Beer Law. Quantum Efficiency - Determination - Photo Processes - Internal Conversion, Inter - system crossing, Fluorescence, Phosphorescence, Chemiluminescence and Photo-sensitization. Spectroscopy: Electromagnetic Spectrum- Absorption of Radiation - Electronic, Vibrational and Rotational transitions. UV - visible and IR Spectroscopy.

UNIT V PHASE RULE AND ALLOYS 9

Phase Rule: Introduction, Definition of terms with examples, One Component System - Water System - Reduced Phase Rule - Two Component Systems - Classification - Lead - Silver system, Zinc - Magnesium system. Alloys: Introduction - Definition- Properties of Alloys - Significance of Alloying, Functions and Effect of Alloying elements- Ferrous Alloys- Nichrome and Stainless Steel - Heat Treatment of Steel.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Learners able to

1. Describe the General Structure of Polymers. Identify and Explain differences between Addition and Stepwise Polymerization.
2. Explain how selected Isomers could be used for measurement of Surface Area of Materials or in Rationalization of Catalysis.
3. Derive and discuss the First and Second Laws of Thermodynamics.
4. Making possible to apply this knowledge in different areas, other than Photo Chemistry and Spectroscopy.
5. Illustrate the Phase Transition of One Component and Two Component system and Types of Alloys and their applications in industries.

TEXT BOOKS:

1. Jain P.C. and Monica Jain, "Engineering Chemistry", Dhanpat Rai Publishing Company (P) Ltd., New Delhi, 2010.
2. Kannan P., Ravikrishnan A., "Engineering Chemistry", Sri Krishna Hi- tech Publishing Company Pvt. Ltd. Chennai, 2009.

REFERENCES:

1. Dara S.S, Umare S.S, "Engineering Chemistry", S. Chand & Company Ltd., New Delhi 2010.
2. Sivasankar B., "Engineering Chemistry", Tata McGraw-Hill Publishing Company, Ltd., New Delhi, 2008.

3. Gowariker V. R. , Viswanathan N.V. and Jayadev Sreedhar, “Polymer Science”, New Age International P (Ltd.,), Chennai, 2006.
4. Shashi Chawla, “A Text Book of Engineering Chemistry”, Dhanapat Rai & Co. (P) Ltd, Delhi, 2013.
5. Satya Prakash and Manish Agarwal, “Engineering Chemistry”, Khanna Book Publishing Co.(P) Ltd, Delhi,2018.

U20GE101	C - PROGRAMMING (COMMON TO ALL BRANCHES)	L	T	P	C
		3	0	0	3

Pre-requisite: Basic Computer knowledge to access a computer.

COURSE OBJECTIVES:

- To develop C Programs using basic programming constructs
- To develop C programs using arrays and strings
- To develop applications in C using functions , pointers and structures
- To do input/output and file handling in C.

UNIT I BASICS OF C PROGRAMMING 9

Introduction to programming paradigms - Structure of C program - C programming: Data Types - Storage classes - Constants - Keywords - Operators: Precedence and Associativity - Expressions - Input/ Output statements, Assignment statements - Decision making statements - Switch statement - Looping statements - Pre-processor directives - Compilation process

UNIT II ARRAYS AND STRINGS 9

Introduction to Arrays: Declaration, Initialization - One dimensional array - Example Program: Computing Mean, Median and Mode - Two dimensional arrays.- String operations: length, compare, concatenate, copy - Selection sort, linear and binary search.

UNIT III FUNCTIONS AND POINTERS 9

Introduction to functions: Function prototype, function definition, function call, Built-in functions (string functions, math functions) - Recursion - Example Program: Scientific calculator using built-in functions, Binary Search using recursive functions - Pointers - Pointer operators - Pointer arithmetic - Arrays and pointers - Array of pointers.

UNIT IV STRUCTURES 9

Structure - Nested structures - Pointer and Structures - Array of structures - Example Program using structures and pointers - Union- Example Program using unions and pointers.

UNIT V FILE PROCESSING 9

Files - Types of file processing: Sequential access, Random access - Sequential access file - Example Program: Finding average of numbers stored in sequential access file - Random access file - Example Program: Transaction processing using random access files - Command line arguments.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Learners are able to

1. Develop simple applications in C using basic constructs.
2. Design and implement applications using arrays and strings.
3. Develop and implement applications in C using functions and pointers.
4. Develop applications in C using structures.
5. Design applications using sequential and random access file processing.

TEXT BOOKS:

1. Reema Thareja, ”Programming in C”, Oxford University Press, Second Edition, 2016.
2. Kernighan, B.W and Ritchie, D.M, “The C Programming language”, Second Edition, Pearson Education, 2006.

REFERENCES:

1. Paul Deitel and Harvey Deitel, —”C How to Program”, Seventh edition, Pearson Publication
2. Juneja, B. L and Anita Seth, “Programming in C”, CENGAGE Learning India pvt. Ltd., 2011
3. Pradip Dey, Manas Ghosh, “Fundamentals of Computing and Programming in C”, First Edition, Oxford University Press, 2009.
4. Anita Goel and Ajay Mittal, “Computer Fundamentals and Programming in C”, Dorling Kindersley (India) Pvt. Ltd., Pearson Education in South Asia, 2011.

U20GE102	ENGINEERING GRAPHICS (COMMON TO ALL BRANCHES)	L	T	P	C
		2	0	4	4

Pre-requisite: Basic knowledge in practical geometry construction, imagination and mathematics.

COURSE OBJECTIVES:

- To develop the students in graphic skills for communication concepts, ideas and design of engineering products.
- To expose them to existing national standards related to technical drawings.

UNIT I PLANE CURVES AND ORTHOGRAPHIC PROJECTION 6+12

Importance of graphics in engineering applications - Use of drafting instruments - BIS conventions and specifications - Size, layout and folding of drawing sheets - Lettering and dimension. Basic Geometrical constructions, Curves used in engineering practices: Conics - Construction of ellipse, parabola and hyperbola by eccentricity method - Construction of cycloid - construction of involutes of square and circle - Drawing of tangents and normal to the above curves. Visualization concepts and Free Hand sketching: Visualization principles –Representation of Three Dimensional objects - Layout of views- Freehand sketching of multiple views from pictorial views of objects.

UNIT II PROJECTION OF POINTS, LINES AND PLANE SURFACE 6+12

Orthographic projection- principles-Principal planes-First angle projection-projection of points. Projection of straight lines (only First angle projections) inclined to both the principal planes - Determination of true lengths and true inclinations by rotating line method (polygonal and circular surfaces) inclined to both the planes.

UNIT III PROJECTION OF SOLIDS 6+12

Projection of simple solids like prisms, pyramids, cylinder, cone and truncated solids when the axis is inclined to one of the principal planes by rotating object method.

UNIT IV PROJECTION OF SECTIONED SOLIDS AND DEVELOPMENT OF SURFACES 6+12

Sectioning of above solids in simple vertical position when the cutting plane is inclined to the one of the principal planes and perpendicular to the other - obtaining true shape of section. Development of lateral surfaces of simple solids - Prisms, pyramids cylinders and cones.

UNIT V ISOMETRIC PROJECTION 6+12

Principles of Isometric Projection - Isometric scale –Isometric projections of simple solids and truncated solids - Prisms, Pyramids, Cylinders, Cones- combination of two solid objects in simple vertical positions.

TOTAL: 30+60 = 90 PERIODS

COURSE OUTCOMES:

Learners are able to

1. Familiarize with the fundamentals and standards of Engineering graphics.
2. Perform freehand sketching of basic geometrical constructions and multiple views of objects.
3. Project orthographic projections of lines and plane surfaces.
4. Draw projections and solids and development of surfaces.
5. Visualize and to project isometric and perspective sections of simple solids.

TEXT BOOKS:

1. Natrajan K.V., “A text book of Engineering Graphics”, Dhanalakshmi Publishers, Chennai, 2009.
2. Venugopal K. and Prabhu Raja V., “Engineering Graphics”, New Age International (P) Limited, 2008.

REFERENCES:

1. Bhatt N.D. and Panchal V.M., “Engineering Drawing”, Charotar Publishing House, 50th Edition, 2010.
2. Basant Agarwal and Agarwal C.M., “Engineering Drawing”, Tata McGraw Hill Publishing Company Limited, New Delhi, 2008.
3. Gopalakrishna K.R., “Engineering Drawing” (Vol. I&II combined), Subhas Stores, Bangalore, 2007.
4. N S Parthasarathy and Vela Murali, “Engineering Graphics”, Oxford University, Press, New Delhi, 2015.
5. Shah M.B., and Rana B.C., “Engineering Drawing”, Pearson, 2nd Edition, 2009.

Publication of Bureau of Indian Standards:

1. IS 10711 - 2001: Technical products Documentation - Size and lay out of drawing sheets.
2. IS 9609 (Parts 0 & 1) - 2001: Technical products Documentation - Lettering.
3. IS 10714 (Part 20) - 2001 & SP 46 - 2003: Lines for technical drawings.
4. IS 11669 - 1986 & SP 46 - 2003: Dimensioning of Technical Drawings.
5. IS 15021 (Parts 1 to 4) - 2001: Technical drawings - Projection Methods.

Special points applicable to Engineering Graphics:

1. There will be five questions, each of either or type covering all units of the syllabus.
2. All questions will carry equal marks of 20 each making a total of 100.
3. The answer paper shall consist of drawing sheets of A3 size only. The students will be permitted to use appropriate scale to fit solution within A3 size.
4. The examination will be conducted in appropriate sessions on the same day.

U20BS101	PHYSICS AND CHEMISTRY LABORATORY	L	T	P	C
		0	0	4	2

Pre-requisite: Basic knowledge of Physics and chemistry laboratory apparatus.

PHYSICS LABORATORY

COURSE OBJECTIVE:

- To handle different experiments to test the physics concepts applied in optics, thermal physics, electronics, sound, elasticity and etc.

LIST OF EXPERIMENTS:

1. Find the Young's modulus by non-uniform bending method
2. Verify of band gap energy of a PN junction semiconductor using PN junction kit
3. Determination of wavelength of Laser and particle size using Laser grating method
4. Determination of rigidity modulus of given wire using Torsion pendulum method
5. Determination of thickness of a thin specimen using Air wedge method

LABORATORY REQUIREMENT FOR BATCH OF 30 STUDENTS:

Young's Modulus: Non-Uniform bending

a. Travelling Microscope - 6 Nos.
b. Pin -Scale Knife edge - 6 Nos.

Band gap

a. PN Junction diode setup - 6 Nos.
b. Eliminator - 6 Nos.

Particle Size

a. Laser grating - 6 Nos.
b. Circular disc with particle coated - 6 Nos.
c. Laser Source - 6 Nos.

Torsional Pendulum

a. Torsional Pendulum - 6 Nos.
b. Thin wire - 6 Nos.

c. Cloch - 6 Nos.
d. Screw gauge - 6 Nos.

Air wedge

a. Air wedge - 6 Nos.
b. Travelling Microscope - 6 Nos.
c. Mercury vapour lamp - 6 Nos.

TOTAL :30 PERIODS

COURSE OUTCOMES:

Learners are able to

1. Apply the basic theory for the corresponding experiment.
2. Know the procedure to use physics equipment.

CHEMISTRY LABORATORY

COURSE OBJECTIVES:

- To make the student to acquire practical skills in the determination of water quality
- Parameters through volumetric and instrumental analysis.
- To acquaint the students with the determination of molecular weight of a polymer by viscometery.

LIST OF EXPERIMENTS:

1. Determination of DO content of water sample by Winkler's method.
2. Determination of chloride content of water sample by argentometric method.
3. Determination of strength of given hydrochloric acid using pH meter.
4. Determination of strength of HCL using conductivity meter
5. Determination of molecular weight of polyvinyl alcohol using Ostwald visco meter.

LABORATORY REQUIREMENT FOR BATCH OF 30 STUDENTS:

a. Iodine flask - 30 Nos.
b. PH meter - 5 Nos.
c. Conductivity meter - 5Nos.
d. Spectrophotometer - 5 Nos.
e. Ostwald Viscometer - 10 Nos.
f. Common Apparatus: Pipette, Burette, Conical Flask, Porcelain tile, Dropper

TOTAL :30 PERIODS

COURSE OUTCOMES :

Learners are able to

1. The students will be outfitted with hands-on knowledge in the quantitative chemical analysis of water quality related parameters.
2. Utilize the fundamental laboratory techniques for analyses such as titrations, separation, purification and spectroscopy.

U20GE103	C - PROGRAMMING LABORATORY (COMMON TO ALL BRANCHES)	L	T	P	C
		0	0	4	2

Pre-requisite: Basic computer knowledge to install software.

COURSE OBJECTIVES:

- To develop programs in C using basic constructs.
- To develop applications in C using strings, pointers, functions, structures.
- To develop applications in C using file processing.

LIST OF EXPERIMENTS:

1. Programs using I/O statements and expressions.
2. Programs using decision-making constructs.
3. Write a program to find whether the given year is leap year or Not? (Hint: not every centurion year is a leap. For example 1700, 1800 and 1900 is not a leap year)
4. Design a calculator to perform the operations, namely, addition, subtraction, multiplication, division and square of a number.
5. Check whether a given number is Armstrong number or not?
6. Populate an array with height of persons and find how many persons are above the average height.
7. Populate a two dimensional array with height and weight of persons and compute the Body Mass Index of the individuals.
8. Given a string “a$bcd./fg “find its reverse without changing the position of special characters.(Example input:a@gh%;j and output:j@hg%;a)
9. Convert the given decimal number into binary, octal and hexadecimal numbers using user defined functions.
10. From a given paragraph perform the following using built-in functions:
    a. Find the total number of words.
    b. Capitalize the first word of each sentence.
    c. Replace a given word with another word.
11. Solve towers of Hanoi using recursion.
12. Sort the list of numbers using pass by reference.
13. Generate salary slip of employees using structures and pointers.
14. Compute internal marks of students for five different subjects using structures and functions.
15. Insert, update, delete and append telephone details of an individual or a company into a telephone directory using random access file.

TOTAL: 60 PERIODS

LABORATORY REQUIREMENT FOR BATCH OF 30 STUDENTS:

HARDWARE:

1. Standalone desktops 30 Nos.

SOFTWARE:

1. C / Equivalent Compiler 30 Nos.

COURSE OUTCOMES:

Learners are able to

1. Develop C programs for simple applications making use of basic constructs, arrays and strings.
2. Develop C programs involving functions, recursion, pointers, and structures.
3. Design applications using sequential and random access file processing.

SEMESTER II

		L	T	P	C
U20HS201	**FUNCTIONAL ENGLISH (COMMON TO ALL BRANCHES)**	**3**	**0**	**0**	**3**

Pre-requisite: Basics skills development of Reading and Writing.

COURSE OBJECTIVES:

- To develop the basic reading and writing skills of first year engineering and technology students.
- To help learners develop their listening skills, which will, enable them listen to lectures and comprehend them by asking questions; seeking clarifications.
- To help learners develop their speaking skills and speak fluently in real contexts.
- To help learners develop vocabulary of a general kind by developing their reading skills.

UNIT I VOCABULARY AND GRAMMAR 9

Listening - Listening to talks mostly of a scientific/technical .Speaking - Asking for and giving directions- Reading - reading short technical texts from journals-newspapers- Writing- purpose statements– extended definitions- issue-writing instructions - recommendations- Language Development–subject verb agreement -compound words. Technical vocabulary.

UNIT II TECHNIQUES OF READING AND WRITING 9

Listening: Listening Process; Types of Listening; Intensive vs. Extensive Listening; Barriers to Listening. Speaking - describing a process-Reading - reading longer technical texts- identifying the various transitions in a text- paragraphing- Writing- interpreting charts, graphs- Language Development - vocabulary used informal letters/emails and reports .Homonyms and Homophones-Common Errors. Numerical adjectives.

UNIT III GRAMMAR AND SKILL DEVELOPMENT 9

Listening- Listening to classroom lectures/ talks on engineering/technology -Speaking –introduction to technical presentations- Reading–longer texts both general and technical, practice in speed reading; Writing- checklists- Describing a process, use of sequence words-Language Development -sequence words- Misspelled words.-use of clauses. Verb forms. Direct/Indirect Speech.

UNIT IV INTERVIEW SKILL AND LANGUAGE DEVELOPMENT 9

Listening- Listening to documentaries and making notes. Speaking - mechanics of presentations- Reading- Reading for detailed comprehension-Writing-email etiquette -job application–cover letter- Résumé preparation (via email and hard copy)- analytical essays and issue based essays-- Language Development -finding suitable synonyms-paraphrasing-. -if conditionals.

UNIT V TECHNICAL WRITING **9**

Listening- TED/Ink talks; Speaking–participating in a group discussion - Reading- reading and understanding technical articles Writing- Writing reports- minutes of a meeting- accident and survey- Language Development- Comparative Adjectives

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Learners are able to

1. Use academic and technical vocabulary in relevant contexts. Construct meaningful and grammatically correct sentence.
2. Effectively listen and acquire language and content, read fast and understand texts.
3. Use oral presentation skills in all professional contexts.
4. Demonstrate the understanding of the nature and importance of technical communication Draft various types of technical and business documents like, reports, proposals and business letters.
5. Compose documents like job application, book review etc.

TEXT BOOKS:

1. Board of editors. Fluency Using English" A Course book for Undergraduate Engineering Technologists". Orient Blackswan, Hyderabad, 2015.
2. Sudharshana. N.P and Saveetha.C. "English for Technical Communication". Cambridge University Press: New Delhi, 2016.

REFERENCES:

1. Barrass, Robert. "Scientists Must Write". London: Routledge.2003.
2. Faculty of English. "Technical Communication". SASTRA Publication. 2017.
3. Raman, Meenakshi & Sangeeta Sharma. "Technical Communication: Wren & Martin. High School English Grammar and Composition". (Revised edn.) New Delhi: Chand & Co. 1995.
4. Dr.S.Sumant, "Technical English" Tata McGraw-Hill, New Delhi, 2001.
5. Essential English - E.Suresh Kumar, P. Sreehari, J. Savithri - Orient Blackswan 2011.

		L	T	P	C
U20MA201	**ADVANCED CALCULUS AND ORDINARY DIFFERENTIAL EQUATIONS (COMMON TO ALL BRANCHES)**	**3**	**1**	**0**	**4**

Pre-requisite: Basic concepts of vectors and complex numbers.

COURSE OBJECTIVES:

- To familiarize the prospective engineers with techniques in ordinary differential equations, complex variables and complex integration.
- The Study of Laplace transforms help to solve the differential equations that occur in various branches of engineering disciplines.
- Vector calculus can be widely used for modeling the various laws of physics.
- The various methods of complex analysis can be used for efficiently solving the problems that occur in various branches of engineering disciplines.

UNIT I APPLICATIONS OF ORDINARY DIFFERENTIAL EQUATIONS 12

Basic concepts - Separable differential equations - Exact differential equations - Integrating factors - Linear differential equations - Second order linear differential equations with constant coefficients - Particular Integral using operator method and Method of variation of parameters - Homogenous equation of Euler‘s and Legendre‘s type-Physical Applications-Oscillations of a Spring.

UNIT II LAPLACE TRANSFORMS 12

Existence conditions - Transforms of elementary functions –Transform of unit step function and unit impulse function - Basic properties - Shifting theorems -Transforms of derivatives and integrals - Transform of periodic functions - Inverse transforms: Convolution theorem (Statement only) and Partial Fractions - Application to solution of linear second order ordinary differential equations with constant coefficients-Unit Step Function-Unit impulse function.

UNIT III VECTOR CALCULUS AND APPLICATIONS 12

Gradient and directional derivative - Divergence and curl - Irrotational and Solenoidal vector fields - Line integral - Surface integral - Area of a curved surface - Green’s, Gauss divergence and Stokes’ theorems in evaluating line, surface and volume integrals (Planar, Cylindrical and Spherical Surfaces).

UNIT IV ANALYTIC FUNCTIONS 12

Analytic functions - Necessary and sufficient conditions for analyticity in Cartesian form - Properties - Harmonic conjugates - Construction of analytic function - Conformal mapping - Mapping by function-Bilinear Transformation.

UNIT V CALCULUS OF COMPLEX FUNCTIONS 12

Complex integral - Cauchy’s integral theorem - Cauchy’s integral formula - Taylor’s and Laurent’s series - Singularities - Residues - Residue theorem - Application of residue theorem for evaluation of real integrals - Use of circular contour and semicircular contour (No poles on the real axis).

TOTAL: 60 PERIODS

COURSE OUTCOMES:

Learners are able to

1. Evaluate the effective mathematical tools to obtain the solutions of first and second order differential equations that model physical processes.
2. Express Gradient, divergence and curl of a vector point function and related identities. Evaluation of line, surface and volume integrals using Gauss, Stokes and Green’s theorems and their verification.
3. Apply the tools of differentiation and integration of functions of a complex variable that are used in various techniques dealing engineering problems.
4. Express Analytic functions, conformal mapping and complex integration.
5. Solve Laplace transform and inverse transform of simple functions, properties, various related theorems and application to solve the differential equations with constant coefficients.

TEXT BOOKS:

1. Grewal B.S., “Higher Engineering Mathematics”, Khanna Publishers, New Delhi, 43rd Edition, 2014.
2. Veerarajan T., “Engineering Mathematics for first year”, Tata McGraw-Hill, New Delhi.

REFERENCES:

1. Erwin Kreyszig, “Advanced Engineering Mathematics”, 9th Edition, John Wiley & Sons, 2014.
2. N. P. Bali and Manish Goyal “Engineering Mathematics” (For Semester II) Third Edition, University Science Press.
3. O’Neil, P.V. “Advanced Engineering Mathematics”, Cengage Learning India Pvt., Ltd, New Delhi, 2007.
4. James Stewart, "Calculus: Early Transcendentals", Cengage Learning, 7th Edition, New Delhi, 2015.
5. Venkatraman M K, “Engineering Mathematics”, Volume 1,Second edition, National Publishing Co,Chennai,2003.

U20PH201	ENGINEERING PHYSICS - II (COMMON TO ALL BRANCHES)	L	T	P	C
		3	0	0	3

Pre-requisite: Basic knowledge in material property and its uses.

COURSE OBJECTIVES:

- To understand the basics of electric, thermal, magnetic, super conducting and di electric properties of materials.
- To aware about recent trends in physics.

UNIT I ELECTRON THEORY OF SOLIDS 9

Introduction: types of materials- classical free electron theory: postulates- derivation of electrical conductivity and thermal conductivity- derivation. Wiedemann-Franz law and its verification-merits and demerits of classical free electron theory. Quantum free electron theory: Fermi energy level and its importance -Fermi-Dirac distribution function and its variation with temperature - density of energy states –carrier concentration in metals -average energy of electrons at 0 K.

UNIT II FUNDAMENTALS OF SEMICONDUCTORS 9

Introduction: properties- Types semiconductors- concept of effective mass of an electron and hole. Intrinsic semiconductor: carrier concentration in an intrinsic semiconductor-derivation –variation of Fermi energy level with temperature - Extrinsic semiconductor: carrier concentration derivation (P and N type semiconductor) - Hall effect–theory and experimental determination of Hall coefficient - Applications.

UNIT III DIELECTRICS AND FERRO ELECTRICS 9

Introduction: fundamental definitions in dielectrics–expressions for electronic and ionic polarization mechanisms- orientation polarization - space charge polarization - Langevin - Debye equation - frequency and temperature effects on polarization. Capacitor-energy stored in capacitor- Internal field - Clausius Mossotti relation-dielectric loss –dielectric breakdown - various breakdown mechanisms with characteristics - applications of dielectric materials - Ferro electrics -properties and applications.

UNIT IV MAGNETISM AND SUPER CONDUCTORS 9

Magnetic Materials: Introduction-basic definitions - origin of magnetic moment –Bohr magneton - magnetic materials: classification of dia, para, ferro magnetic materials. Ferro magnetic domains-energies involved in the growth of magnetic domains-hysteresis-explanation of hysteresis curve based on domain theory-soft and hard magnetic materials. Superconducting Materials: properties - types - BCS theory of super conductivity-Applications: cryotron and Mag-lev.

UNIT V NANOMATERIALS 9

Definition of nano system- Quantum confinement - 0D to 3D Quantum confined nanostructures - density of energy states from 3D to 0D- Preparation: top down and bottom up approaches- PLD - PVD - CVD - Electro deposition- Carbon nanotubes-types - SWCNT and MWCNT, Armchair, Zig-zag and Chiral structures-properties-applications

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Learners are able to

1. Select the metals required for specific applications in the area of engineering and technology.
2. Distinguish between different types of semiconductor and determination of Hall co-efficient.
3. Understand the property of dielectric and ferro electric property of materials.
4. Identify different magnetic materials and super conducting materials.
5. Understand the idea used in new technologies.

TEXT BOOKS:

1. V.Rajendran, “Materials Science”, Tata McGraw- Hill, New Delhi, 2011.
2. S. Vadivel, A. Pannerselvam, “Solid State Physics”, Jaitech Publications, 2015 (Revised edition).

REFERENCES:

1. Charles Kittel, “Introduction to Solid State Physics”, John Wiley & sons, 7th edition, Singapore (2007).
2. M. Arumugam, “Materials Science”. Anuradha publishers, 2010.
3. Dr. W. R. Fahrner, "Nanotechnology and Nanoelectronics Materials”, Devices, Measurement Techniques", Springer, 2005
4. J M D. Coey, “Magnetism and Magnetic Materials”, Combridge University Press, 1st edition, 2009.
5. V. Pokropivny, R. Lohmus, I. Hussainova, A. Pokropivny, S. Vlassov. Introduction in nanomaterials and nanotechnology. - University of Tartu. - 2007.

U20GE201	PYTHON PROGRAMMING (COMMON TO ALL BRANCHES)	L	T	P	C
		3	0	0	3

Pre-requisite: Basic Knowledge of concepts like variables, loops and control statement.

COURSE OBJECTIVES:

- To acquire programming skills in core Python.
- To develop Python programs with conditionals and loops.
- To develop the skill of designing Graphical user Interfaces in Python
- To use Python data structures – lists, tuples, dictionaries.
- To do input/output with files in Python.

UNIT I ALGORITHMIC PROBLEM SOLVING 9

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

UNIT II DATA, EXPRESSIONS AND STATEMENTS 9

Python interpreter and interactive mode; values and types: int, float, boolean, string, and list; variables, expressions, statements, tuple assignment, precedence of operators, comments; modules and functions, function definition and use, flow of execution, parameters and arguments; Illustrative programs: exchange the values of two variables, circulate the values of n variables, distance between two points.

UNIT III CONTROL FLOW AND FUNCTIONS 9

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

UNIT IV LISTS, TUPLES AND DICTIONARIES 9

Lists: list operations, list slices, list methods, list loop, mutability, aliasing, cloning lists, list parameters; Tuples: tuple assignment, tuple as return value; Dictionaries: operations and methods; advanced list processing - list comprehension; Illustrative programs: selection sort, insertion sort, merge sort, histogram.

UNIT V FILES, MODULES AND PACKAGES 9

Files and exception: text files, reading and writing files, format operator; command line arguments, errors and exceptions, handling exceptions, modules, packages; Illustrative programs: word count, copy file.

TOTAL: 45 PERIODS

COURSE OUTCOMES :

Learners are able to

1. Develop algorithmic solutions to simple computational problems
2. Decompose a Python program into functions.
3. Implement database and GUI applications
4. Represent compound data using Python lists, tuples, dictionaries.
5. Read and write data from/to files in Python Programs.

TEXT BOOKS:

1. Allen B. Downey,"Think Python: How to Think Like a Computer Scientist‘", 2nd edition, Updated for Python 3, Shroff/O‘Reilly Publishers, 2016 (http://greenteapress.com/wp/think-python/)
2. Guido van Rossum and Fred L. Drake Jr, “An Introduction to Python “, Revised and updated for Python 3.2, Network Theory Ltd., 2011.

REFERENCES:

1. John V Guttag, “Introduction to Computation and Programming Using Python‘”, Revised and expanded Edition, MIT Press , 2013
2. Robert Sedgewick, Kevin Wayne, Robert Dondero, “Introduction to Programming in Python: An Inter-disciplinary Approach”, Pearson India Education Services Pvt. Ltd., 2016.
3. Kenneth A. Lambert, “Fundamentals of Python: First Programs”, CENGAGE Learning, 2012.
4. Charles Dierbach, “Introduction to Computer Science using Python: A Computational Problem-Solving Focus”, Wiley India Edition, 2013.
5. Paul Gries, Jennifer Campbell and Jason Montojo, “Practical Programming: An Introduction to Computer Science using Python 3”, Second edition, Pragmatic Programmers, LLC, 2013.

U20BM201	FUNDAMENTALS OF BIOCHEMISTRY	L	T	P	C
		3	0	0	3

Pre-requisite: Basic Knowledge of concepts in fundamentals of Chemistry and Biology.

COURSE OBJECTIVES:

- To study structural and functional properties of carbohydrates, proteins, lipids and nucleic acids.
- To emphasize the role of these biomolecules by providing basic information on specific metabolic diseases and disorders of these biomolecules.
- To analyse the enzyme catalyst process and metabolism.
- To study the structure of amino acids and nucleic acids.

UNIT I INTRODUCTION TO BIOCHEMISTRY 9

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

UNIT II CARBOHYDRATES 9

.Classification of carbohydrates - mono, di, oligo and polysaccharides. Structure, physical and chemical properties of carbohydrates Isomerism, racemisation and mutarotation. Digestion and absorption of carbohydrates. Metabolic pathways and bioenergetics – Glycolysis, glycogenesis, glycogenolysis and its hormonal regulation. TCA cycle and electron transport chain. Oxidative phosphorylation. Biochemical aspect of Diabetes mellitus and Glycogen storage Disease.

UNIT III LIPIDS 9

Classification of lipids- simple, compound and derived lipids. Nomenclature of fatty acid, physical and chemical properties of fat..Metabolic pathways: synthesis and degradation of fatty acid (beta oxidation), hormonal regulation of fatty acid metabolism, ketogenesis, Biosynthesis of Cholesterol. Disorders of lipid metabolism.

UNIT IV NUCLEIC ACID AND PROTEIN 9

Structure of purines and pyrimidines, nucleoside, nucleotide, DNA act as a genetic material, chargoffs rule. Watson and crick model of DNA. Structure of RNA and its type. Metabolism and Disorder of purines and pyrimidines nucleotide Classification, structure and properties of proteins, structural organization of proteins, classification and properties of amino acids. Separation of protein, Inborn Metabolic error of amino acid metabolism.

UNIT V ENZYME AND ITS CLINICAL APPLICATION 9

Classification of enzymes, apoenzyme, coenzyme, holoenzyme and cofactors. Kinetics of enzymes - Michaelis-Menten equation. Factors affecting enzymatic activity: temperature, pH, substrate concentration and enzyme concentration. Inhibitors of enzyme action: Competitive, non- competitive, irreversible. Enzyme: Mode of action, allosteric and covalent regulation. Clinical enzymology. Measurement of enzyme activity and interpretation of units.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Learners are able to

1. Explain the fundamentals of biochemistry.
2. Clinical application of Biochemistry.
3. Analyse a structural unit of biomolecules.

TEXT BOOKS:

1. Rafi M.D. —Text book of biochemistry for Medical Student, Second Edition, University Press, 2014.
2. David.W.Martin, Peter.A.Mayes , Victor. W.Rodwell, —Harper‘s Review of Biochemistry, LANGE Medical Publications, 1981.

REFERENCES:

1. Keith Wilson & John Walker, —Practical Biochemistry - Principles & Techniques, Oxford University Press, 2009.
2. Pamela.C.Champe & Richard.A.Harvey, —Lippincott Biochemistry Lippincott‘s Illustrated Reviews, Raven publishers,1994.
3. Sucheta P Dandekar- “concise Medical biochemistry” Reed Elsevier India Pvt. Ltd 2011.

U20BM202	ENGINEERING MECHANICS FOR BIOMEDICAL ENGINEERS	L	T	P	C
		3	0	0	3

Pre-requisite: Basic Knowledge of Mathematics and Applied Physics.

COURSE OBJECTIVES:

- To be exposed to the fundamental principles of mechanics.
- To learn effect of force on bodies.
- To learn basics of fluid mechanics and relate it to bio-fluids.
- To understand the action of friction and motion.

UNIT I BASICS AND STATICS OF PARTICLES 9

Introduction – Units and Dimensions – Laws of Mechanics – Lami‘s theorem, Parallelogram and triangular Law of forces —- Vectorial representation of forces – Vector operations of forces - additions, subtraction, dot product, cross product – Coplanar Forces – rectangular components – Equilibrium of a particle – Forces in space – Equilibrium of a particle in space – Principle of transmissibility.

UNIT II EQUILIBRIUM OF RIGID BODIES 9

Free body diagram – Types of supports –Action and reaction forces –stable equilibrium – Moments and Couples – Moment of a force about a point and about an axis – Scalar components of a moment – Varignon‘s theorem – Single equivalent force -Equilibrium of Rigid bodies in two dimensions – Equilibrium of Rigid bodies in three dimensions.

UNIT III MECHANICS OF SOLIDS 9

Rigid bodies and deformable solids – Tension, Compression and Shear Stresses – Deformation of rigid and non rigid bodies - Centroids and centre of mass- Centroids of lines and areas – Principal moments of inertia of plane areas – Principal axes of inertia-Mass moment of inertia – mass moment of inertia for prismatic, cylindrical and spherical solids from first principle.

UNIT IV BASICS OF MECHANICS OF FLUIDS 9

Fluids – density – pressure – blood pressure and gravity – buoyancy – moments of force and stability – movement in water –Newton‘s laws of viscosity – Definitions and simple problems on Newtonian fluid, Non-Newtonian fluid, Euler equations and Viscoelasticity, laminar flow, turbulent flow and Hagenpoiseuille equation.

UNIT V DYNAMICS OF PARTICLES 9

Displacements, Velocity and acceleration, their relationship – Relative motion – Newton‘s laws of motion – Work Energy Equation– Friction force – Laws of sliding friction – equilibrium analysis of simple systems with sliding friction.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Learners are able to

1. Use scalar and vector analytical techniques for analysing forces in statically determinate structures
2. Apply fundamental concepts of kinematics and kinetics of particles to the analysis of simple, practical problems

TEXT BOOKS:

1. Beer, F.P and Johnston Jr. E.R., Vector Mechanics for Engineers (In SI Units): Statics and Dynamics, 8th Edition, Tata McGraw-Hill Publishing company, New Delhi (2004).
2. Dr. R. K. Bansal, A Text Book of Fluid Mechanics, Laxmin Publications (P) Ltd., New Delhi.

REFERENCES:

1. Vela Murali, Engineering Mechanics, Oxford University Press (2010).
2. Frank Bell, Principles of Mechanics and Biomechanics,Stanley Thorne (Publishers) Ltd., 1998.
3. Lee Waite, Biofluid Mechanics in Cardiovascular Systems, The McGraw-Hill Companies, 2006.

U20GE203	ENGINEERING PRACTICES LABORATORY (COMMON TO ALL BRANCHES)	L	T	P	C
		0	0	4	2

Pre-requisite: Basic knowledge of Civil, Mechanical, Electrical and Electronics Engineering Equipments.

COURSE OBJECTIVE:

- To provide exposure to the students with hands on experience on various basic engineering practices in Civil, Mechanical, Electrical and Electronics Engineering.

GROUP A (CIVIL & MECHANICAL)

CIVIL ENGINEERING PRACTICES

Buildings:

a) Study of plumbing and carpentry components of residential and industrial buildings. Safety aspects.

Plumbing Works:

a) Study of pipeline joints, its location and functions: valves, taps, couplings, unions, reducers, elbows in household fittings.
b) Study of pipe connections requirements for pumps and turbines.
c) Preparation of plumbing line sketches for water supply and sewage works.
d) Hands-on-exercise:
e) Basic pipe connections - Mixed pipe material connection - Pipe connections with different joining components.
f) Demonstration of plumbing requirements of high-rise buildings.

Carpentry using Power Tools only:

a) Study of the joints in roofs, doors, windows and furniture.
b) Hands-on-exercise: Wood work, joints by sawing, planing and cutting.

MECHANICAL ENGINEERING PRACTICES

Welding:

a) Preparation of butt joints, lap joints and T- joints by Shielded metal arc welding.
b) Gas welding practice.

Basic Machining:

a) Simple Turning and Taper turning
b) Drilling Practice

Sheet Metal Work:

a) Forming & Bending:
b) Model making - Trays and funnels.
c) Different type of joints.

Machine assembly practice:

a) Study of centrifugal pump.
b) Study of air conditioner.

Demonstration on:

a) Smithy operations, upsetting, swaging, setting down and bending.
   Example –Exercise - Production of hexagonal headed bolt.
b) Foundry operations like mould preparation for gear and step cone pulley.
c) Fitting - Exercises - Preparation of square fitting and V - fitting models.

GROUP B (ELECTRICAL & ELECTRONICS)

ELECTRICAL ENGINEERING PRACTICES

1. Residential house wiring using switches, fuse, indicator, lamp and energy meter.
2. Fluorescent lamp wiring.
3. Stair case wiring
4. Measurement of electrical quantities - voltage, current, power & power factor in RLC circuit.
5. Measurement of energy using single phase energy meter.
6. Measurement of resistance to earth of an electrical equipment.

ELECTRONICS ENGINEERING PRACTICES

1. Study of Electronic components and equipments - Resistor, colour coding measurement of AC signal parameter (peak-peak, rms period, frequency) using CRO.
2. Study of logic gates AND, OR, EX-OR and NOT.
3. Generation of Clock Signal.
4. Soldering practice - Components Devices and Circuits - Using general purpose PCB.
5. Measurement of ripple factor of HWR and FWR.

TOTAL: 60 PERIODS

LIST OF EQUIPMENTS FOR A BATCH OF 30 STUDENTS:

CIVIL

1. Assorted components for plumbing consisting of metallic pipes, plastic pipes, flexible pipes, couplings, unions, elbows, plugs and other fittings. 15 Sets.
2. Carpentry vice (fitted to work bench) 15 Nos.
3. Standard woodworking tools 15 Sets.
4. Models of industrial trusses, door joints, furniture joints 5 each
5. Power Tools:
   (a) Rotary Hammer 2 Nos.
   (b) Demolition Hammer 2 Nos.
   (c) Circular Saw 2 Nos.
   (d) Planer 2 Nos.
   (e) Hand Drilling Machine 2 Nos.
   (f) Jigsaw 2 Nos.

MECHANICAL

1. Arc welding transformer with cables and holders — 5 Nos.
2. Welding booth with exhaust facility — 5 Nos.
3. Welding accessories like welding shield, chipping hammer, wire brush. — 5 Sets.
4. Oxygen and acetylene gas cylinders, blow pipe and other welding outfit. — 2 Nos.
5. Centre lathe — 2 Nos.
6. Hearth furnace, anvil and smithy tools — 2 Sets.
7. Moulding table, foundry tools — 2 Sets.
8. Power Tool: Angle Grinder — 2 Nos.
9. Study-purpose items: centrifugal pump, air-conditioner — One each

ELECTRICAL

1. Assorted electrical components for house wiring — 15 Sets
2. Electrical measuring instruments — 10 Sets
3. Study purpose items: Iron box, fan and regulator, emergency lamp — 1 each
4. Megger (250V/500V) — 1 No.
5. Power Tools: (a) Range Finder — 2 Nos.
   (b) Digital Live-wire detector — 2 Nos.

ELECTRONICS

1. Soldering guns — 10 Nos.
2. Assorted electronic components for making circuits — 50 Nos.
3. Small PCBs — 10 Nos.
4. Multimeters — 10 Nos.
5. Study purpose items: Telephone, FM radio, low-voltage power supply

COURSE OUTCOMES:

Learners are able to

1. Fabricate carpentry components and pipe connections including plumbing works.
2. Use welding equipments to join the structures.
3. Carry out the basic machining operations
4. Make the models using sheet metal works
5. Illustrate on centrifugal pump, Air conditioner, operations of smithy, foundary and fittings
6. Carry out basic home electrical works and appliances
7. Measure the electrical quantities
8. Elaborate on the components, gates, soldering practices.

		L	T	P	C
U20BM203	**FUNDAMENTALS OF BIOCHEMISTRY LABORATORY**	**0**	**0**	**4**	**2**

Pre-requisite: Basic Knowledge of concepts in Fundamentals of Biochemistry.

COURSE OBJECTIVES:

To provide practice on:

- Estimation and quantification of biomolecules. Separation of macromolecules.
- Estimation an interpretation of biochemical parameter.

LIST OF EXPERIMENTS:

1. General guidelines for working and functional component of biochemistry lab

2. Preparation of solutions: 1) percentage solutions, 2) molar solutions, 3) normal solutions.
3. Standardization of pH meter, preparation of buffers, emulsions.
4. Spectroscopy: Determination of absorption maxima (λmax) of a given solution.
5. General tests for carbohydrates, proteins and lipids.
6. Identification of Blood Collection Tubes and Phlebotomy equipments.
7. Preparation of serum and plasma from blood.
8. Estimation of Haemoglobin.
9. Estimation of blood glucose.
10. Estimation of creatinine.
11. Estimation of urea.
12. Estimation of Uric acid.
13. Estimation of cholesterol.
14. Assay of SGOT/SGPT.
15. ELISA test.
16. Separation of proteins by SDS electrophoresis(Demo).
17. Separation of amino acids by thin layer chromatography (Demo).
18. Identification of Blood groups (Forward and Reverse).
19. Bleeding and Clotting time.
20. Total RBC Count.
21. Total WBC Count.
22. Differential count of Blood cells.
23. Estimation of ESR.
24. PCV, MCH, MCV, MCHC.
25. Hearing test – Tuning fork.
26. Visual Activity – Snellen‘s Chart and Jaeger‘s Chart.

TOTAL: 60 PERIODS

LAB REQUIREMENTS FOR A BATCH OF 30 STUDENTS:

- Colorimeter - 2 Nos.
- Spectrophotometer - 1 No.
- pH meter - 1 No.
- Weighing balance - 1 No.
- Refrigerator - 1 No.
- SDS gel electrophoresis - 1 No.
- TLC, ready TLC plates - 1 No.
- Wintrobe‘s tube - 2 Nos.
- Centrifuge Normal - 1 No.
- Microslides - 2 packets.
- Lancet - 5 boxes.
- Microscope - 1 No.
- Neubaur‘s Chamber - 2 Nos.
- Heparinized Syringe - 1 box
- Haemoglobinometer - 1 No.
- Elisa reader - 1 Nos.
- Capillary tubes - 1 box

COURSE OUTCOMES:

Learners are able to

1. Understand the Biochemistry laboratory functional components
2. Understand the basics principle of preparation of buffers.
3. Have a sound knowledge of qualitative test of different biomolecules.
4. Understand the basics knowledge of Biochemical parameter and their interpretation in Blood sample.
5. Have a sound knowledge of separation technology of proteins and amino acids.

U20GE204	PYTHON PROGRAMMING LABORATORY (COMMON TO ALL BRANCHES)	L	T	P	C
		0	0	4	2

Pre-requisite: Basic knowledge of installing the programming software.

COURSE OBJECTIVES:

- To read, write and debug simple Python programs.
- To implement Python programs with conditionals and loops.
- To implement functions for structuring Python programs.
- Represent compound data using Python lists, tuples, and dictionaries.
- To get input data from/to files in Python.

LIST OF PROGRAMS

1. Write python program to Compute the GCD of two numbers.
2. Write python program to Find the square root of a number (Newton‘s method).
3. Write python program to Exponentiation (power of a number).
4. Write python program to Find the maximum of a list of numbers.
5. Write python program to Linear search and Binary search.
6. Write python program to Selection sort, Insertion sort.
7. Write python program to Merge sort
8. Write python program to First n prime numbers.
9. Write python program to Multiply matrices.
10. Implement python programs that take command line arguments (word count).
11. Implement python program to Find the most frequent words in a text read from a file .
12. Write python program to Simulate elliptical orbits in Pygame.
13. Write python program to Simulate bouncing ball using Pygame.

TOTAL :60 PERIODS

LABORATORY REQUIREMENT FOR BATCH OF 30 STUDENTS:

HARDWARE:

1. Standalone desktops - 30 Nos.

SOFTWARE:

1. Python 3 interpreter for Windows/Linux.

COURSE OUTCOMES:

Learners are able to

1. Compile and execute simple Python programs.
2. Implement mathematical calculation in programs.
3. Develop Python programs step-wise by defining functions and calling them.
4. Use Python lists, tuples, dictionaries for representing compound data.
5. Execute simulation of pygame programs.

SEMESTER III

U20MA301	TRANSFORMS AND PARTIAL DIFFERENTIAL EQUATION	L T P C 4 0 0 4

Pre-requisite: Knowledge of Integral Calculus, Ordinary differential equations, Complex variables.

COURSE OBJECTIVES:

- To introduce the basic concepts of PDE for solving standard partial differential equations.
- To introduce Fourier series analysis which is central to many applications in engineering apart from its use in solving boundary value problems.
- To acquaint the student with Fourier series techniques in solving heat flow problems used in various situations.
- To acquaint the student with Fourier transform techniques used in wide variety of situations.
- To introduce the effective mathematical tools for the solutions of partial differential equations that model several physical processes and to develop Z transform techniques for discrete time systems.

UNIT I PARTIAL DIFFERENTIAL EQUATIONS 12

Origin of partial differential equations, its order and degree, concept of solution in PDE - Solutions of standard types of first order partial differential equation - Lagrange's linear equation - Linear partial differential equations of second and higher order with constant coefficients of both homogeneous and non-homogeneous types.

UNIT II FOURIER SERIES 12

Dirichlet's conditions – General Fourier series – Odd and even functions – Half range sine series – Half range cosine series – Complex form of Fourier series – Parseval's identity – Harmonic analysis.

UNIT III APPLICATIONS OF PARTIAL DIFFERENTIAL EQUATIONS 12

Classification of PDE – Method of separation of variables - Fourier Series Solutions of one dimensional wave equation – One dimensional equation of heat conduction – Steady state solution of two dimensional equation of heat conduction.

UNIT IV FOURIER TRANSFORMS 12

Statement of Fourier integral theorem – Fourier transform pair – Fourier sine and cosine transforms – Properties – Transforms of simple functions – Convolution theorem – Parseval's identity.

UNIT V Z - TRANSFORMS AND DIFFERENCE EQUATIONS 12

Z-transforms - Elementary properties – Inverse Z-transform (using partial fraction and residues) – Initial and final value theorems - Convolution theorem - Formation of difference equations – Solution of difference equations using Z - transform.

TOTAL : 60 PERIODS

COURSE OUTCOMES :

Learners are able to

1. Understand how to solve the given standard partial differential equations.
2. Solve differential equations using Fourier series analysis which plays a vital role in engineering applications.
3. Appreciate the physical significance of Fourier series techniques in solving one and two dimensional heat flow problems and one dimensional wave equations.
4. Understand the mathematical principles on transforms and partial differential equations would provide them the ability to formulate and solve some of the physical problems of engineering.

5. Use the effective mathematical tools for the solutions of partial differential equations by using Z transform techniques for discrete time systems.

TEXT BOOKS :

1. Grewal B.S., “Higher Engineering Mathematics", 43rd Edition, Khanna Publishers, New Delhi, 2014.
2. Narayanan S., Manicavachagom Pillay.T.K and Ramanaiah.G "Advanced Mathematics for Engineering
3. Students", Vol. II & III, S.Viswanathan Publishers Pvt. Ltd, Chennai, 1998.
4. Veerarajan, T., 'Engineering mathematics’, Tata McGraw-Hill(Education) India Pvt.Ltd, 2006.
5. Kandasamy P., Thilagavathy K., and Gunavathy K., “ Engineering Mathematics” Volume III, S. Chand & Company Ltd., 2011.

REFERENCES :

1. Ramana. B.V., "Higher Engineering Mathematics", McGraw Hill Education Pvt. Ltd, New Delhi, 2016.
2. Venkatraman, M.K., ‘ Engineering Mathematics Vol.4’, National publishing company, 2004.
3. Andrews, L.C and Shivamoggi, B, "Integral Transforms for Engineers" SPIE Press, 1999.
4. Bali. N.P and Manish Goyal, "A Textbook of Engineering Mathematics", 9th Edition, Laxmi Publications Pvt. Ltd, 2014.
5. Erwin Kreyszig, "Advanced Engineering Mathematics ", 10th Edition, John Wiley, India, 2016.
6. James, G., "Advanced Modern Engineering Mathematics", 3rd Edition, Pearson Education, 2007.

U20BM301 SENSORS AND TRANSDUCERS

L	T	P	C
3	0	0	3

Pre-requisite: Basic knowledge of Engineering Physics.

COURSE OBJECTIVES:

- To understand the purpose of measurement, the methods of measurements, errors associated with measurements
- To Know the principle of Sensors, classifications and the characteristics of different Sensors
- To Know the different transducers and application
- To explore the characteristics of sensor, transducer and medical application.

UNIT I SCIENCE OF MEASUREMENT 12

Measurement System – Instrumentation - Classification and Characteristics of Transducers - Static and Dynamic - Errors in Measurements and their statistical analysis – Calibration - Primary and secondary standards.

UNIT II PHOTO ELECTRIC AND PIEZO ELECTRIC SENSORS 12

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

UNIT III TEMPERATURE TRANSDUCERS 12

Strain Gauge: Gauge factor, sensing elements, configuration, and unbounded strain gage. Capacitive transducer - various arrangements, Inductive transducer, LVDT, Passive types: RTD materials & range, relative resistance vs. temperature characteristics, thermistor characteristics,

Thermistor used for Cardiac output measurement and Nasal air flow measurement, Thermo electric –Thermocouple- characteristics, Non-contact type temperature measurements techniques- Radiation thermography, Pyrometer, Infrared temperature probe, Optical Pyrometer. Applications

UNIT IV PRESSURE TRANSDUCERS 12

Occlusive cuff method, Force balance methods, Direct hydraulically Coupled Catheter transducer system, Diaphragm pressure transducers, Piezoelectric pressure transducer, Electrical transduction methods for Catheter tip transducer, Optical transducers, Implantable pressure transducer, Micro pressure transducer, Strain Gauge type Blood pressure transducers. Application

UNIT V APPLICATION AND USES OF BIOSENSORS 12

Biosensors in clinical chemistry, medicine and health care, biosensors for veterinary, agriculture and food Low cost - biosensor for industrial processes for online monitoring; biosensors for environmental monitoring. Application of enzymes in analysis; design of enzyme electrodes and their application as biosensors in industry, healthcare, food and environment

TOTAL: 60 PERIODS

COURSE OUTCOMES:

Learners are able to

- Measure the various parameters with accuracy, precision, resolution
- Select appropriate passive or active transducers for measurement of physical phenomenon
- know about the pressure transducer in real time application in physiology system
- understand basic principle of Transducers and various biomedical sensors
- understand the importance of the sensors and transducers for medical Application

TEXT BOOKS:

1. A.K.Sawhney, “Electrical & Electronics Measurement and Instrumentation”,10th edition, DhanpatRai& Co, New Delhi, 19th Revised edition 2011, Reprint 2014.
2. Prof. H. T. Kashipara, Biomedical Transducers , Akshat publication
3. Loic J Blum, Pierre R Coulet - Biosensors Principles and Applications, First edition, Marcel Dekker,Inc, 1991.

REFERENCES:

1. Principles of Applied Biomedical Instrumentation L.A Geddas and L.E.Baker – John Wiley and sons,
2. Khandpur R.S, “Handbook of Biomedical Instrumentation”, Tata McGraw-Hill, New Delhi, 2003
3. Biomedical Sensors- Fundamentals and applications By: Harry.N. Norton
4. Transducers for Biomedical measurements By: Richard S.C. Cobbold,
5. Graham Ramsay - Commercial Biosensors, First edition, John Wiley & Sons, Inc. 1998.

U20BM302 PATHOLOGY AND MICROBIOLOGY

L	T	P	C
3	0	0	3

Pre-requisite: Basic knowledge in Fundamental of Biochemistry and Biology.

COURSE OBJECTIVES:

- To empower the importance of public health.
- To gain a knowledge on the structural and functional aspects of living organisms.
- To know the etiology and remedy in treating the pathological diseases.

UNIT I INTRODUCTION OF PATHOLOGY 9

History and Scope of Pathology & Microbiology – General Structural Organisation of bacterial and viral cell and fungal cell - Classification of bacteria, Virus, Fungi.

Viral disease - AIDS, Influensa, Dengue and Chikenguniya - **Bacterial disease** –Typhoid and Pneumonia - **Fungal disease** - Skin disease and ear disease. Culture media, Antibacterial activity - Identification of disease producing organisms, simple stain, Gram stain, AFB stain, Fluorescent techniques, antigen-antibody techniques, microbial biosensors.

UNIT II HAEMOTOLOGY 9

Different kinds of blood cells – structure and function, Fluid and hemodynamic derangements, - edema, normal hemostasis, thrombosis, disseminated intravascular coagulation, embolism, infarction, shock.Hematological disorders-Bleeding disorders, Leukaemias, Lymphomas.

UNIT III MICROSCOPES AND MICROBIAL CULTURES 9

Light microscope – bright field, dark field, phase contrast, fluorescence, Electron microscope (TEM &SEM). Preparation of samples for electron microscope, Morphological features and structural organization of bacteria, growth curve, identification of bacteria.

UNIT IV IMMUNOLOGY 9

Genetic disorders, Infection and Immunity-Mutations, Autosomal and X linked disorders, Mendelian disorders, types of immune response, hypersensitivity disorders, Immune deficiency syndrome, Viral disease, Chlamydial ,Bacterial, Mycoplasma, Rickettsial, Fungal, protozoal and helminthic disease.

UNIT V IMMUNO PATHOLOGY 9

Natural and artificial immunity, types of Hypersensitivity, antibody and cell mediated tissue injury: opsonization, phagocytosis, inflammation, Secondary immunodeficiency including HIV infection. Auto- immune disorders: Basic concepts and classification, SLE.Antibodies and its types, antigen and antibody reactions, immunological techniques: immune diffusion, immuno electrophoresis, RIA and ELISA, monoclonal antibodies.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Learners are able to

- Analyze structural and functional aspects of living organisms
- Explain the function of microscope
- Importance of public health
- Know about the methods involved in treating the pathological diseases
- Know about the immunological aspects and its techniques

TEXT BOOKS:

1. Ramzi S Cotran, Vinay Kumar & Stanley L Robbins: Pathologic Basis of diseases. WB Saunders Co. 7th edn-2005.
2. Harsh Mohan: Text book of Pathology. Jaypee publishers. 4th edn. 2000.
3. Ananthanarayanan R&PanickerCKJ:Textbook of Microbiology. Orient Longmans.7th ed.2006.
4. Dubey RC and Maheswari DK.A textbook of Microbiology. S Chand 2007

REFERENCES:

1. Underwood JCE: General and Systematic Pathology Churchill Livingstone 3edn.2000.
2. Prescott,Harley,Klein, “Microbiology”, Mc Graw Hill 5th ed. 2002.
3. Manual of Microbiology tools and techniques. Kanika Sharma. Ane’s student edition.2007.

U20BM303 SIGNALS AND SYSTEMS

L	T	P	C
4	0	0	4

Pre-requisite: Basic knowledge of Mathematics and Engineering Physics.

COURSE OBJECTIVES:

- To understand the basic properties of signal & systems
- To know the methods of characterization of LTI systems in time domain, Fourier and Z transform domain
- To analyze continuous time discrete time signals and system in the Fourier and Laplace domain
- To Quantify the frequency content of bioelectrical signals using both continuous and discrete Fourier and Z transforms

UNIT I INTRODUCTION OF SIGNALS AND SYSTEMS 12

Standard signals- Step, Ramp, Pulse, Impulse, Real and complex exponentials and Sinusoids, Classification of signals – Continuous time (CT) and Discrete Time (DT) signals, Periodic & A periodic signals, Deterministic & Random signals, Energy & Power signals - Classification of systems- CT systems and DT systems- – Linear & Nonlinear, Time-variant & Time-invariant, Causal & Non-causal, Stable & Unstable, Introduction to systems, system properties, interconnection of system, LTI systems- linear and circular convolution, correlation, auto-correlation.

UNIT II SIGNAL ANALYSIS 12

Basic concepts of the Fourier Series, Properties of continuous and discrete time Fourier series, Continuous Time Fourier Transform (CTFT) and Discrete Time Fourier Transform (DTFT), Discrete Fourier transform (DFT) and its inverse (IDFT), Introduction to Fast Fourier transform (FFT), ECG signal analysis, direct form-I and direct form-II representations, parallel and cascade representations, s, physiological signals and their properties.

UNIT III SAMPLING THEOREM, LAPLACE TRANSFORMS AND Z-TRANSFORM 12

Representation of continuous time signals by its sample, Sampling theorem, Reconstruction of a Signal from its samples, aliasing, Laplace transform: basics, properties, inverse; z-transform: definition, properties, Poles and Zeros, inverse z-transform; Region of convergence (ROC), Representation of systems by differential equations and transfer functions.

UNIT IV PHYSIOLOGICAL SYSTEM 12

Physiological fluctuations (pressure, arterial CO2, heart rate, respiration), Electrical analog of blood vessels and its transfer function. Characteristics of ECG, EEG and EMG signals
, signal conditioning of these bio-potential signals.

UNIT V MODELING OF PHYSIOLOGICAL SYSTEM 12

Modelling of Myoelectric activity. Modelling of cardiovascular system: Block diagram representation of cardio vascular system, Electrical circuit model of Blood Pressure, and Electrical circuit model of oxygenation. A model of immune response to disease (Block Diagram)

TOTAL: 60 PERIODS

COURSE OUTCOMES:

Learners are able to

- Determine if a given system is linear/causal/stable
- Capable of determining the frequency components present in a deterministic signal
- Capable of characterizing LTI systems in the time domain and frequency domain
- compute the output of an LTI system in the time and frequency domains
- Design appropriate continuous and discrete-time filters for neural, cardiac and other bio signals, and determine their outputs

TEXT BOOKS:

1. Allan V.Oppenheim, S.Wilsky and S.H.Nawab, —Signals and System, Pearson, 2015.
2. R.M. Rangayyan, Biomedical Signal Analysis, Wiley
3. Wills J. Tompkins, " Biomedical digital signal processing", Prentice Hall of India Pvt. Ltd

REFERENCES:

1. B. P. Lathi, —Principles of Linear Systems and Signals, Second Edition, Oxford, 2009.
2. R.E.Zeimer, W.H.Tranter and R.D.Fannin, —Signals & Systems - Continuous and Discrete‖, Pearson, 2007.
3. John alanstuller,"An introduction to signal and systems", Thomson, 2007
4. John semmlow, "signals and systems for bioengineers" Elsevier 2nd edition

U20BM304 ANATOMY AND HUMAN PHYSIOLOGY L T P C
3 0 0 3

Pre-requisite: Basic knowledge in Fundamental of Biochemistry and Biology

COURSE OBJECTIVES:

- To identify all the organelles of an animal cell and their function
- To understand structure and functions of the various types of systems of human body, types of glands
- To demonstrate their knowledge of importance of anatomical features and physiology of human systems

UNIT I CELL AND TISSUE STRUCTURE 9

Structure of Cell – structure and functions of sub organelles – Cell Membrane –Transport of Across Cell Membrane - Action Potential – Cell to Cell Signaling – Cell Division. Types of Specialized tissues – Functions, Tissue, Types of glands.

UNIT II SKELETAL, MUSCULAR AND RESPIRATORY SYSTEMS 9

Skeletal:Types of Bone and function – Physiology of Bone formation – Division of Skeleton – Types of joints and function – Types of cartilage and function. **Muscular**: Parts of Muscle – Movements. **Respiratory**: Parts of Respiratory Systems – Types of respiration - Mechanisms of Breathing – Regulation of Respiration.

UNIT III CARDIOVASCULAR AND LYMPHATIC SYSTEMS 9

Cardiovascular: Components of Blood and functions.- Blood Groups and importance – Structure of Heart – Conducting System of Heart – Properties of Cardiac Muscle - Cardiac Cycle - Heart Beat – Types of Blood vessel – Regulation of Heart rate and Blood pressure, Coronary Circulation. Factors regulating Blood flow. Lymphatic: Parts and Functions of Lymphatic systems – Types of Lymphatic organs and vessels.

UNIT IV NERVOUS AND ENDOCRINE SYSTEMS AND SENSE ORGANS 9

Nervous: Cells of Nervous systems – Types of Neuron and Synapses – Mechanisms of Nerve impulse – Brain : Parts of Brain – Spinal Cord – Tract and Pathways of Spines – Reflex Mechanism – Classification of Nerves - Autonomic Nervous systems and its functions. Endocrine - Pituitary and thyroid gland, Sense Organs: Eye and Ear

UNIT V DIGESTIVE AND URINARY SYSTEMS 9

Digestive: Organs of Digestive system – Digestion and Absorption. Urinary: Structure of Kidney and Nephron – Mechanisms of Urine formation – Regulation of Blood pressure by Urinary System – Urinary reflex

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Learners are able to

- Identify the organelles of a typical cell and describe their functions.
- Understand the major components of the skeletal system and describe their functions, then breathing mechanisms.
- Describe the role of blood cells and major components of the circulatory system and describe their functions.
- Understand the importance of the reflex arc as a homeostatic regulator and nervous function.
- Know about the functions among the primary organs and accessory organs of the digestive tract.

TEXT BOOKS:

1. Prabhjot Kaur. Text Book of Anatomy and Physiology. Lotus Publsihers. 2014
2. Elaine.N. Marieb , ―Essential of Human Anatomy and Physiology‖, Eight Edition, Pearson Education, New Delhi, 2007

REFERENCES:

1. Frederic H. Martini, Judi L. Nath, Edwin F. Bartholomew, Fundamentals of Anatomy and Physiology. Pearson Publishers, 2014
2. Gillian Pocock, Christopher D. Richards, The human Body – An introduction for Biomedical and Health Sciences, Oxford University Press, USA, 2013
3. William F.Ganong, ―Review of Medical Physiology‖, 22nd Edition, Mc Graw Hill, New Delhi, 2010
4. Eldra Pearl Solomon, ―Introduction to Human Anatomy and Physiology‖, W.B. Saunders Company, 2015
5. Guyton & Hall, ―Medical Physiology‖, 13th Edition, Elsevier Saunders, 2015

U20BM305 ELECTRONIC DEVICES AND CIRCUITS

L	T	P	C
3	0	0	3

Pre-requisite: Basic knowledge of Engineering Physics.

COURSE OBJECTIVES:

- To introduce the fundamental concepts of semiconductor devices.
- To understand the basic theory of electrical circuits and analysis.
- To familiarize the operation and applications of transistor like BJT and FET.
- To explore the characteristics of amplifier gain and frequency response.
- To learn the required functionality of positive and negative feedback systems.

UNIT I INTRODUCTION TO SEMICONDUCTOR DEVICES 9

Evolution of electronics –. Resistors, Capacitors and Inductors (constructional features not required): types, specifications. Standard values, color coding. Semiconductor materials- intrinsic and extrinsic types, Ideal Diode, Terminal characteristics of diodes: p-n junction under open circuit condition p-n junction under forward bias and reverse bias conditions p-n junction in breakdown region, Diode small signal model, Zener diode and applications, Clipping and Clamping circuits.

UNIT II ELECTRICAL CIRCUITS AND ANALYSIS 9

Ohm‘s law, DC and AC circuits fundamentals, Energy sources, Kirchhoff‘s laws, Mesh and Nodal analysis, Star -delta and Delta -star transformation; theorems and simple problems: Superposition, Thevenins‘s, Maximum power transfer theorem.

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

BIMOS cascade amplifier, Differential amplifier – Common mode and Difference mode analysis – FET input stages – Single tuned amplifiers – Gain and frequency response – Neutralization methods, power amplifiers –Types (Qualitative analysis).

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: 45 PERIODS

COURSE OUTCOMES:

Learners are able to

- Explain the structure and working operation of basic electronic devices.
- Design simple electrical circuits and understand through nodal, mesh analysis.
- Analyze the characteristics of different electronic devices such as diodes and transistors.
- Choose and adapt the required components to construct an amplifier circuit.
- Employ the acquired knowledge in design and analysis of oscillator.

TEXT BOOKS:

1. Dr. D P Kothari, Prof I J Nagrath, ―Basic Electrical Engineering , 3rd Edition, Tata McGraw- Hill, 2009
2. P.C. Sen,Principles of Electrical Machines and Power Electronics,Wiley,2016(Reprint)
3. David A. Bell, Electronic devices and circuits, Oxford University higher education, 5th edition 2008.
4. Sedra and smith, ―Microelectronic circuits, 7th Ed., Oxford University Press.

REFERENCES:

1. Balbir Kumar, Shail.B.Jain, ―Electronic devices and circuits PHI learning private limited, 2nd edition 2014.
2. Thomas L.Floyd, ―Electronic devices‖ Conventional current version, Pearson prentice hall, 10th Edition, 2017.
3. Donald A Neamen, ―Electronic Circuit Analysis and Design Tata McGraw Hill, 3rd Edition, 2003.
4. Robert L.Boylestad, ―Electronic Devices and Circuit Theory, 2002.
5. Robert B. Northrop, ―Analysis and Application of Analog Electronic Circuits to Biomedical Instrumentation‖, CRC Press, 2004.

U20BM306 PATHOLOGY AND MICROBIOLOGY LABORATORY L T P C
0 0 4 2

Pre-requisite: Basic knowledge in Microbiology and Hematological laboratory Apparatus

COURSE OBJECTIVES:

- Use Compound microscope
- Practice on chemical examinations, Cryoprocessing, Histopathological examinations etc.

LIST OF EXPERIMENTS

1. Urine physical and chemical examination protein, reducing substances, ketones, bilirubin and blood)
2. Study of parts of compound microscope
3. Histopathological slides of benign and malignant tumours.
4. Manual paraffin tissue processing and section cutting (demonstration)
5. Cryo processing of tissue and cryosectioning (demonstration)
6. Basic staining – Hematoxylin and eosin staining.
7. Special stains – cresyl fast Blue (CFV)- Trichrome – oil red O – PAS
8. Capsule stain
9. Simple stain.
10. Gram stain.

11. AFB stain.
12. Antigen-Antibody reaction Immuno electrophoresis
13. Slides of Malarial Parasites, Microfilaria and LeishmaniaDonovani
14. Haematology slides of anemia and leukemia.
15. Study of bone marrow charts

TOTAL: 60 PERIODS

COURSE OUTCOMES:

Learners are able to

- Students can perform practical experiments on tissue processing, cryoprocessing, staining Processes etc.

TEXT BOOK :

1. Textbook of Medical Laboratory Technology, Ramnik Sood, 6th Edition, Jaypee Brothers Medical Publishers, 2009

U20BM307	DEVICES AND CIRCUITS LABORATORY	L	T	P	C
		0	0	4	2

Pre-requisite: Basic knowledge of Physics and Electrical Laboratory apparatus

COURSE OBJECTIVES:

- To learn the characteristics of basic electronic devices such as Diode, BJT,FET, SCR
- To understand the working of RL,RC and RLC circuits
- To gain hand on experience in Thevenin& Norton theorem, KVL & KCL, and Super Position Theorems.

LIST OF EXPERIMENTS

1. Characteristics of PN Junction Diode
2. Zener diode Characteristics & Regulator using Zener diode
3. Common Emitter input-output Characteristics
4. Common Base input-output Characteristics
5. FET Characteristics
6. SCR Characteristics
7. Clipper and Clamper & FWR
8. Verifications of Thevenin& Norton theorem
9. Verifications of KVL & KCL
10. Verifications Of Super Position Theorem
11. Verifications of maximum power transfer & reciprocity theorem
12. Determination Of Resonance Frequency of Series & Parallel RLC Circuits
13. Transient analysis of RL and RC circuits

LABORATORY REQUIREMENTS

BC 107, BC 148, 2N2646, BFW10 - 25 each
1N4007, Zener diodes - 25 each
Resistors, Capacitors, Inductors - sufficient quantities
Bread Boards - 15 Nos
CRO (30MHz) – 10 Nos.
Function Generators (3MHz) – 10 Nos.
Dual Regulated Power Supplies (0 – 30V) – 10 Nos

TOTAL: 60 PERIODS

COURSE OUTCOMES:

Learners are able to

- Analyze the characteristics of basic electronic devices
- Design RL and RC circuits
- Verify Thevinin& Norton theorem KVL & KCL, and Super Position Theorems

U20MA403	PROBABILITY AND STATISTICS	L	T	P	C
		4	0	0	4

Pre-requisite : Basic Probability, Partial Differential Equation.

COURSE OBJECTIVES:

- Providing the required skill to apply the statistical tools in engineering problems.
- To introduce the basic concepts of probability and random variables.
- To introduce the basic concepts of two dimensional random variables.
- To acquaint the knowledge of testing of hypothesis for small and large samples which plays an important role in real life problems.
- To introduce the basic concepts of classifications of design of experiments which plays very important roles in the field of agriculture and statistical quality control.

UNIT I PROBABILITY AND RANDOM VARIABLES 12

Probability – The axioms of probability – Conditional probability – Baye's theorem - Discrete and continuous random variables – Moments – Moment generating functions – Binomial, Poisson,Geometric, Uniform, Exponential and Normal distributions.

UNIT II TWO - DIMENSIONAL RANDOM VARIABLES 12

Joint distributions – Marginal and conditional distributions – Covariance – Correlation and linear regression – Transformation of random variables – Central limit theorem (for independent and identically distributed random variables).

UNIT III TESTING OF HYPOTHESIS 12

Sampling distributions - Estimation of parameters - Statistical hypothesis - Large sample tests based on Normal distribution for single mean and difference of means -Tests based on t, Chisquare and F distributions for mean, variance and proportion - Contingency table (test for independent) - Goodness of fit.

UNIT IV DESIGN OF EXPERIMENTS 12

One way and Two way classifications - Completely randomized design – Randomized block design – Latin square design - 2^2 factorial design.

UNIT V STATISTICAL QUALITY CONTROL 12

Control charts for measurements (X and R charts) – Control charts for attributes (p, c and np charts) – Tolerance limits - Acceptance sampling.

TOTAL: 60 PERIODS

COURSE OUTCOMES :

Learners are able to

1. Understand the fundamental knowledge of the concepts of probability and have Knowledge of standard distributions which can describe real life phenomenon.
2. Understand the basic concepts of one and two dimensional random variables and apply in engineering applications.
3. Apply the concept of testing of hypothesis for small and large samples in real life problems.
4. Apply the basic concepts of classifications of design of experiments in the field of agriculture and statistical quality control.
5. Have the notion of sampling distributions and statistical techniques used in Engineering and management problems.

TEXT BOOKS:

1. Johnson, R.A., Miller, I and Freund J., "Miller and Freund's Probability and Statistics for Engineers", Pearson Education, Asia, 8th Edition, 2015.
2. Vijay. K Rohatgi., A. K. Md. Ehsanes Saleh., " An Introduction to Probability and Statistics", Wiley, 3rd Edition 2015.
3. Milton. J. S. and Arnold. J.C., "Introduction to Probability and Statistics", Tata McGraw Hill,4th Edition, 2007.

REFERENCES:

1. J. Ravichandran, " Probability and Random Processes for Engineers", First Edition, Ik International , 2015.
2. Devore. J.L., "Probability and Statistics for Engineering and the Sciences", Cengage Learning, New Delhi, 8th Edition, 2014.
3. Papoulis, A. and Unnikrishnapillai, S., "Probability, Random Variables and Stochastic Processes", McGraw Hill Education India, 4th Edition, New Delhi, 2010.
4. Ross, S.M., "Introduction to Probability and Statistics for Engineers and Scientists", 3rd Edition, Elsevier, 2004.
5. Spiegel. M.R., Schiller. J. and Srinivasan, R.A., "Schaum's Outline of Theory and Problems of Probability and Statistics", Tata McGraw Hill Edition, 2004.
6. Walpole. R.E., Myers. R.H., Myers. S.L. and Ye. K., "Probability and Statistics for Engineers and Scientists", Pearson Education, Asia, 8th Edition, 2007.

U20BM401 MICROPROCESSORS AND MICROCONTROLLERS

L	T	P	C
3	0	0	3

Pre-requisite : Basic Knowledge of Engineering Physics.

COURSE OBJECTIVES:

- To understand the Architecture of 8086 microprocessor
- To learn the design aspects of I/O and Memory Interfacing circuits.
- To interface microprocessors with supporting chips
- To study the Architecture of 8051 microcontroller
- To design a microcontroller based system.

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 8086 SYSTEM BUS STRUCTURE **9**

8086 signals – Basic configurations – System bus timing –System design using 8086 – I/O programming– Introduction to Multiprogramming – System Bus Structure – Multiprocessor configurations – Coprocessor, Closely coupled and loosely Coupled configurations – Introduction to advanced processors..

UNIT III I/O INTERFACING **9**

Memory Interfacing and I/O interfacing - Parallel communication interface – Serial communication interface – D/A and A/D Interface - Timer – Keyboard /display controller – Interrupt controller – DMA controller – Programming and applications Case studies: Traffic Light control, LED display , LCD display, Keyboard display interface and Alarm Controller.

UNIT IV MICROCONTROLLER **9**

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

UNIT V INTERFACING MICROCONTROLLER 9

Programming 8051 Timers - Serial Port Programming - Interrupts Programming – LCD & Keyboard Interfacing - ADC, DAC & Sensor Interfacing - External Memory Interface- Stepper Motor and Waveform generation - Comparison of Microprocessor, Microcontroller, PIC and ARM processors.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Learners are able to

- Understand and execute programs based on 8086 microprocessor.
- Design Memory Interfacing circuits.
- Design and interface I/O circuits.
- Design and implement 8051 microcontroller based systems.
- Comparison of microprocessor and microcontroller.

TEXT 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. (UNITI-III)
2. Mohamed Ali Mazidi, Janice GillispieMazidi, RolinMcKinlay, ―The 8051 Microcontroller and Embedded Systems: Using Assembly and C‖, Second Edition, Pearson education, 2011.(UNIT IV-V)

REFERENCES:

1. DoughlasV.Hall, ―Microprocessors and Interfacing, Programming and Hardware‖,TMH,2012
2. A.K.Ray,K.M.Bhurchandi, "Advanced Microprocessors and Peripherals" 3rd edition, Tata McGrawHill, 2012.

U20BM402 DIGITAL AND INTEGRATED CIRCUITS

L	T	P	C
3	0	0	3

Pre-requisite: Basics Knowledge in Engineering Physics.

COURSE OBJECTIVES:

- To know the Digital fundamentals, Boolean algebra and its applications in digital systems
- To understand the concept of combinational and sequential circuits
- To provide in depth understanding of the fundamentals of Op-Amp and various circuits using 741
- To expose the students to the principles of integrated circuit fabrication
- To know the concepts of ADC and DAC and its types.

UNIT I DIGITAL FUNDAMENTALS 12

Number Systems – Decimal, Binary, Octal, Hexadecimal, 1‗s and 2‗s complements, Codes – Binary, BCD, Excess 3, Gray, Alphanumeric codes, Boolean theorems, Logic gates, Universal gates, Sum of products and product of sums, Minterms and Maxterms, Karnaugh map Minimization and Quine-McCluskey method of minimization

UNIT II COMBINATIONAL AND SEQUENTIAL CIRCUIT 12

Design of Half and Full Adders, Half and Full Subtractors, Binary Parallel Adder – Carry look ahead Adder, BCD Adder, Multiplexer, Demultiplexer, Magnitude Comparator, Decoder, Encoder, Priority Encoder, Design of Counters- Ripple Counters, Ring Counters, Shift registers, Universal Shift Register.

UNIT III OPERATIONAL AMPLIFIERS 12

Basic information about op-amps, General operational amplifier stages -and internal circuit diagrams of IC 741, Inverting and Non Inverting Amplifiers, Applications of operational amplifiers - adder, subtractor, Instrumentation amplifier, Integrator, Differentiator, Logarithmic amplifier,

Antilogarithmic amplifier, Comparators, Schmitt trigger, Precision rectifier, peak detector, clipper and clamper, Low-pass, high-pass and band-pass Butterworth filter.

UNIT IV MULTIVIBRATOR 12

Astable, Monostable, Bistablemultivibrators using op amps, triangular wave generator, saw tooth wavegenerator. Time base generators (Basic principle), Timer IC 555- Block diagram- Astable and Monostablecircuits using IC 555, PLL - Basic principles & applications. Voltage regulators-Voltage Regulators,Design of Series Voltage Regulator- 723 switching regulators, Voltage regulator ICs – 78XX and79XXseries , 8038 Function generator chip applications

UNIT V ACTIVE FILTERS AND DATA CONVERTERS 12

First order RC active low pass and high pass filter, Band pass filter and basics of Notch filter,Digital to analog converter (DAC)/Analog to digital converter (ADC) specifications,Weighted resistor DAC, R-2R ladder DAC, inverted R-2R DAC . Flash type ADC, successive approximation ADC and dual slope ADC.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

Learners are able to

- Understand the basic of the Digital systems and logic gates.
- Explain the application of combinational and sequential circuit.
- Know operational amplifiers and its Applications.
- Design various functional circuits using these ICs.
- Know about types of DAC and ADC devices.

TEXT BOOKS:

1. S.Salivahanan and S.Arivazhagan—Digital Electronics‖, Ist Edition, Vikas Publishing House pvt Ltd, 2012
2. D Roy Choudhury and Shail Jain, “Linear integrated circuits”, New Age Science Limited, 4th edition,2011.

REFERENCES:

1. Anil K.Maini —Digital Electronics‖, Wiley, 2014.
2. A.Anand Kumar —Fundamentals of Digital Circuits‖, 4th Edition, PHI Learning Private Limited, 2016
3. Coughlin & Driscoll, “Operational amplifiers &linear integrated circuits”, Prentice Hall of India, 6th edition, 2003.
4. Gayakwad A.R, “Op-Amp and linear integrated circuits”, Prentice Hall of India, 4th edition, 2009.

U20BM403 MEDICAL PHYSICS

L	T	P	C
3	0	0	3

Pre-requisite: Basic knowledge of Engineering Physics.

COURSE OBJECTIVES:

- To study principles and effects of ionizing and non-ionizing radiation in human body
- To discuss the physics of the senses
- To explore the effects of radiation in matter and how isotopes are produced
- To understand various detectors for detecting the presence of ionizing radiation.

UNIT I NON-IONIZING RADIATION AND ITS MEDICAL APPLICATIONS 9

Introduction and objectives - Tissue as a leaky dielectric - Relaxation processes, Debye model, Cole– Cole model, Overview of non-ionizing radiation effects-Low Frequency Effects- Higher frequency effects. Physics of light, Measurement of light and its unit- Electromagnetic spectrum -

Different sources of Non Ionizing radiation, Radio-frequency, Microwaves, Infrared, Visible and Ultra violet radiation production, physical properties and their interaction with tissues.

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 radionuclides – Cyclotron produced Radionuclide- Reactor produced Radio- nuclide-fission and electron Capture reaction, Target and Its Processing Equation for Production of Radionuclides, radionuclide Generator-Technetium generator..

UNIT III X-RAY GENERATORS 9

Discovery- Production - Properties of X-rays - Characteristics and continuous spectra - Design of hotcathode X-ray tube - Basic requirements of medical diagnostics, therapeutic and industrialradiographic tubes - Rotating anode tubes - Hooded anode tubes - Industrial X-ray tubes – Safetydevices in X-ray tubes - X ray tubes for crystallography- rating of tubes - Safety devices in X-ray tubes -Ray proof and shock proof tubes - Insulation and cooling of X- ray tubes - mobile and dental units. Faults in X -ray tubes - Limitations on loading- Electric Accessories for X-ray tubes - Filament and highvoltage transformers - High voltage circuits - Half wave and full wave rectifiers - condenser dischargeapparatus - Three phase apparatus - voltage doubling circuits - current and voltage stabilisers - Automatic exposure control - Automatic Brightness Control - Measuring instruments – Measurementof kV and mA - timers - Control Panels - Complete X-ray circuit- Image intensifiers and closed circuit TVsystems - Modern trends.

UNIT IV INTERACTION OF PARTICLES WITH MATTER 9

Classical theory of inelastic collisions with atomic electrons - Energy loss per ion pair by primary and secondary ionization - Dependence of collision energy losses on the physical and chemical state of the absorber - Cerenkov radiation - Electron absorption process - Scattering Excitation and Ionization - Radiative collision - Bremstrahlung - Range energy relation - Continuous slowing down approximation(CSDA) - transmission and depth dependence methods for determination of particle penetration -empirical relation between range and energy - Back scattering - Passage of heavy charged particles through matter - Energy loss per collision - Range energy relation - Bragg curve - Specific ionization -stopping Power - Bethe Bloch formula - Interaction of neutrons with matter - scattering - capture -neutron induced nuclear reactions

UNIT V DOSIMETERS FOR MEDICAL APPLICATIONS 9

Pocket chambers - Dosimeters based on current measurements - Different types of electrometers - MOSFET, vibrating condenser and Varactor bridge types - Secondary standard therapy level Dosimeters- Farmer dosimeters - Radiation field analyser (RFA) - Radio isotope calibrator - Multipurpose dosimeter - Water phantom dosimetry systems - Brachytherapy Dosimeters - Thermoluminescent dosimeter readers for Medical Applications - Calibration and Maintenance of dosimeters

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Learners are able to

- Explain about non-ionizing radiation, interaction with tissue and its effects.
- Define and compare intensities of sensor stimuli.
- Summarizes how ionizing radiation interacts with the human body.
- how to quantify it and its levels seen in the environment and healthcare.
- Explain the fundamentals of radioactivity and radioactive isotopes.
- Illustrates the methods of detecting and recording.

TEXT BOOKS:

1. J. T. Bushberg, et al. The Essential Physics of Medical Imaging (3rd Ed.), (LWW, 2011)
2. Radiation oncology physics: A handbook of Teachers and Students (IAEA Publication)

3. G. F. Knoll, Radiation Detection and Measurement 4th Ed., (John Wiley & Sons, 2010)
4. Gopal B. Saha, ―Physics and Radiobiology of Nuclear Medicine‖, 4th Edition, Springer, 2013.
5. B H Brown, R H Smallwood, D C Barber, P V Lawford and D R Hose, ―Medical Physics and Biomedical Engineering‖, 2nd Edition, IOP Publishers.2001.

REFERENCES:

1. P.Uma Devi, A.Nagarathnam , B S SatishRao , "Introduction to Radiation Biology" B.I Chur ChillLivingstone pvt Ltd, 2000
2. S.Webb " The Physics of Medical Imaging", Taylor and Francis, 1988
3. J.P.Woodcock, Ultrasonic,Medical Physics Handbook series 1, Adam Hilger, Bristol, 2002
4. HyltonB.Meire and Pat Farrant "Basic Ultrasound" John Wiley & Sons, 1995.

U20BM404 BIO ELECTRIC PHYSIOLOGY AND CHEMICAL ANALYSIS **L T P C**
3 0 0 3

Pre-requisite: Basic knowledge of Biochemistry and Human Physiology

COURSE OBJECTIVES:

- To develop skills of the students in the area of Chemical analysis with emphasis in process calculations and fluid mechanics.
- This will enable the students to understand Physiology processes.

UNIT I BASIC ELECTRO PHYSIOLOGY **9**

Ohm's law, diffusion, electric fields, potentials, and charge, I-V curves, rectification, basics of voltage clamp, ODEs, stochastic processes, membrane biophysics- Basic structure and composition of membrane Donnan equilibrium, Ion transport system overview,Ion channel types and characterization, Channel types, structure, function ,Same channels in different cell types , Molecular biology in ion channels.

UNIT II CARDIO PHYSIOLOGY **9**

Determinants of the normal cardiac rhythm (genesis of the resting potential and action potentials, ion channels, ionic currents), Determinants of normal conduction (for example passive membrane properties, maximal upstroke velocity, cell to cell interaction), Genesis of tachyarrhythmias (automaticity, triggered activity, re-entry, anisotropy, influence of various modulators such as autonomic tone and electrolyte disturbances), Antiarrhythmic drug actions (modulated receptor hypothesis, antiarrhythmic drug classifications, cellular electro physiologic effects of various classes of antiarrhythmic drugs).

UNIT III NEURO PHYSIOLOGY **9**

Integration, Propagation, saltatory conduction, Neuron synapse, synaptic plasticity- Structure of the synapse ,Electrochemical transduction, Postsynaptic integration and information processing, Modeling and simulation of whole cell EP ,Review of HH formalism; modern extensions ,Mathematical formulation, numerical implementation, examples of software, Strengths and limitations of simulation.

UNIT IV ELECTRO CHEMICAL REDUCTION AND OXIDATION OF FUNCTIONAL GROUPS **9**

Basic concepts in electrochemistry, Chemical energy of system, relationship of chemical energy to electro potential, electrochemical analytic systems-Membrane Electrodes, Enzyme electrodes, solid state electrodes. Electrohydrodimerization and cathodic coupling reactions, cathodic reactions using mediators. Anodic halogenation, oxidation through redox carriers – metal ion, non-metal ion and organic mediators. Anodic coupling reactions. Mechanism and applications. Anodic oxidation of aromatic hydrocarbons and phenol. Anodic substitution reactions: alkoxylation, acetoxylation, cyanation and acetamidation.

UNIT V BIO CHEMICAL ANALYTIC SYSTEM 9

Biochemical sensors - pH, pO2 and pCO2, Ion selective Field effect Transistor (ISFET), Immunologically sensitive FET (IMFET), Blood glucose sensors - Blood gas analyzers, colorimeter, flame photometer, spectrophotometer, blood cell counter, auto analyzer (simplified schematic description)..

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Learners are able to

- Explore the electrical activity of living neurons and investigates the molecular and cellular processes that govern their signalling.
- Identify cardiovascular centers and cardiac reflexes that regulate heart function and factors affecting the heart rate.
- Gain the knowledge of physiology of relationship and of central integrative functions typical of human. Focused on the physiologic mechanisms for integrative functions of central nervous system.
- Understanding of basic principles of organic chemistry and how they relate to everyday experiences in functional group to analyze a problems.
- Understand the strengths, limitations and creative use of techniques for problem-solving by using chemical analysis process.

TEXT BOOKS:

1. Thomas Scott 1935 Concise encyclopedia biochemistry and molecular biology. Mercer (Eric Ian) 1997
2. Rettinger, Jürgen, Schwarz Electrophysiology Basics, Modern Approaches and Applications Authors: , Silvia, Schwarz, Wolfgang

REFERENCES:

1. G. H. Bell, J. Norman Davidson and H. Scarborough Textbook of Physiology and Biochemistry. 3rd Edition. Edinburgh and London: E. & S. Livingstone, Ltd.
2. John R. Heckenlively Principles and Practice of Clinical Electrophysiology of Vision (A Bradford Book) second edition
3. Rohan Wijesurendra, Clinical handbook of cardiac electrophysiology, Springer International Publishing 2015
4. An Essential Introduction to Cardiac ElectrophysiologyPublication Imperial College Press; Illustrated Edition, 2014.

U20HS202 ENVIRONMENTAL SCIENCE AND ENGINEERING

L	T	P	C
3	0	0	3

Pre-requisite: Basic knowledge of Biochemistry.

COURSE OBJECTIVES:

- To the study of nature and the facts about environment.
- To finding and implementing scientific, technological,economic and political solutions to environmental problems.
- To study the interrelationship between living organism and environment.
- To appreciate the importance of environment by assessing its impact on the human world; envision the surrounding environment,its functions and its value.
- To study the dynamic processes and understand the features of the earth's interior and surface.
- To study the integrated themes and biodiversity, natural resources, pollution control and waste management.

UNIT I ECO SYSTEMS AND BIODIVERSITY 9

Definition – concept of an ecosystem– structure and function of an ecosystem - Oxygen cycle and Nitrogen cycle –energy flow in the ecosystem – ecological succession- structure and function of the (a) forest ecosystem (b) grassl and ecosystem(c)desert ecosystem(d)aquatic ecosystems.Introduction- definition,classification of India–value of biodiversity-India as a mega-diversity nation –hot-spots of biodiversit– threats to biodiversity endangered and endemic species of India–conservation of biodiversity.

UNIT II 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- disaster management: floods, earthquake, cyclone and landslides.

UNIT III NATURAL RESOURCES 9

Forest resources-deforestation-Water resources-dams-benefits and problems–Mineral resources - mineral resources–Food resources–Energy resources,Land resources–Role of an individual in conservation of natural resources.

UNIT IV GREEN CHEMISTRY 9

Introduction,Principles,Toxicity-Green chemistry in Plastics, Energy, sustainable development – Controlled environmental agriculture Avoidance of toxic fictional group- reduce the toxic chemicals-Advantage and disadvantages of protected cultivation- Green chemistry using the biocatalytic reactions- Fermentation and Bio transformations. Eco mark, Eco symbol, Green lable.

UNIT V SOCIAL ISSUES AND ENVIRONMENT 9

Human health Risk and hazards; Chemical hazards, Physical hazards, Biological hazards in the environment From unsustainable to sustainable development–water conservation, rain water harvesting, water shed management – resettlement and rehabilitation - Population growth, variation among nations– population explosion –family welfare programme human rights, consumerism-value education –HIV /AIDS –women and child welfare.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Learners are able to

- Environmental Pollution or problems cannot be solved by mere laws. Public participation is an important aspect which serves the environmental Protection. One will obtain knowledge on the following after completing the course.
- Public awareness of environmental is at infant stage.
- Ignorance and incomplete knowledge has lead to misconceptions
- Development and improvement in std. of living has lead to serious environmental disasters

TEXT BOOKS:

1. Gilbert M.Masters, ‘Introduction to Environmental Engineering and Science’, 2nd edition, Pearson Education (2004).
2. Benny Joseph, ‘Environmental Science and Engineering’, Tata McGraw-Hill, New Delhi, (2006).

REFERENCES:

1. R.K.Trivedi,‘Handbook of Environmental Laws,Rules,Guidelines,Compliances and Standards’, Vol. I and II, Enviro Media.
2. Cunningham, W.P. Cooper,T.H.Gorhani,‘Environmental Encyclopedia’,Jaico Publ., House, Mumbai, 2001.
3. Dharmendra S. Sengar,‘Environmental law’,Prentice hall of India PVT LTD, New Delhi, 2007.
4. Rajagopalan,R,‘Environmental Studies-From Crisis to Cure’, Oxford University Press (2005)

U20BM405 MICROPROCESSORS AND MICROCONTROLLERS LABORATORY L T P C
0 0 4 2

COURSE OBJECTIVES:

- To Introduce ALP concepts, features and Coding methods
- Write ALP for arithmetic and logical operations in 8086 and 8051
- Differentiate Serial and Parallel Interface
- Interface different I/Os with Microprocessors
- Be familiar with MASM.

LIST OF EXPERIMENTS: 8086 Programs using kits and MASM

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. Password checking, Print RAM size and system date
6. Counters and Time Delay

Peripherals and Interfacing Experiments

7. Traffic light controller
8. Stepper motor control
9. Digital clock
10. Key board and Display
11. Printer status
12. Serial interface and Parallel interface
13. A/D and D/A interface and Waveform Generation

8051 Experiments using kits and MASM

14. Basic arithmetic and Logical operations
15. Square and Cube program, Find 2‘s complement of a number
16. Unpacked BCD to ASCII

TOTAL: 60 PERIODS

COURSE OUTCOMES:

Learners are able to

- Write ALP Programs for fixed and Floating Point and Arithmetic operations
- Interface different I/Os with processor
- Generate waveforms using Microprocessors
- Execute Programs in 8051
- Explain the difference between simulator and Emulator

LAB EQUIPMENT FOR A BATCH OF 30 STUDENTS:

HARDWARE:

8086 development kits - 30 nos
Interfacing Units - Each 10 nos
Microcontroller - 30 nos

SOFTWARE:

Intel Desktop Systems with MASM - 30 nos
8086 Assembler
8051 Cross Assembler

U20BM406 DIGITAL AND INTEGRATED CIRCUITS LABORATORY L T P C
0 0 4 2

COURSE OBJECTIVES:

- To expose the students to linear and integrated circuits
- To understand the basics of linear integrated circuits and available ICs.

- To understand characteristics of operational amplifier.
- To apply operational amplifiers in linear and nonlinear applications.
- To acquire the basic knowledge of special function IC.
- To use SPICE software for circuit design.

LIST OF DIGITAL EXPERIMENTS

1. Design and implementation of code converters using logic gates
2. BCD to excess-3 code and vice versa (ii) Binary to gray and vice-versa
3. Design and implementation of 4 bit binary Adder/ Subtractor and BCD adder using IC 7483
4. Design and implementation of Multiplexer and De-multiplexer using logic gates
5. Design and implementation of encoder and decoder using logic gates
6. Construction and verification of 4 bit ripple counter and Mod-10 / Mod-12 Ripple counters
7. Design and implementation of 3-bit synchronous up/down counter
8. Implementation of SISO, SIPO, PISO and PIPO shift registers using Flip- flops.
9. SPICE Simulation studies

LIST OF INTEGRATED CIRCUIT EXPERIMENTS

1. Inverting, Non inverting and Differential amplifiers.
2. Integrator and Differentiator.
3. Instrumentation amplifier
4. Active low-pass, High-pass and band-pass filters.
5. Astable&Monostablemultivibrators and Schmitt Trigger using op-amp.
6. RC Phase shift and Wien bridge oscillators using op-amp.
7. Astable and monostablemultivibrators using NE555 Timer.
8. PLL characteristics and its use as Frequency Multiplier.
9. DC power supply using LM317 and LM723

TOTAL: 60 PERIODS

COURSE OUTCOMES:

Learners are able to

- Design oscillators and amplifiers using operational amplifiers.
- Design filters using Opamp and perform experiment on frequency response.
- Analyse the working of PLL and use PLL as frequency multiplier.
- Design DC power supply using ICs.
- Aquire knowledge in using SPICE.

U20BM501	BIO SIGNAL PROCESSING	L	T	P	C
		4	0	0	4

Pre-requisite: Basic knowledge of Signals and system and Partial Differential Equations

COURSE OBJECTIVES:

- To learn discrete fourier transform, properties of DFT and its application to linear filtering
- To understand the characteristics of digital filters, design digital IIR and FIR filters and
- Apply these filters to filter undesirable signals in various frequency bands
- To understand the fundamental concepts of multi rate signal processing and its applications
- To learn the concepts of biosignals from different parameters.

UNIT I DISCRETE FOURIER TRANSFORM **12**

Review of signals and systems, concept of frequency in discrete-time signals, summary of analysis & synthesis equations for FT & DTFT, frequency domain sampling, Discrete Fourier transform (DFT) - deriving DFT from DTFT, properties of DFT - periodicity, symmetry, circular convolution, Linear filtering using DFT, Filtering long data sequences - overlap save and overlap add method, Fast computation of DFT - Radix-2 Decimation-in-time (DIT) Fast Fourier transform (FFT), Decimation-in- frequency (DIF), Fast Fourier transform (FFT), Linear filtering using FFT.

UNIT II INFINITE IMPULSE RESPONSE FILTERS 12

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

UNIT III FINITE IMPULSE RESPONSE FILTERS 12

Design of FIR filters - symmetric and Anti-symmetric FIR filters - design of linear phase FIR filters using Fourier series method - FIR filter design using windows (Rectangular, Hamming and Hanning window), Frequency sampling method. FIR filter structures - linear phase structure, direct form realizations.

UNIT IV NOISE CANCELLATION 12

Adaptive filters – Principle noise canceller model – 50 Hz adaptive cancelling using a sine wave model – Maternal ECG cancellation in fetal electrocardiography – ECG cancellation in EMG recording – High frequency noise cancellation in Electro surgery. Signal averaging – Basics and limitations.

UNIT V BIO SIGNALS ANALYSIS 12

EEG signal characteristics – EEG analysis - time and frequency domain methods parametric model – Phenomenological model – linear prediction theory – Autoregressive method, ECG QRS detection Techniques – Estimation of R-R interval – Estimation of ST segment inclination – Arrhythmia analysis monitoring – Long term ECG recording – Basics of ECG data reduction techniques.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

Learners are able to

- Design IIR and FIR filters
- Characterize the effects of finite precision representation on digital filters
- Design multirate filters
- Apply adaptive filters appropriately in communication systems
- Apply the analysis of bio signals.

TEXT BOOKS:

1. John G. Proakis & Dimitris G.Manolakis, — Digital Signal Processing – Principles, Algorithms & Applications‖, Fourth Edition, Pearson Education / Prentice Hall, 2007.
2. DC Reddy, Biomedical Signal Processing – Principles and Techniques, Tata McGraw Hill Publishing company Ltd., 2005 (UNITS IV & V)

REFERENCES:

1. Willis J.Tompkins, Biomedical Digital signal processing, Prentice Hall of India Pvt.Litd., 2000
2. Biomedical Signal Analysis A case study approach by RangarajM.Rangayyan, John Wiley publications
3. J. Candy, Signal Processing: The Model Based approach, Mc. Graw Hill.
4. P.RameshBabu, “Digital Signal Processing”, Second Edition, Scitech publications, Chennai, 2003.

U20BM502	BIOMECHANICS	L	T	P	C
		3	0	0	3

Pre-requisite: Basic knowledge of Engineering mechanics and Physics.

COURSE OBJECTIVES:

- To explain the principles of mechanics

- To discuss the mechanics of physiological systems
- To explain the mechanics of joints
- To Illustrate the mathematical models used in the analysis of biomechanical systems.

UNIT I INTRODUCTION TO MECHANICS 9

Newton's law- mechanical behavior of bodies in contact, work, power and energy relationship – Angular kinematics of human movement-measuring angles, angular kinematic relationships – relationships between linear and angular motion. Angular kinetics of human movement-resistance to angular acceleration, angular momentum – Equilibrium and human movement-equilibrium, center of gravity, stability and balance – Kinematic concepts for human motion-forms of motion and joint movement terminology – Kinetic concepts for human motion-basic concepts related to kinetics .- mechanical loads on the human body. Introduction to Constitutive equations – Constitutive equations of Nonviscous fluid, Newtonian Viscous fluid and Hookean Elastic solid.

UNIT II BIOFLUID MECHANICS 9

Intrinsic fluid properties – Density, Viscosity, Compressibility and Surface Tension, Viscometers – Capillary, Coaxial cylinder and cone and plate, Rheological properties of blood, Pressure-flow relationship for Non-Newtonian Fluids, Fluid mechanics in straight tube – Steady Laminar flow, Turbulent flow, Flow development, Viscous and Turbulent Sheer Stress, Effect of pulsatility, Boundary Layer Separation, Structure of blood vessels, Material properties and modeling of Blood vessels, Heart – Cardiac muscle characterisation, Native heart valves – Mechanical properties and valve dynamics, Prosthetic heart valve fluid dynamics.

UNIT III BIOSOLID MECHANICS 9

Constitutive equation of viscoelasticity – Maxwell &Voight models, anisotropy, Hard Tissues – Structure, blood circulation, elasticity and strength, viscoelastic properties, functional adaptation, Soft Tissues – Structure, functions, material properties and modeling of Soft Tissues – Cartilage, Tendons and Ligaments Skeletal Muscle – Muscle action, Hill's models, mathematical modeling, Bone fracture mechanics, Implants for bone fractures.

UNIT IV BIOMECHANICS OF JOINTS 9

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

UNIT V MODELING AND ERGONOMICS 9

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

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Learners are able to

- Explore the electrical activity of living neurons and investigates the molecular and cellular processes that govern their ssignallin
- Identify cardiovascular centers and cardiac reflexes that regulate heart function and factors affecting the heart rate
- Gain the knowledge of physiology of relationship and of central integrative functions typical of human.
- Understanding of basic principles of organic chemistry and how they relate to everyday experiences in functional group to analyze a problems
- Understand the strengths, limitations and creative use of techniques for problem-solving by using chemical analysis process.

TEXT BOOKS:

1. Y.C. Fung, ―Bio-Mechanics- Mechanical Properties of Tissues‖, Springer-Verlag, 1998.
2. Subrata Pal, ―Textbook of Biomechanics‖, Viva Books Private Limited, 2009.

REFERENCES:

1. Krishna B. Chandran, Ajit P. Yoganathan and Stanley E. Rittgers, ―Biofluid Mechanics: The Human Circulation‖, Taylor and Francis, 2007.
2. Sheraz S. Malik and Shahbaz S. Malik, ―Orthopaedic Biomechanics Made Easy‖, Cambridge University Press, 2015.
3. Jay D. Humphrey, Sherry De Lange, ―An Introduction to Biomechanics: Solids and Fluids, Analysis and Design‖, Springer Science Business Media, 2004.
4. Shrawan Kumar, ―Biomechanics in Ergonomics‖, Second Edition, CRC Press 2007.
5. Neil J. Mansfeild, ―Human Response to Vibration‖, CRC Press, 2005.
6. Carl J. Payton, ―Biomechanical Evaluation of movement in sports and Exercise 2008.

U20BM503 BIOMEDICAL INSTRUMENTATION L T P C
3 0 0 3

Pre-requisite: Basic knowledge of Biochemistry and Bioelectric Physiology

COURSE OBJECTIVES:

- To Describe the functioning of the major physiological systems of the human body
- To Examine the various sources of bioelectric signals and the type of electrode to be used for signal pick up
- To learn the different measurement techniques for non-physiological PARAMETERS
- To know about the safety procedures to prevent various risk and Distortion.

UNIT I INTRODUCTION TO BIOMEDICAL INSTRUMENTATION 9

Fundamentals of biomedical Instrumentation – Performance requirement – Generalconstraints in design. Recording Systems: Basic recording system, Electrode electrolyteinterface, half-cell potential,polarization and non- polarizable electrode, needle and wireelectrodeTransducers - Classification, selection of transducers, circuit based on transduction. Temperature transducers - Displacement transducer - Pressure transducer - catheter tiptransducers. Photoelectric transducers - Flow transducers - Piezoelectric transducers and their applications, Biological receptors and receptor characteristics.

UNIT II MEASUREMENT OF ELECTRICAL PARAMETERS 9

Origin of bioelectric potentials: resting and action potential, propagation of action potential.Electrophysiology of heart, origin of ECG, ECG waveforms and characteristics, electrodes and leadconfigurations, 12 lead ECG system Vector cardiograph, magneto cardiograph ,EEG waveforms andcharacteristics, 10-20 electrodeplacement system, EEG machine, evoked potential study. Recoding of EMG, measurement of conduction velocity,Recording of EOG, ERG.

UNIT III MEASUREMENT OF NON-ELECTRICAL PARAMETERS 9

Temperature, respiration rate and pulse rate measurements. Blood Pressure: indirect methods - Auscultatory method, oscillometric method, direct methods: electronic manometer, Pressure amplifiers, Systolic, diastolic, mean detector circuit. Blood flow and cardiac output measurement: Indicator dilution, thermal dilution and dye dilution method, Electromagnetic and ultrasound blood flow measurement.

UNIT IV SENSORY MEASUREMENT 9

Psychophysiological Measurements – polygraph, basal skin resistance (BSR), galvanic skin resistance (GSR), Sensory responses - Audiometer-Pure tone, Speech, Eye Tonometer, Applanation Tonometer, slit lamp, auto refractometer.

UNIT V INSTRUMENTS FOR SURGERY AND PATIENT SAFETY 9

IR and UV lamp and its application. Short wave diathermy, ultrasonic diathermy, Microwave diathermy, Electro surgery machine - Current waveforms, Safety codes for electro medical equipment and electrical safetyAnalyzer, Testing of biomedical equipment, Leakage current and its types.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Learners are able to

- Differentiate different bio potentials and its propagations.
- Illustrate different electrode placement for various physiological recording
- Explain various technique for non-electrical physiogical measurements
- Know about the Sensory measurement system
- Understand the safety procedure and techniques which interact with physiological aspects.

TEXT BOOKS:

1. R. S. Khandpur, Biomedical Instrumentation Technology and Applications, McGraw-Hill Professional, 2004
2. Leslie Cromwell, Fred. J. Weibell and Erich. A. Pfeiffer, “Biomedical Instrumentation and Measurements”, 2nd Edition, PHI, 2003.

REFERENCES:

1. Myer Kutz, “Standard Handbook of Biomedical Engineering and Design”, McGraw Hill Publisher, 2003.
2. Joseph J. Carr and John M. Brown, “Introduction to Biomedical Equipment Technology”, Pearson Education, 2004.
3. Dr M.Arumugam, Biomedical instrumentation, Anuradha Publications.
4. John G. Webster, Medical Instrumentation: Application and Design, 3rd edition, John Wiley & Sons, New York, 1998
5. Raja Rao, C, Guha, S.K, Principles of Medical Electronics and Biomedical Instrumentation, Orient Longman Publishers (2000).

U20BM504 CLINICAL MANAGEMENT

L	T	P	C
3	0	0	3

Pre-requisite: Basic knowledge of Hospital Administration.

COURSE OBJECTIVES:

- To understand the fundamentals of hospital administration and management.
- To know the market related research process
- To explore various information management systems and relative supportive services.
- To learn the quality and safety aspects in hospital.

UNIT I OVERVIEW OF HOSPITAL ADMINISTRATION 9

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

UNIT II HUMAN RESOURCE MANAGEMENT IN HOSPITAL 9

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

UNIT III MARKETING RESEARCH PROCESS 9

Marketing information systems - assessing information needs, developing & disseminating information - Market Research process - Other market research considerations – Consumer Markets & Consumer Buyer Behaviour - Model of consumer behaviour - The buyer decision process - Model of business buyer behavior – Major types of buying situations - WTO and its implications.

UNIT IV HOSPITAL INFORMATION SYSTEMS & SUPPORTIVE SERVICES 9

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

UNIT V QUALITY AND SAFETY ASPECTS IN HOSPITAL 9

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

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Learners are able to

- Successfully demonstrate knowledge of the clinical site's organization, administration, policies and procedures, organizational planning and operation.
- Describe legal and facility standards related to fiscal, billing and reimbursement issues, fraud and abuse.
- Describe communication processes within the clinical arena including referral process, patient delegation, review of records
- Describe possible modifications to interventions outlined in the PT POC by determining what progressions can be made within the POC
- Identifying major indications, contraindication, precautions and safety issues in the documents.

TEXT BOOKS:

1. R.C.Goyal, “Hospital Administration and Human Resource Management”, PHI – Fourth Edition,2006.
2. G.D.Kunders, “Hospitals – Facilities Planning and Management – TMH, New Delhi – Fifth Reprint 2007.

REFERENCES:

1. Cesar A.Caceres and Albert Zara, “The Practice of Clinical Engineering, Academic Press, New York, 1977.
2. Norman Metzger, “Handbook of Health Care Human Resources Management”, 2nd edition Aspen Publication Inc. Rockville, Maryland, USA, 1990.

U20BM505 PROFESSIONAL COMMUNICATION LABORATORY L T P C

0 0 2 1

Pre-requisite: Basic knowledge of Communicative English

COURSE OBJECTIVES:

- Enhance the Employability and Career Skills of students
- Orient the students towards grooming as a professional
- Make them Employable Graduates
- Develop their confidence and help them attend interviews successfully.
- Strengthen their prospects of success in competitive examinations.

UNIT I
Introduction to Soft Skills-- Hard skills & soft skills - employability and career Skills—Grooming as a professional with values—Time Management—General awareness of Current Affairs

UNIT II
Self-Introduction-organizing the material - Introducing oneself to the audience – introducing the topic – answering questions – individual presentation practice— presenting the visuals effectively – 5 minute presentations

UNIT III
Introduction to Group Discussion— Participating in group discussions – understanding group dynamics - brainstorming the topic -— questioning and clarifying –GD strategies- activities to improve GD skills

UNIT IV
Interview etiquette – dress code – body language – attending job interviews– telephone/skype interview -one to one interview &panel interview – FAQs related to job interviews

UNIT V
International English Language Testing System (IELTS) - Test of English as a Foreign Language (TOEFL) - Verbal Ability.

TOTAL: 30 PERIODS

COURSE OUTCOMES:
Learners are able to:
- Make effective presentations
- Participate confidently in Group Discussions.
- Attend job interviews and be successful in them.
- Develop adequate Soft Skills required for the workplace

RECOMMENDED SOFTWARE
1. Globearena
2. Win English

REFERENCES:

1. Peter, Francis. Soft Skills and Professional Communication. New Delhi: Tata McGraw Hill. 2012. Print.
2. E. Suresh Kumar et al. Communication for Professional Success. Orient Blackswan: Hyderabad, 2015
3. Robert M Sherfield and et al. “Developing Soft Skills” 4th edition, New Delhi: Pearson Education, 2009..
4. Raman, Meenakshi and Sangeeta Sharma. Professional Communication. Oxford University
5. Press: Oxford, 2014
6. Roberts, Rachael, Joanne Gakonga, and Andrew Preshous (2004) IELTS Foundation: Study Skills. Oxford: Macmillan Education.

U20BM506	BIOMEDICAL INSTRUMENTATION LABORATORY	L	T	P	C
		0	0	4	2

Pre-requisite: Basic knowledge of Bioelectric Physiology and Apparatus

COURSE OBJECTIVES:
- To provide hands-on training on designing of bio signal acquisition system and measurement of physiological parameters, biochemical parameters.

LIST OF EXPERIMENTS

1. Design and analysis of biological pre amplifiers
2. Recording of ECG signal and EMG-Signal
3. Recording of EEG-Signal
4. Recording of various physiological parameters using patient monitoring system and telemetry units.
5. Measurement of pH and conductivity.
6. Measurement and recording of peripheral blood flow
7. Measurement of visually evoked potential.
8. Study of characteristics of optical Isolation amplifier
9. Galvanic skin resistance (GSR) measurement
10. Design a PCB layout for any bio amplifier using suitable software tool.
11. Measurement of pH and conductivity

LAB REQUIREMENTS FOR A BATCH OF 30 STUDENTS:

1. Multiparameter patient monitoring system : 1 No.
2. EEG recorder with accessories for evoked studies : 1 No.
3. ECG recorder : 1 No.
4. EMG recorder : 1 No.
5. pH meter, conductivity meter : 1 No.
6. Blood flow measurement system using ultrasound transducer: 1 No.
7. GSR measurement setup. : 1 No.
8. Function Generators
9. DSOs
10. Regulated Power supplies
11. Bread boards
12. IC 741

TOTAL: 60 PERIODS

COURSE OUTCOMES:

Learners are able to

- Design the amplifier for Bio signal measurements
- Recording and analysis of bio signals.

U20BM507	BIO SIGNAL PROCESSING LABORATORY	L	T	P	C
		0	0	4	2

Pre-requisite: Basic knowledge of Signals and Systems

COURSE OBJECTIVES:

- To impart the basic concepts of signal processing applied to various bio signals so as to analyse them.
- To understand the major areas of biomedical engineering include Medical instrumentation, Biosensors and signal Rehabilitation engineering, Medical image processing etc.
- To know the basics of various bio signals, their characteristics, processing and analysis.

LIST OF EXPERIMENTS

1. Sine wave generation using MATLAB.
2. Generation of AM, FM & PWM waveforms using MATLAB.
3. Computation of convolution and correlation sequence using MATLAB.
4. Analog and digital signal conditioning
5. Discrete Fourier Transform: (Unfolding the spectrum, Frequency Unwrapping) using MATLAB
6. Design & implementation of IIR filters. (Butterworth andChebyshev Filters) using MATLAB

7. Design & implementation of FIR filters. (Window method and Frequency sampling Method) using MATLAB
8. Implementation of FFT for ECG Signal using MATLAB
9. Spectrum analysis & Noise removal of biomedical signals
10. Design of Notch filter for elimination of 50 Hz from ECG signal.
11. EMG Processing using MATLAB – Rectification and Signal averaging.
12. PC based ECG analyser.
13. EMG processing using MATLAB –Rectification and Signal Averaging
14. ECG data reduction algorithms
15. Down sampling & up-sampling of ECG signal

TOTAL: 60 PERIODS

COURSE OUTCOMES:
Learners are able to

- Understand the basic concepts of signal processing applied to various bio signals.
- Know the major areas of biomedical engineering include Medical instrumentation, Biosensors and signal Rehabilitation engineering, Medical image processing etc.
- Know the basics of various bio signals, their characteristics, processing and analysis

U20BM601 BIO CONTROL SYSTEMS L T P C
4 0 0 4

Pre-requisite: Basic knowledge of Signals and Systems

COURSE OBJECTIVES:

- To understand the concept of closed loop feedback in physiological systems.
- To analyse the systems in time domain and to understand the concept of stability
- To apply mathematical modelling principles in understanding the various fundamental biological systems
- To develop the model of various biological systems based on the time domain analysis.
- To analyse biological system models using MATLAB

UNIT I INTRODUCTION OF CONTROL SYSTEM 12

Open and Closed loop Systems, Modeling and Block Diagrams, Block diagram and signal flow graph representation of systems, reduction of block diagram and signal flow graph, Introduction to Physiological control systems- Illustration, Linear models of physiological systems, Difference between engineering and physiological control system

UNIT II TIME RESPONSE ANALYSIS 12

Time Domain analysis: Standard test signals, Transient and steady state response analysis of first andsecond order systems-Time response specifications, Steady state error constants-generalized error series.Stability-definition. Routh's stability criterion. Absolute and relative stability. Root locus plots - Rules forconstruction -Stability analysis using root locus.

UNIT III BIOLOGICAL SYSTEM MODELS 12

Distributed parameter versus lumped parameter models, Model development of Cardiovascular system- Heart model-circulatory model, Pulmonary mechanics- Lung tissue visco-elastance-chest wall- airways, Interaction of Pulmonary and Cardiovascular models, Static analysis of physiological systems – Regulation of cardiac output, Regulation of ventilation.

UNIT IV BIOLOGICAL CONTROL SYSTEM ANALYSIS 12

Simple models of muscle stretch reflex action, Study of steady state analysis of muscle stretch reflex action, Study of transient response analysis of neuromuscular reflex model action, Study of frequency response of circulatory control model

UNIT V PHYSIOLOGICAL CONTROL SYSTEM MODELS 12

Sugar Level Control Mechanism. Endocrine Control System. Excretion Control, Human Operator Tracking Characteristics. Biological Receptors-Receptor Characteristics. Transfer Function Models of Receptors

TOTAL: 60 PERIODS

COURSE OUTCOMES:

Learners are able to

- Understand the need for mathematical modeling of various systems, representation of systems in block diagrams and signal flow graphs and are introduced to biological control systems
- Analyze the time response of various systems and discuss the concept of system stability
- Understand the concept of modeling basic physiological systems.
- Understand the modeling concepts of physiological control system models.
- Comprehend the application aspects of time and frequency response analysis in physiological control systems.

TEXT BOOKS:

1. I.J. Nagarath and M. Gopal —Control Systems Engineering", Fifth Edition, Anshan Publishers, 2008.(UNIT
2. MichaelCKKhoo,—PhysiologicalControlSystemsǁ,IEEEPress,PrenticeHallofIndia,2005

REFERENCES:

1. Benjamin C. Kuo, — Automatic Control Systemsǁ, Prentice Hall of India,1995.
2. John Enderle Susan Blanchard, Joseph Bronzino —Introduction to Biomedical Engineering, second edition, Academic Press,2005.
3. Richard C. Dorf, Robert H. Bishop, — Modern control systems, Pearson,2004.
4. Carson, E. Salzsieder, Modelling and Control in Biomedical Systems 2000 (including Biological Systems) (IFAC Proceedings Volumes) (Paperback), Pergamon Publishing, January 2001.

U20BM602 ADVANCED BIO MEDICAL INSTRUMENTATION L T P C

3 0 0 3

Pre-requisite: Basic knowledge of Bioelectric Physiology and it's Instrumentation function

COURSE OBJECTIVES:

- To understand the devices for measurement of parameters related to cardiology.
- To illustrate the recording and measurement of EEG Demonstrate EMG recording unit and its uses.
- To explain diagnostic and therapeutic devices related to respiratory parameters.
- To understand the various sensory measurements that hold clinical importance.

UNIT I CARDIAC EQUIPMENT 9

Electrocardiograph, Normal and Abnormal Waves, Heart rate monitor,Holter Monitor, Phono-cardiography, ECG machine maintenance and troubleshooting, Cardiac Pacemaker- Internal andExternal Pacemaker– Batteries, AC and DC Defibrillator- Internal and External,Defibrillator Protection Circuit, Cardiac ablation catheter.

UNIT II NEUROLOGICAL EQUIPMENT 9

significance of EEG, Multi-channel EEG recording system, Epilepsy, Evoked Potential–Visual, Auditory and Somatosensory, MEG (Magneto Encephalo Graph). EEG Bio Feedback Instrumentation. EEG system maintenance and troubleshooting. Brain computer Interface.

UNIT III MUSCULAR AND BIOMECHANICAL MEASUREMENTS 9

Recording and analysis of EMG waveforms, fatigue characteristics, Muscle stimulators, nerve stimulators, Nerve conduction velocity measurement, EMG Bio Feedback Instrumentation. Static Measurement – Load Cell, Pedobarograph. Dynamic Measurement – Velocity, Acceleration, GAIT, Limb position.

UNIT IV RESPIRATORY MEASUREMENT SYSTEM 9

Instrumentation for measuring the mechanics of breathing – Spirometer -Lung Volume and vital capacity, measurements of residual volume, Pneumotachometer – Airway resistance measurement, Whole body Plethysmograph, Intra-Alveolar and Thoracic pressure measurements, Apnoea Monitor. Types of Ventilators – Pressure, Volume, and Time controlled. Flow, Patient Cycle Ventilators,Humidifiers, Nebulizers, Inhalators.

UNIT V SAFETY MEASUREMENTS 9

Physiological effects of electrical currents, macroshock and microshock, preventive measures to reduce shock hazards, Leakage current, isolation of patient circuits, safety of electrically susceptible patients, radiation hazards and safety, shielding, open ground problem and earthing methods.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Learners are able to

- Describe the working and recording setup of all basic cardiac equipment.
- Understand the working and recording of all basic neurological equipment‘s.
- Discuss the recording of diagnostic and therapeutic equipment‘s related to EMG.
- Explain about measurements of parameters related to respiratory system.
- Describe the measurement techniques of sensory responses

TEXT BOOKS:

1. John G. Webster, ―Medical Instrumentation Application and Design‖, 4th edition, Wiley India Pvt Ltd, New Delhi, 2015.
2. Joseph J. Carr and John M. Brown, ―Introduction to Biomedical Equipment Technology‖, Pearson education, 2012.

REFERENCES:

1. Myer Kutz, ―Standard Handbook of Biomedical Engineering & Design, McGraw Hill, 2003.
2. L.A Geddes and L.E.Baker, ―Principles of Applied Biomedical Instrumentation, 3rd Edition, 2008
3. Leslie Cromwell, ―Biomedical Instrumentation and Measurement‖, Pearson Education, New Delhi, 2007.
4. Antony Y.K.Chan,‖Biomedical Device Technology, Principles and design, Charles Thomas Publisher Ltd, Illinois, USA, 2008.
5. B H Brown, R H Smallwood, D C Barber, P V Lawford and D R Hose, ―Medical Physics and Biomedical Engineering‖, 2nd Edition, IOP Publishers. 2001.

U20BM603 MEDICAL IMAGING TECHNIQUES L T P C

3 0 0 3

Pre-requisite: Basic knowledge of Medical Physics and it’s Advanced Techniques

COURSE OBJECTIVES:

- To understand the generation of X-ray and its uses in imaging
- To describe the principle of Computed Tomography.
- To know the techniques used for visualizing various sections of the body.

- To learn the principles of different radio diagnostic equipment in Imaging
- To discuss the radiation therapy techniques and radiation safety.

UNIT I MEDICAL X-RAY EQUIPMENT 9

Nature of X-rays- X-Ray absorption – Tissue contrast. X- Ray Equipment (Block Diagram) – X-Ray Tube, the collimator, Bucky Grid, power supply, Cathode and filament currents, Focusing cup, Thermionic emission, Electromagnetic induction, Line focus principle and the heel effect, Causes of x- ray tube failure: Electron arcing/filament burn out, Failure to warm up tube, High temp due to over exposure, x-ray tube rating charts.X-ray Image Intensifier tubes – Fluoroscopy – Digital Fluoroscopy. Angiography, Cine Angiography, Digital subtraction Angiography. Mammography and Dental x-ray unit.

UNIT II COMPUTED TOMOGRAPHY 9

Principles of tomography, CT Generations, X- Ray sources- collimation- X- Ray detectors-Viewing systems- spiral CT scanning – Ultra fast CT scanners. Advantages of computed radiography over film screen radiography: Time, Image quality, Lower patient dose, Differences between conventional imaging equipment and digital imaging equipment: Image plate, Plate readers, Image characteristics, Image reconstruction techniques- back projection and iterative method. Spiral CT, 3D Imaging and its application.

UNIT III MAGNETIC RESONANCE IMAGING 9

Fundamentals of magnetic resonance- Interaction of Nuclei with static magnetic field and Radio frequency wave- rotation and precession – Induction of magnetic resonance signals – bulk magnetization– Relaxation processes T1 and T2. Block Diagram approach of MRI system- system magnet (Permanent, Electromagnet and Super conductors), generations of gradient magnetic fields, Radio Frequency coils (sending and receiving), and shim coils, Electronic components, fMRI.

UNIT IV NUCLEAR MEDICINE TECHNIQUES 9

Nuclear imaging – Anger scintillation camera –Nuclear tomography – single photon emission computer tomography, positron emission tomography – Recent advances .Radionuclide imaging-Bone imaging, dynamic renal function, myocardial perfusion. Non imaging techniques-hematological measurements, Glomerular filtration rate, volume measurements, clearance measurement, whole -body counting, surface counting.

UNIT V RADIATION THERAPY AND RADIATION SAFETY 9

Radiation therapy – linear accelerator, Telegamma Machine. SRS –SRT,-Recent Techniques in radiation therapy - 3DCRT – IMRT – IGRT and Cyber knife- radiation measuring instruments-Dosimeter, film badges, Thermo Luminescent dosimeters- electronic dosimeter- Radiation protection in medicine- radiation protection principles.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Learners are able to

- Describe the working principle of X ray machine and its application.
- Illustrate the principle computed tomography.
- Interpret the technique used for visualizing various sections of the body using magnetic resonance imaging
- Demonstrate the applications of radio nuclide imaging.
- Outline the methods of radiation safety

TEXT BOOKS:

1. Steve Webb, ―The Physics of Medical Imaging‖, Adam Hilger, Philadelpia, 1988
2. R.Hendee and Russell Ritenour ―Medical Imaging Physics‖, Fourth Edition William, Wiley-Liss, 2002.

REFERENCES:

1. Gopal B. Saha ―Physics and Radiobiology of Nuclear Medicine‖- Third edition Springer, 2006.
2. B.H.Brown, PV Lawford, R H Small wood, D R Hose, D C Barber, ―Medical physics and
3. Biomedical Engineering‖, - CRC Press, 1999.
4. Myer Kutz, ―Standard handbook of Biomedical Engineering and design‖, McGraw Hill, 2003.
5. P.Ragunathan, ―Magnetic Resonance Imaging and Spectroscopy in Medicine Concepts and Techniques‖,Paperback – Import, 2007

U20BM604 MEDICAL IMAGE PROCESSING L T P C
3 0 0 3

Pre-requisite: Basic knowledge of Image processing and Mathematics of Image Formation

COURSE OBJECTIVES:

- To become familiar with digital image fundamentals
- To get exposed to simple image enhancement techniques in Spatial and Frequency domain.
- To learn concepts of degradation function and restoration techniques.
- To study the image segmentation and representation techniques.
- To become familiar with image compression and recognition methods.

UNIT I DIGITAL IMAGE FUNDAMENTALS 9

Steps in Digital ImageProcessing, Sampling and Quantization – Relationships between pixels - Color image fundamentals- RGB, HSI models, Two-dimensional mathematical preliminaries, 2D transforms -DFT, DCT.

UNIT II IMAGE RESTORATION AND SEGMENTATION 9

Noise models – Mean Filters – Order Statistics – Adaptive filters – Band reject Filters – Band pass Filters – Notch Filters – Optimum Notch Filtering – Inverse Filtering – Wiener filtering **Segmentation**: Detection of Discontinuities–Edge Linking and Boundary detection – Region based segmentation- Morphological processing- erosion and dilation.

UNIT III IMAGE ENHANCEMENT AND COMPRESSION9 9

Spatial Domain: Gray level transformations – Histogram processing – Basics of Spatial Filtering– Smoothing and Sharpening Spatial Filtering, Frequency Domain: Introduction to Fourier Transform– Smoothing and Sharpening frequency domain filters – Ideal,Butterworth and Gaussian filters, Homomorphic filtering, Color image enhancement.

UNIT IV DIFFERENT MODES OF MEDICAL RECORDING 9

Quality assurance and image improvement in diagnostic radiology with X-Rays,specific Quality assurance tests for X-rays, need for sectional images, principles of sectional images recording, computer tomography. Mammographic X-Rays Equipment, Fluoroscopy.

UNIT V MATHEMATICS OF IMAGE FORMATION AND IMAGE PROCESSING 9

Concept of object and image, general image processing problem, discrete fourier representation and models for imaging, image restoration, image sampling, perception of moving images. – Image reconstruction in computed tomography and MRI.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Learners are able to

- Know and understand the basics and fundamentals of digital image processing, such as digitization, sampling, quantization, and 2D-transforms.
- Operate on images using the techniques of smoothing, sharpening and enhancement.
- Understand the restoration concepts and filtering techniques.
- Applying a mathematical formulation in medical field.
- Know about the medical recording process.

TEXT BOOKS:

1. K.Kirkshung, Michael B.Smith and Benjamin Tsui " Principles of Medical Imaging"san Diego, California.
2. Anil K. Jain, ‗Fundamentals of Digital Image Processing', Pearson, 2002.

REFERENCES:

1. Kenneth R. Castleman, ‗Digital Image Processing', Pearson, 2006.
2. Paul Suetens - "Fundamentals of Medical Imaging", Cambridge Medicine
3. Rafael C. Gonzalez, Richard E. Woods, Steven Eddins, Digital Image Processing using MATLAB', Pearson Education, Inc., 2011.
4. D,E. Dudgeon and RM. Mersereau, ‗Multidimensional Digital Signal Processing', Prentice Hall Professional Technical Reference, 1990.
5. Albert Macouski, "Medical Imaging systems", Prentice Hall, New Jersey 2nd edition 1997.

U20BM605	MEDICAL IMAGE PROCESSING LABORATORY	L	T	P	C
		0	0	4	2

Pre-requisite: Basic knowledge of Image processing and Mathematics.

COURSE OBJECTIVES:

- To practice the basic image processing techniques.
- To compute magnitude and phasor representation of images.
- To understand the concepts of image restoration and segmentation.
- To explore the applications of image processing techniques.

LIST OF EXPERIMENTS

Simulation using MATLAB

1. Image sampling and quantization
2. Analysis of spatial and intensity resolution of images.
3. Intensity transformation of images.
4. DFT analysis of images
5. Transforms (Walsh, Hadamard, DCT, Haar)
6. Histogram Processing and Basic Thresholding functions
7. Image Enhancement-Spatial filtering
8. Image Enhancement- Filtering in frequency domain
9. Image segmentation – Edge detection, line detection and point detection.
10. Basic Morphological operations.
11. Segmentation using watershed transformation 12.Analysis of images with different color models.
12. Study of Mammography imaging
13. Study of Thermography Imaging
14. Study of SPECT imaging
15. Study the importance of gamma camera in Imaging
16. A mini project based on medical image processing

TOTAL: 60 PERIODS

COURSE OUTCOMES:

Learners are able to

- Perform enhancing operations on the image using spatial filters and frequency domain filters.
- Use transforms and analyse the characteristics of the image.
- Perform segmentation operations in the images.
- Estimate theefficiency of the compression technique on the images.
- Apply image processing technique to solve real health care problems

U20BM606 ADVANCED BIO MEDICAL INSTRUMENTATION LABORATORY **L T P C**
0 0 4 2

Pre-requisite: Basic knowledge of Bioelectric Physiology.

COURSE OBJECTIVES:

- To demonstrate recording and analysis of different Bio potentials
- To examine different therapeutic modalities.

LIST OF EXPERIMENTS

1. Measurement of visually evoked potential
2. Study of shortwave and ultrasonic diathermy
3. Measurement of various physiological signals using biotelemetry
4. Study of hemodialysis model
5. Electrical safety measurements
6. Measurement of Respiratory parameters using spirometry.
7. Study of medical stimulator
8. Analyze the working of ESU – cutting and coagulation modes
9. Recording of Audiogram
10. Analysis of ECG, EEG and EMG.
11. Study the working of Defibrillator and pacemakers
12. Study of ventilators
13. Study of Ultrasound Scanners
14. Study of heart lung machine model
15. Study of CATH LAB setup
16. Study of medical stimulator

LAB REQUIREMENTS FOR A BATCH OF 30 STUDENTS:

- Visually evoked potential setup: 1 No.
- GSR setup: 1 No.
- Multi-output power supply (+15v, -15v, +30V variable, +5V, 2A): 2 Nos.
- Short wave Diathermy 1 No.
- Ultrasound diathermy 1 No. Multiparameter biotelemetry system 1 No.
- Electrical Safety Analyser 1 No.
- Spirometry with associated analysis system: 1 No.
- ECG Simulator 1 No.
- Medical stimulator 1 No
- Surgical diathermy with analyzer 1 No
- Audiometer 1No
- Pacemaker and Defibrillator: 1 No. each
- Haemodialysis model and Heart lung Model: 1 No. each
- Ventilator: 1 No.
- Ultrasound Scanner: 1 No.
- Software to Analyze ECG,EEG and EMG: 1 No

TOTAL: 60 PERIODS

COURSE OUTCOMES:

Learners are able to

- Measure different bioelectrical signals using various methods
- Assess different non-electrical parameters using various methodologies
- Illustrate various diagnostic and therapeutic techniques
- Examine the electrical safety measurements
- Analyze the different bio signals using suitable tools.

U20BM701 TELEHEALTH TECHNOLOGY **L T P C**
3 0 0 3

Pre-requisite: Basic knowledge of Biomedical instrumentation.

COURSE OBJECTIVES:

- Learn the key principles for telemedicine and health.
- Understand telemedical technology.
- 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: 45 PERIODS

COURSE OUTCOMES:

Learners are able to

- Apply multimedia technologies in telemedicine
- Explain protocols behind encryption techniques for secure transmission of data
- Apply telehealth in healthcare
- Know About the Standards which in PACS
- Various application of telemedicine.

TEXT BOOKS:

1. Norris, A.C. “Essentials of Telemedicine and Telecare”, Wiley, 2002.
2. Wootton, R., Craig, J., Patterson, V. (Eds.), “Introduction to Telemedicine. Royal Society of Medicine” Press Ltd, Taylor & Francis 2006

REFERENCES:

1. O'Carroll, P.W., Yasnoff, W.A., Ward, E., Ripp, L.H., Martin, E.L. (Eds), “Public Health Informatics and Information Systems”, Springer, 2003.
2. Ferrer-Roca, O., Sosa - Iudicissa, M. (Eds.), Handbook of Telemedicine. IOS Press (Studies in Health Technology and Informatics, Volume 54, 2002.
3. Simpson, W. Video over IP. A practical guide to technology and applications. Focal Press Elsevier, 2006.
4. Bemmel, J.H. van, Musen, M.A. (Eds.) Handbook of Medical Informatics. Heidelberg, Germany: Springer, 1997.
5. Mohan Bansal, “Medical Informatics”, Tata McGraw-Hill, 2004.

U20BM702 ARTIFICIAL INTELLIGENCE IN HEALTHCARE L T P C
3 0 0 3

Pre-requisite: Basic Concept of Artificial Intelligence and Health care application

COURSE OBJECTIVES:

- To understand the artificial intelligence in health care
- Deals with logistical analysis for AI evaluation in medicine
- Knowledge on the neural network systems in AIs

UNIT I INTRODUCTION 9

Introduction-Artificial Intelligence-Artificial Neural Networks-Fuzzy Systems-Genetic Algorithm and Evolutionary Programming-Swarm Intelligent Systems-Classification of ANNs-McCulloch and Pitts Neuron Model-Learning Rules: Hebbian and Delta- Perceptron Network-Adaline Network-Madaline Network

UNIT II IMPLEMENTATION AND EVALUATION 9

Tools and Technologies for implementing AI methods, Model evaluation and performance metrics, cross-validation, model interpretability. Ethics of AI- bias, fairness, accountability, and transparency in machine learning; Ethical, Legal, and Social Issues of AI in medicine and healthcare.

UNIT III ARTIFICIAL INTELLIGENCE IN NEURAL NETWORK 9

Forms of Learning: supervised, semi-supervised, unsupervised, active, and transfer learning Supervised Learning: Decision trees, non-parametric methods for learning, support vector machines, Unsupervised Learning: basic and advanced clustering techniques, dimensionality reduction (feature selection and feature extraction).

UNIT IV DEEP LEARNING NEURAL NETWORK 9

Bio-inspired Learning(from perceptron to deep learning): neural basis of computing, classicalneural networks, deep neural networks, deep belief networks, recurrent neural networks, and convolutional neural networks.

UNIT V ARTIFICIAL INTELLIGENCE APPLICATIONS 9

Unique characteristics and challenges in medicine and healthcare; History and status quo of intelligent and expert systems in medicine, Clinical decision-making and intelligent systems to support evidence-based medicine, Phenotype and clinical/bio-marker discovery, Relevance to personalized medicine. Analysis of tissue morphology and other medical imaging applications.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Learners are able to

- Understand models of human and artificial intelligence, specifically computational models of intelligence.
- Comprehend a collection of machine learning models(identified and covered in the course), and their applications in medicine and healthcare.
- Identify and apply appropriate intelligent system models and computational tools to specificproblems in biomedicine and healthcare.
- Analyze the performance of specific models as applied to biomedicalproblems, and justify their use and limitations.
- Identify, understand, and interpret methods and evidence from artificial intelligence and other relevant literature.

TEXT BOOKS:

1. Begg, Rezaul, Daniel TH Lai, and MarimuthuPalaniswami. Computational intelligence in biomedical engineering. CRC Press, 2007.

2. Hudson, Donna L., and Maurice E. Cohen. "Neural networks and artificial intelligence for biomedical engineering." Institute of Electrical and Electronics Engineers, 2000.
3. Agah, Arvin. "Introduction to medical applications of artificial intelligence." Medical

REFERENCES:

1. Stuart Russell and Peter Norvig. Artificial Intelligence: A Modern Approach(3rd ed.). Prentice Hall Press, Upper Saddle River, NJ, USA2009.
2. Toby Segaran. Programming Collective Intelligence(First ed.). O'Reilly.2007.
3. Tony J. CleophasandAeilkoH. Zwinderman. Machine Learning in Medicine -a Complete Overview. Springer2015.
4. Sunila Gollapudi, S. Practical Machine Learning. Packt Publishing Ltd.2016.
5. Neural Networks and Artificial Intelligence for Biomedical Engineering, IEEE Press Series in Biomedical Engineering Metin Akay, Series Editor

U20BM703 MEDICAL EQUIPMENT MAINTENANCE AND TROUBLESHOOTING L T P C
3 0 0 3

Pre-requisite: Basic Concept of Equipment Maintenance and Troubleshooting

COURSE OBJECTIVES:

- To understand troubleshooting of electrical and electronic equipment.
- To learn the troubleshooting of medical equipment.
- To apply the tools in design, testing and developing medical equipment

UNIT I TESTING OF ELECTRICAL EQUIPMENTS 9

AC, DC power supply, Grounding, shielding, Guarding, insulation testing, insulation resistance measurement, Types of Circuit Breakers, Rating – Testing of circuit breakers –Transformer testing-Earthing –Earth wires - Earthing of appliances –contactor, relay testing–CT and PT, Panel wiring-Megger-Testing equipment and instruments.

UNIT II TESTING OF ELECTRONIC COMPONENTS 9

Troubleshooting of PCB boards, Calibration of analog and digital sensor probe, Display interface, DC Power supply design, testing, Safe electrical practice,
Cables and standard, Fuse.

UNIT III TESTING OF SURGICAL EQUIPMENT 9

Functions and operating procedure-Testing and maintenance of Heart lung machine, surgical lights, ventilator, patient monitor, anesthesia machine, dialyzer, surgical tools.

UNIT IV TROUBLESHOOTING OF EQUIPMENTS 9

X-ray machines, Troubleshooting of ECG recorders, incubator, baby warmer, infusion pumps, annual maintenance, contract requirements, vendor services, quality and safety standards.

UNIT V LIFE CYCLE MANAGEMENT OF MEDICAL EQUIPMENT 9

Cost of the medical equipment, maintenance cost, replacement analysis, managing equipment service, decision making, extracting optimal benefit from medical equipment over its life cycle. Case study.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Learners are able to

- Identify the reasons for equipment failure.
- Interpret the need for grounding aspects, maintenance and troubleshooting.
- Construct the test bench, tools and methods for troubleshooting
- Compare various standards and specifications.
- Decide quality and safety standards
- Formulate advanced methods to solve critical problems

TEXT BOOKS:

1. JohnnaFisher, “Biomedical Ethics: A Canadian Focus.” Oxford University Press Canada 2009.
2. Ben Mepham,”Bioethics-—An Introduction for the biosciences”,Oxford, 2008.
3. Domiel A Vallero, “Biomedical Ethics for Engineers”, Elsevier Pub.1st edition, 2007.

REFERENCES:

1. Joint Commission Accreditation Standards for Hospitals, 2nd edition 2003.
2. NilsHoppe and Jose Miola, “Medical law and Medical Ethics”, Cambridge University Press2014.
3. Robert M Veatch,” Basics of Bio Ethics”, Second Edition. Prentice- Hall,Inc, 2003
4. Physical Environment Online: A Guide to The Joint Commissions Safety Standards, HCPro, Inc.2010
5. Mohan Bansal, “Medical informatics”, Tata Mc Graw Hill Publishing Ltd, 2003.

U20BM704 HOSPITAL TRAINING L T P C
0 0 4 2

Pre-requisite: Basic Knowledge of Hospital Administration and Equipment.

ASSESSMENT:

- Students need to complete training in any leading Multi-speciality hospital for a period of 15 days. They need to prepare an extensive report and submit to their respective course in-charges during the session.
- Out of the following departments, it is mandatory to complete training in any 10. The students can give a presentation of the remaining departments during laboratory hours.

LIST OF DEPARTMENTS:

Sl. No.	Departments for visit
1	Cardiology
2	ENT
3	Ophthalmology
4	Orthopaedic and Physiotherapy
5	ICU/CCU
6	Operation Theatre
7	Neurology
8	Nephrology
9	Radiology
10	Nuclear Medicine
11	Pulmonology
12	Urology
13	Obstetrics and Gynaecology

TOTAL: 60 PERIODS

COURSE OUTCOMES:

Learners are able to

- Advocate a patient-centred approach in healthcare
- Communicate with other health professionals in a respectful and responsible manner
- Recognize the importance of inter-professional collaboration in healthcare.
- Propose a patient-centred inter-professional health improvement plan based upon the patient‘s perceived needs
- Use the knowledge of one‘s own role and those of other professions to address the healthcare needs of populations and patients served.

U20BM705 **MINI PROJECT** **L T P C**
0 0 2 1

Pre-requisite: Basic Knowledge of Biomedical Modules and hardware apparatus.

OBJECTIVES

- To develop skills to formulate a technical project.
- To estimate the ability of the student in transforming the theoretical knowledge studied so far into a working model of a Biomedical/ Electronics/ Mechatronic/ Instrumentation system.
- To teach use of new tools, algorithms and techniques required to carry out the projects.
- To give guidance on the various procedures for validation of the product and analyze the cost effectiveness.
- For enabling the students to gain experience in organization and implementation of a small
- project and thus acquire the necessary confidence to carry out main project in the final year.
- To provide guidelines to prepare technical report of the project.

TOTAL: 30 PERIODS

COURSE OUTCOMES:
Learners are able to:

- Formulate a real world problem, identify the requirement and develop the design solutions.
- Express the technical ideas, strategies and methodologies.
- Utilize the new tools, algorithms, techniques that contribute to obtain the solution of the project.
- Test and validate through conformance of the developed prototype and analysis the cost effectiveness.
- Prepare report and present the oral demonstrations.

U20BM801 HUMAN ASSIST DEVICES AND IMPLANT TECHNOLOGY **L T P C**
3 0 0 3

Pre-requisite: Basic Knowledge of Assist device and Implant Process.

COURSE OBJECTIVES:

- To mimic the natural pulsing action of the heart
- To carry out any physical activity without discomfort
- To provide temporary support while a patient waits for heart transplantation.

UNIT I ASSISTIVE TECHNOLOGY FOR MOBILITY **9**

Basic assessment and evaluation for mobility, Control systems, navigation in virtual space by wheelchairs, Wheel chair seating and pressure ulcers, Fuzzy logic expert system for automatic tuning of myoelectric Prostheses, Intelligent prosthesis.

UNIT II TECHNOLOGY AND SENSORY IMPAIRMENTS **9**

Visual and auditory impairment, assessment methods, Libraille, GRAB, mathematical Braille, Augmentative and alternative methods for hearing impairment, Use of multimedia technology to help hard of hearing children , Haptic as a substitute for vision

UNIT III ASSIST DEVICES FOR VITAL ORGANS AND ADVANCEMENTS IN TECHNOLOGY **9**

Cardiac assist devices, Intra-Aortic Balloon Pump (IABP), auxiliary ventricles, Dialysis for kidneys, Intermittent positive pressure breathing (IPPB) type assistance for lungs, Latest use of Assistive technology for chronic heart diseases and Healthcare, Information technology,

telecommunications, new media in assisting healthcare, Future trends in assistive technology, virtual reality based training system for disabled children.

UNIT IV PRINCIPLES OF IMPLANT DESIGN 9

Principles of implant design, cardiac implants, Clinical problems requiring implants for solution, replacement, Tissue engineering, scaffolds, cells and for materials selection, Case study of organ regeneration.

UNIT V IMPLANT DESIGN PARAMETERS AND ITS SOLUTION 9

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

TOTAL :45 PERIODS

COURSE OUTCOMES:

Learners are able to

- Comprehend the assistive technology (AT) used for mobility
- Summarize the AT for sensory impairment of vision and hearing
- Uncover the assist devices for vital organs and advancements in AT
- Describe the principles of implant design with a case study
- Explain the implant design parameters and solution in use.

TEXT BOOKS

1. Yadin David, Wolf W. von Maltzahn, Michael R. Neuman, Joseph.D, Bronzino, “Clinical Engineering”, CRC Press, 1st edition,2010.
2. Kenneth J. Turner, “Advances in Home Care Technologies: Results of thematch Project”, Springer, 1st edition, 2011.
3. Gerr . M. Craddock “Assistive Technology-Shaping the future”, IOS Press, 1st edition, 2003.

REFERENCES

1. Levine S.N. “Advances in Bio-medical engineering and Medical physics”, Vol. I, II, IV, Interuniversity publications, New York, 1st edition, 1968.
2. Kopff W.J, “Artificial Organs”, John Wiley and sons, New York, 1st edition, 1976.
3. Brownsell, Simon, et al. “A systematic review of lifestyle monitoring technologies,” Journal of telemedicine and telecare 17.4 (2011): 185-189.
4. Daniel Goldstein, Mehmet Oz, “Cardiac assist Devices”, Wiley, 2000.
5. Marion. A. Hersh, Michael A. Johnson, “Assistive Technology for visually impaired and blind”,Springer Science & Business Media, 1st edition.

U20BM802 PROJECT WORK L T P C
0 0 12 6

Pre-requisite: Basic Knowledge of Mini project, Hands on training in Hardware Modules.

COURSE OBJECTIVES:

- To develop the ability to solve a specific problem right from its identification and literature review till the successful solution of the same.

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

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

TOTAL: 180 PERIODS

COURSE OUTCOMES:

Learners are able to

- Take up any challenging practical problems and find solution by formulating proper methodology.

U20BM507 PHYSIOLOGICAL MODELING L T P C
3 0 0 3

Pre-requisite: Basic concepts of Bio control system Models.

COURSE OBJECTIVES:

- Understand and appreciate the value and application of Physiological models and Vital organs.
- Model dynamically varying physiological system
- Understand methods and techniques for analysis and synthesis of dynamic models
- Develop differential equations to describe the dynamic models, simulate and visualize, dynamic responses of physiological models using software.

UNIT I SYSTEM CONCEPT 9

Review of physiological system modelling- system properties- different configurations of tracheal network, static and dynamic resistance, Thermal resistance in human systems, System with volume storage capacity and its electrical analog, Simplified model of respiratory system, Simulation of aortic segments, Comparison of muscle model isotonic response, Step response of resistant / compliant systems –Dye dilution study of circulation, pulse response of first order system.

UNIT II TRANSFER FUNCTION 9

System as an operator and use of Transfer function, Bio Engineering of coupled systems, Examples of transformed signals and circuits for transfer function with impedance concept-Development of lung model, Impedance of a two stage ladder network, Measurement of airway resistance.

UNIT III PERIODIC SIGNALS 9

Sinusoidal Functions, Analysis of Instrumentation to measure air flow system, second order system – representation of a respiratory system, Evaluation of Transfer function from frequency response for muscle response modes, Relationship between Phase lag and Time Delay-closed loop aspects of pupillary control system , Transient Response of an Undamped Second order system, General Description of Natural Frequency Damping, Physical Significance of under damped responses of post systolic operations in aortic arch

UNIT IV FEEDBACK 9

Characterization of Physiological Feedback systems- Hypophysis adrenal systems, pupillary hippus, Uses and Testing of System Stability, Simulation-Hodgkin-Huxley model, Model of cardiovascular variability

UNIT V SIMULATION OF BIOLOGICAL SYSTEMS 9

Simulation of thermal regulation, pressure and flow control in circulation, occulo motor system, Endocrinal system, functioning of receptors, introduction to digital control system

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Learners are able to

- Explain the application of Physiological models
- Describe the methods and techniques for analysis and synthesis of Linear and dynamic system
- Develop differential equations to describe the compartmental physiological model
- Describe Nonlinear models of physiological systems
- Implement physiological models using software to get dynamic responses

TEXT BOOKS:

1. Willian B. Blesser, “A System Approach to Biomedicine”, Mc Graw Hill Book Co., New York, 1969.
2. Manfreo Clynes and John H.Milsum, “Biomedical Engineering System”, McGraw Hill and Co., New York , 1970.
3. Micheal C.K.Khoo, ”Physiological Control System” Analysis, Simulation and Estimation“.- Prentice Hall of India , New Delhi , 2001.

REFERENCES:

1. Richard Skalak and Shu Chien, “Hand Book of Biomedical Engineering”, Mc Graw Hill and Co. New York, 1987.
2. Douglas S.Rigg., “Control Theory and Physiological Feedback Mechanism”, TheWilkliam and Wilkins Co. Baltimore, 1970.

U20BM508 BIOMETRIC SYSTEMS L T P C
3 0 0 3

Pre-requisite: Basic Concepts of Biometric systems

OBJECTIVE:

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

UNIT I INTRODUCTION TO BIOMETRICS 9

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

UNIT II FINGERPRINT TECHNOLOGY 9

History of fingerprint pattern recognition - General description of fingerprints - Finger print feature processing techniques - fingerprint sensors using RF imaging techniques – fingerprint quality assessment– computer enhancement and modelling of fingerprint images – fingerprint enhancement– Feature extraction – fingerprint classification – fingerprint matching.

UNIT III FACE RECOGNITION AND HAND GEOMETRY 9

Introduction to face recognition, Neural networks for face recognition – face recognition from correspondence maps – Hand geometry – scanning – Feature Extraction - Adaptive Classifiers - Visual- Based Feature Extraction and Pattern Classification - feature extraction – types of algorithm –Biometric fusion.

UNIT IV MULTIMODAL BIOMETRICS AND PERFORMANCE EVALUATION 9

Voice Scan – physiological biometrics –Behavioural Biometrics - Introduction to multimodal biometric system – Integration strategies – Architecture – level of fusion – combination strategy –

training and adaptability – examples of multimodal biometric systems – Performance evaluation-Statistical Measures of Biometrics – FAR – FRR – FTE – EER – Memory requirement and allocation.

UNIT V BIO METRIC AUTHENTICATION 9

Introduction – Biometric Authentication Methods-Biometric Authentication Systems–Biometric authentication by fingerprint -Biometric Authentication by Face Recognition. -. Expectation-Maximization theory - Support Vector Machines. Biometric authentication by fingerprint – biometric authentication by hand geometry- Securing and trusting a biometric transaction – matching location –local host - authentication server – match on card (MOC) – Multibiometrics and Two-Factor Authentication.

TOTAL: 45 PERIODS

COURSCE OUTCOMES:

Learners are able to

- Demonstrate knowledge engineering principles underlying biometric systems.
- Analyze design basic biometric system applications
- Understand about the face recognition and hand geometry
- Apply a multimodal technique in biometrics and evaluation
- Know about the Authentication in SVM Techniques

TEXT BOOKS:

1. James Wayman, Anil Jain, DavideMaltoni, Dario Maio, “Biometric Systems, Technology Design and Performance Evaluation”, Springer, 2005 (Units I, II, III & IV)
2. S.Y. Kung, S.H. Lin, M.W.Mak, “Biometric Authentication: A Machine Learning Approach” Prentice Hall, 2005(Unit V)**.**

REFERENCES:

1. Paul Reid, “Biometrics for Network Security”, Pearson Education, 2004.
2. Nalini K Ratha, Ruud Bolle, “Automatic fingerprint Recognition System”, Springer, 2003
3. L C Jain, I Hayashi, S B Lee, U Halici, “Intelligent Biometric Techniques in Fingerprint and Face Recognition” CRC Press, 1999.
4. John Chirillo, Scott Blaul, “Implementing Biometric Security”, John Wiley, 2003.
5. Arun A. Ross, Karthik Nanda Kumar, Anil K. Jain, “Handbook of Multibiometrics”, Springer, 2006**.**

U20BM509 BIO MEMS L T P C

3 0 0 3

Pre-requisite: Basic Knowledge of BioMEMS system

COURSE OBJECTIVES:

- Learn various MEMS fabrication techniques.
- Understand different types of sensors and actuators and their principles of operation at the micro scale level.
- Know the application of MEMS in different field of medicine

UNIT I MEMS MATERIALS AND FABRICATION 9

Typical MEMs and Microsystems, materials for MEMS - active substrate materials-Silicon and its compounds, Silicon piezo resistors, Gallium Arsenide, quartz, polymers. Micromachining hotolithography, thin film deposition, doping, etching, bulk machining, wafer bonding, LIGA.

UNIT II MECHANICAL AND THERMAL SENSORS AND ACTUATORS 9

Mechanics for MEMs design- static bending of thin plates, mechanical vibration, thermomechanics, fracture and thin film mechanics. Mechanical sensors and actuators – beam and cantilever – microplates, strain, pressure and flow measurements, Thermal sensors and actuators- actuator based on thermal expansion, thermal couples, thermal resistor, Shape memory alloys- Inertia sensor, flow sensor.

UNIT III ELECTROSTATIC AND PIEZOELECTRIC SENSORS AND ACTUATORS 9

Parallel plate capacitor, pull in effect, Electrostatic sensors and actuators- Inertia sensor, Pressure sensor, flow sensor, tactile sensor, comb drive. Properties of piezoelectric materials, Piezoelectric sensor and actuator – inchworm motor, inertia sensor, flow sensor.

UNIT IV MICROFLUIDIC SYSTEMS 9

Fluid dynamics, continuity equation, momentum equation, equation of motion, laminar flow in circular conduits, fluid flow in micro conduits, in sub micrometer and nanoscale. Micro scale fluid, expression for liquid flow in a channel, fluid actuation methods, dielectrophoresis, micro fluid dispenser, micro needle, micro pumps-continuous flow system, micro mixers.

UNIT V APPLICATIONS OF BIOMEMS 9

CAD for MEMS, Drug delivery, micro total analysis systems (MicroTAS) detection and measurement methods, microsystem approaches to polymerase chain reaction (PCR), DNA sensor, MEMS based drug delivery, Biosensors- sensors for glucose, uric acid, urea and triglyceride sensor.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Learners are able to

- Discuss various MEMS fabrication techniques.
- Explain different types of sensors and actuators and their principles of operation at the micro Scale level.
- Know about the different sensors in MEMS.
- Apply MEMS in different field of medicine.
- Analysis different methods in Microfluid Systems

TEXT BOOKS:

1. Tai-Ran Hsu, “MEMS & Microsystems- Design, Manufacture and Nanoscale Engineering”, John Wiley& Sons, 2ndedition 2008.
2. Nitaigour Premch and Mahalik, “MEMS”, Tata McGraw Hill, 2ndreprint, 2008.

REFERENCES BOOKS:

1. Ellis Meng, “Biomedical Microsystems”, CRC Press, 1st edition 2011.
2. Simona Badilescu and MuthukumaranPackirisamy, “BioMEMS Science and Engineering Perspectives”,CRC Press, 1stedition 2011.
3. Albert Folch, “Introduction to BioMEMS”, CRC Press, 1stedition 2013.
4. Gerald A Urban, “BioMEMS”, Springer, 1st edition 2006
5. Steven S.Saliterman, “Fundamentals of BioMEMS & Medical Microdevices”, International Society forOptical Engineering, 1stedition, 2006.

U20BM510 BIOMATERIALS L T P C

3 0 0 3

Pre-requisite: Basic Knowledge of Materials.

OBJECTIVES

- Learn characteristics and classification of Biomaterials
- Understand different metals, ceramics and its nanomaterial‘s characteristics as biomaterials
- Learn polymeric materials and its combinations that could be used as a tissue replacement implants
- Get familiarized with the concepts of Nano Science and Technology
- Understand the concept of biocompatibility and the methods for biomaterials testing

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

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

UNIT II METALLIC AND CERAMIC MATERIALS **9**

Metallic implants - Stainless steels, co-based alloys, Ti-based alloys, shape memory alloy, nanostructured metallic implants, degradation and corrosion, ceramic implant – bio inert, biodegradable or bioresorbable, bioactive ceramics, nano structured bio ceramics.

UNIT III POLYMERIC IMPLANT MATERIALS **9**

Polymerization, factors influencing the properties of polymers, polymers as biomaterials, biodegradable polymers, Bio polymers: Collagen, Elastin and chitin. Medical Textiles, Materials for ophthalmology: contact lens, intraocular lens. Membranes for plasma separation and Blood oxygenation, electro spinning: a new approach.

UNIT IV TISSUE REPLACEMENT IMPLANTS **9**

Small intestinal sub mucosa and other decullarized matrix biomaterials for tissue repair: Extra cellular Matrix. Softtissue replacements, sutures, surgical tapes, adhesive, Percutaneous and skin implants, maxillofacial augmentation, Vascular grafts, hard tissue replacement Implants, joint replacements, tissue scaffolding and engineering using Nano biomaterials.

UNIT V TESTING OF BIOMATERIALS: **9**

Biocompatibility, blood compatibility and tissue compatibility tests, Toxicity tests, sensitization, carcinogenicity, mutagenicity and special tests, Invitro and Invivo testing; Sterilisation of implants and devices: ETO, gamma radiation, autoclaving. Effects of sterilization.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Learners are able to

- Analyze different types of Biomaterials and its classification and apply the concept of nanotechnology towards biomaterials use.
- Identify significant gap required to overcome challenges and further development in metallic and ceramic materials
- Identify significant gap required to overcome challenges and further development in polymeric materials
- Create combinations of materials that could be used as a tissue replacement implant.
- Understand the testing standards applied for biomaterials.

TEXT BOOKS:

1. Sujata V. Bhatt, ―Biomaterials‖, Second Edition, Narosa Publishing House, 2005.
2. Sreeram Ramakrishna, MuruganRamalingam, T. S. Sampath Kumar, and Winston O. Soboyejo, ―Biomaterials: A Nano Approach‖, CRC Press, 2010.

REFERENCES:

1. Myer Kutz, ―Standard Handbook of Biomedical Engineering & Design‖, McGraw Hill, 2003
2. John Enderle, Joseph D. Bronzino, Susan M.Blanchard, ―Introduction to Biomedical Engineering‖, Elsevier, 2005.
3. Park J.B., ―Biomaterials Science and Engineering‖, Plenum Press, 1984.
4. A.C Anand, J F Kennedy, M.Miraftab, S.Rajendran,―Woodhead Medical Textiles and Biomaterials for Healthcare‖, Publishing Limited 2006.

5. D F Williams, —Materials Science and Technology: Volume 14, Medical and Dental Materials: A comprehensive Treatment Volumeǁ, VCH Publishers 1992.
6. Monika Saini, Yashpal Singh, Pooja Arora, Vipin Arora, and KratiJain. —Implant biomaterials: A comprehensive reviewǁ, World Journal of Clinical Cases, 2015.

U20BM511 BIOPHOTONICS AND LASER IN MEDICINE L T P C
3 0 0 3

Pre-requisite: Basic Knowledge of Laser and it's Medical Application.

OBJECTIVE:

- To know about the physical properties of light and its impact and interaction with biological tissue in terms of optical properties, instrumentation in photonics, through the use and design of appropriate optical components.
- To understand the engineering and practical applications of optics related to diagnostics, sensing and therapeutics of the human body.
- To demonstrate optical properties of the tissues and 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 – Photoabalative 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 –Laser Tissue welding and soldering techniques.

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 andnon-oncological applications of PDT - Bio stimulation effect – applications-Laser Safety Procedures.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Learners are able to

- Demonstrate knowledge of the fundamentals of optical properties of tissues.
- Analyze the components of instrumentation in Medical Photonics and Configurations.
- Describe surgical applications of lasers.
- Describe photonics and its diagnostic applications.
- Investigate emerging techniques in medical optics.

TEXT BOOKS:

1. Leon Goldman, M.D., & R.James Rockwell, Jr., "Lasers in Medicine", Gordon and Breach, Science Publishers Inc., 1975.

2. Paras N. Prasad, —Introduction to Biophotonics, A. John Wiley and Sons, Inc. Publications, 2003

REFERENCES:

1. Tuan Vo Dirh, “Biomedical Photonics – Handbook”, CRC Press, Bocaraton,2003
2. Glasser, O., “Medical Physics -- Vol 1, 2, 3 “Adam Hilgar BrustolInc, 1987.
3. G.David Baxter “Therapeutic Lasers – Theory and practice”, Churchill Livingstone Publications Edition- 2001.
4. MarkolfH.Niemz, “Laser-Tissue Interaction Fundamentals and Applications”, Springer, 2007.
5. Abraham Katzir, “Lasers and Optical Fibers in Medicine”, Academic Press Edition,1998.

U20BM607 DEVELOPMENT OF MEDICAL DEVICES L T P C
3 0 0 3

Pre-requisite: Basic Knowledge of Assist device and it’s Instrument Measurements

COURSE OBJECTIVES:

- To be exposed to principle of designing and developments
- To be familiar with the mathematical models, analysis and design of biomedical devices using case studies.

UNIT I INTRODUCTION AND CLASSIFICATION OF MEDICAL DEVICES 9

Medical devices definition, design life cycle, Design process versus design control, FDA regulation and inspection, Design models-Pahl and Beitz , Pugh model, Divergent-convergent model, Common design management models , Cross reference with regulatory requirements.

UNIT II IMPLEMENTING DESIGN PROCEDURE 9

Classification /Product specification procedure, Design verification/validation/Evaluation procedure, Risk assessment procedure, Product design specification, Regulatory bodies, Generating and selecting concepts and ideas.

UNIT III QUALITY IN DESIGN 9

Optimization, Overview of quality function deployment (QFD), QFD process, House of quality, Failure mode and effect of analysis, six sigma.

UNIT IV DESIGN REALIZATION 9

The process to design realization, Design calculation, Material selection and standards, Design for usability, Fundamental safety and effectiveness principle, FDA’S interest in standards, Intellectual property.

UNIT V EVALUATION 9

Risk analysis, Criteria based evaluation- Invitro / Invivo, Value to health care analysis, Clinical trials and clinical studies, Synthetic crafts, total hip prosthesis, Hazard analysis and quality control, Analyzing the outcomes and limits to analysis.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Learners are able to

- Solve complex engineering problems by applying principles of engineering, science, and mathematics
- Medical device and in vitro diagnostic (IVD), classification and types of medical devices.
- Medical device and testing, personnel involved, quality assurance, quality management system
- Biocompatibility studies, clinical investigation, risk management, International practices.
- Manufacturing license, inspection, fees, import, export, etc.

TEXT BOOKS:

1. Peter Ogrodnik, “Medical Device Design Innovation from Concept to Market”, Elsevier, 2013.
2. Richard C. Fries, “Handbook of Medical Device Design”, Marcel Dekker AG, 2ndedition, 2005.

REFERENCES:

1. Gail Baura, “Medical Device Technologies: A Systems Based Overview Using Engineering”, Elsevier science, 2012.
2. Matthew B.Weinger, Michael E, Wiklund, DaryleJ. Gardner-Bonneau, “Handbook of Human factors in Medical Device Design”, Taylor and Francis group, 2010.
3. 2. K.Shridhara Bhat, Quality Management, Himalaya Publishing House Cesar A. Cacere & Albert Zana, The Practice of Clinical Engg. Academic press, New York, 1977.
4. Karen Parsley, Karen Parsley Philomena Corrigan‖ Quality improvement in Healthcare, 2nd edition ,Nelson Thrones Pub, 2002.

U20BM608 REHABILITATION ENGINEERING L T P C
3 0 0 3

Pre-requisite: Basic Knowledge of Biomechanics and Continuum model

COURSE OBJECTIVES:

- To understand the rehabilitation concepts and Rehabilitation team members for future development and applications.
- To study various Principles of Rehabilitation Engineering.
- To understand different types of Therapeutic Exercise Technique.
- To understand the tests to assess the hearing loss, development of electronic devices to compensate for the loss and various assist devices for visually and auditory impaired.
- To study the various orthotic devices and prosthetic devices to overcome orthopedic problems.

UNIT I INTRODUCTION TO REHABILITATION 9

What is Rehabilitation, Epidemiology of Rehabilitation, Health, Levels of Prevention, Preventive Rehabilitation, Diagnosis of Disability, Functional Diagnosis, Importance of Psychiatry in Functional diagnosis, Impairment disability handicap, Primary & secondary Disabilities, Rehabilitation team Classification of members, The Role of Psychiatrist, Occupational therapist, Physical therapist, Recreation therapist, Prosthetist - Orthotist, Speech pathologist, Rehabilitation nurse, Social worker, Corrective therapist, Psychologist, Music therapist, Dance therapist & Biomedical engineer.

UNIT II PRINCIPLES OF REHABILITATION 9

Introduction, The Human Component, Principles of Assistive Technology Assessment, Principles of Rehabilitation Engineering- Key Engineering Principles, Key Ergonomic Principles - Practice of Rehabilitation and Assistive Technology.

UNIT III THERAPEUTIC EXERCISE TECHNIQUE 9

Co-ordination exercises, Frenkels exercises, Gait analyses-Pathological Gaits, Gait Training, Relaxation exercises-Methods for training Relaxation, Strengthening exercises-Strength training, Types of Contraction, Mobilisation exercises, Endurance exercises.

UNIT IV MANAGEMENT OF COMMUNICATION & VIRTUAL REALITY 9

Impairment-introduction to communication, Aphasia, Types of aphasia, Treatment of aphasic patient, Augmentative communication-general form of communication, types of visual aids, Hearing aids, Types of conventional hearing aid, Writing aids. Introduction to virtual reality, Virtual reality based rehabilitation, Hand motor recovery systems with Phantom haptics, Robotics and Virtual Reality Applications in Mobility Rehabilitation.

UNIT V ORTHOTIC, PROSTHETIC DEVICES & RESTORATION TECHNIQUES 9

General orthotics, Classification of orthotics-functional & regional, General principles of Orthosis, Calipers- FO, AFO, KAFO, HKAFO. Prosthetic devices: Hand and arm replacement, Body powered prosthetics, Myoelectric controlled prosthetics and Externally powered limb prosthetics. Functional Electrical Stimulation systems-Restoration of hand function, restoration of standing and walking, Hybrid Assistive Systems (HAS).

TOTAL : 45 PERIODS

COURSE OUTCOMES:

Learners are able to

- Gain adequate knowledge about the needs of rehabilitations and its future development.
- Have an in depth idea about Engineering Concepts in Sensory & Motor rehabilitation.
- Apply the different types of Therapeutic Exercise Technique to benefit the society.
- Design and apply different types Hearing aids, visual aids and their application in biomedical field and hence the benefit of the society.
- Gain in-depth knowledge about different types of models of Hand and arm replacement.

TEXT BOOKS:

1. Sunder 'Textbook of Rehabilitation', Jaypee Brothers Medical Publishers Pvt. Ltd, New Delhi, 2nd Edition, Reprint 2007
2. Joseph D.Bronzino, The Biomedical Engineering Handbook, Third edition-3 volume set, Taylor & Francis, 2006.

REFERENCE BOOKS:

1. Horia- Nocholai Teodorecu, L.C.Jain ,Intelligent systems and technologies in rehabilitation Engineering; CRC; December 2000.
2. Keswick. J., What is Rehabilitation Engineering, Annual Reviews of Rehabilitation-Springer- Verlag, New York, 1982.
3. Warren E. Finn,Peter G. LoPresti; Handbook of Neuroprosthetic Methods CRC; edition 2002.
4. Rory A Cooper (Editor), Hisaichi Ohnabe (Editor), Douglas A. Hobson (Editor), 'An Introduction to Rehabilitation Engineering (Series in Medical Physics and Biomedical Engineering' CRC Press, 2006.

U20BM609 NANO TECHNOLOGY IN MEDICINE L T P C

3 0 0 3

Pre-requisite: Basic Knowledge of materials and it's Nano Medical Application**.**

OBJECTIVE:

- To provide a broad view of the nascent field of nanoscience and nanotechnology to undergraduates
- To explore the basics of nanomaterial synthesis and characterization.
- To introduce the applications of nanotechnology

UNIT I FUNDAMENTALS OF NANOSCIENCE 9

Size dependence of properties - Particle size determination -Bulk to nano transition - Semiconducting nanoparticles - Carbon nanostructures – Mechanical properties (hardness, ductility, elasticity) - Optical properties of nanotubes – Electrical properties of nanotubes.

UNIT II NANO-MATERIALS SYNTHESIS AND PROCESSING 9

Methods for creating Nanostructures; Processes for producing ultrafine powders- Mechanical grinding; Wet Chemical Synthesis of nanomaterials- sol-gel process, Liquid solid reactions; Gas Phase synthesis of nano-materials Furnace, Flame assisted ultrasonic spray pyrolysis; Gas Condensation Processing (GPC), Chemical Vapour Condensation(CVC)- Cold Plasma Methods,

Laser ablation, Vapour –liquid –solid growth, particle precipitation aided CVD, summary of Gas Condensation Processing(GPC).

UNIT III STRUCTURAL CHARACTERIZATION 9

X-ray diffraction, Small angle X-ray Scattering, Optical Microscope and their description, Scanning Electron Microscopy (SEM), Scanning Probe Microscopy (SPM), TEM and EDAX analysis, Scanning Tunnelling Microscopy (STM), Atomic force Microscopy (AFM).

UNIT IV FABRICATION TECHNIQUES 9

Micro fabrication Techniques: Lithography, Thin Film Deposition and Doping, Etching and Substrate Removal, Substrate Bonding, MEMS Fabrication Techniques, Bulk Micromachining, Surface Micromachining, High- Aspect-Ratio Micromachining Nanofabrication Techniques: E-Beam and Nano-Imprint Fabrication, Epitaxy and Strain Engineering, Scanned Probe Techniques, Self-Assembly and Template Manufacturing.

UNIT V NANO APPLICATIONS 9

Potential of nanotechnology in medicine - Nanotubes, nanowires, and nanodevices-introduction - Functional Nanostructures – Introduction to molecular electronics- Field emission and Shielding - Micro electromechanical systems (MEMs) -Nano electromechanical systems (NEMs) - Molecular and Supramolecular Switches –Biosensors – Qdots – Nanoshells – Nanobiotix – Cancer detection – Drug Delivery using Nanoparticles and Molecular Carriers.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Learners are able to

- Know the basic concepts of Nano science and technology, Quantum wire, Quantum well,Quantum dot.
- Learn about Material processing by Sol, Gel method, Chemical Vapor deposition and Physical Vapor deposition
- Study the Characterisation of Nanoparticles
- Select micro and nano-manufacturing methods and identify key variables to improve quality of MEMS.
- Choose appropriate industrially viable process, equipment and tools for a specific product

TEXT BOOKS:

1. Marc Madou,Fundamentals of Microfabrication: The Science of Miniaturization, Second Edition CRC Press, 2002
2. Gabor L. Hornyak, H.F Tibbals, Joydeep Dutta & John J Moore, Introduction to Nanoscience and Nanotechnology, CRC Press, 2009

REFERENCES:.

1. Mark James Jackson, Microfabrication and Nanomanufacturing, CRC Press, 2005.
2. Ray F. Egerton , Physical Principles of Electron Microscopy: An Introduction to TEM, SEM, and AEM, Springer, 2005.
3. Robert F Speyer, Thermal Analysis of Materials, Marcel Dekker Inc , New York, 1994.
4. B.D. Cullity - Elements of X-Ray Diffraction, 3rd edition, Prentice Hall, 2002.
5. Tai-Ran Hsu, “MEMS and Microsystems: Design and Manufacture,” McGraw- Hill, 2008.

U20BM610 EMBEDDED SYSTEMS IN MEDICAL DEVICES L T P C

3 0 0 3

Pre-requisite: Basic Knowledge of Microcontrollers and Design of medical devices.

COURSE OBJECTIVES:

- The purpose of learning this course on embedded systems in medical devices for biomedical engineers
- To impart knowledge in the design of embedded system for various medical devices.

UNIT I EMBEDDED DESIGN WITH MICROCONTROLLERS 9

Product specification – hardware / software partitioning, Detailed hardware and software design – integration, product testing, Microprocessor versus microcontroller, Performance tools, bench marking processors, RTOS micro controller -issues in selection of processors.

UNIT II PARTITIONING DECISION 9

Hardware / software duality, Hardware-software portioning, coding for hardware/software development, ASIC revolution, Managing the risk, co-verification, execution environment, Memory organization of controller, memory enhancement, Firmware, speed and code density, system startup.

UNIT III FUNCTIONALITIES FOR SYSTEM DESIGN 9

Timers, watch dog timers, RAM, flash memory, basic toolset, integration of hardware & firmware, Application programming, IDE, target configuration, Host based debugging analyser Remote debugging, ROM emulators, logic.

UNIT IV DESIGN OF PATIENT MONITORING DEVICES 9

Design consideration of patient monitoring systems, Basic block diagram of pulse oximeter, design requirement of device, Circuit implementation of interfacing of oximeter sensors with microcontroller, Software coding and implementation.

UNIT V DESIGNING OF PACEMAKER 9

System description of pacemaker, Design requirement and basic block diagram of pacemaker, Interfacing of pacemaker elements with processors, Software coding of pacemaker and implementation.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Learners are able to

- Attain knowledge on the basic concepts and the building blocks for embedded system
- Understand the hardware and software partitioning in embedded systems
- Gain knowledge about timers and memory organization of embedded systems
- Design a pulse oximeter using embedded tool
- Design a pacemaker using embedded tool.

TEXT BOOKS:

1. Marilyn Wolf, ―Computers as Components - Principles of Embedded Computing System Design‖, Third Edition ―Morgan Kaufmann Publisher (An imprint from Elsevier), 2012.
2. Jane W.S.Liu, Real Time Systems, Pearson Education, Third Indian Reprint, 2003.

REFERENCES:

1. Lyla B.Das, ―Embedded Systems : An Integrated Approach‖ Pearson Education, 2013.
2. Jonathan W.Valvano, ―Embedded Microcomputer Systems Real Time Interfacing‖, Third Edition Cengage Learning, 2012.
3. David. E. Simon, ―An Embedded Software Primer‖, 1st Edition, Fifth Impression, Addison-Wesley Professional, 2007.
4. Raymond J.A. Buhr, Donald L.Bailey, ―An Introduction to Real-Time Systems- From Design to Networking with C/C++‖, Prentice Hall, 1999.
5. C.M. Krishna, Kang G. Shin, ―Real-Time Systems‖, International Editions, Mc Graw Hill 1997
6. K.V.K.K.Prasad, ―Embedded Real-Time Systems: Concepts, Design & Programming‖, Dream Tech Press, 2005.
7. Sriram V Iyer, Pankaj Gupta, ―Embedded Real Time Systems Programming‖, Tata Mc Graw Hill, 2004.

U20BM611 MACHINES IN EMERGING BIOMEDICAL ENGINEERING **L T P C**
3 0 0 3

Pre-requisite: Basic Knowledge of Machine Learning and it's Medical Application.

COURSE OBJECTIVES:

- To develop classifiers for detection of disorders
- To improve healthcare diagnosis, monitoring and therapy
- To develop a machines learning language and algorithm.

UNIT I MACHINE LEARNING BASICS **9**

Introduction – What is learning History of machine learning, Algorithm types for machine learning, the human Touch, Uses for machine learning, Languages for machine learning.

UNIT II PLANNING FOR MACHINE LEARNING **9**

Machine learning cycle, defining the process, building a data team, Data processing, data storage, Data privacy, data quality and cleaning.

UNIT III WORKING WITH DECISION TREES AND BAYESIAN NETWORKS **9**

Basics of decision trees – uses, advantages and limitations, Different algorithm types and working of decision trees, Bayesian networks – little graph theory, little probability theory, Bayes theorem, working of Bayesian networks.

UNIT IV MACHINE LEARNING DELIVERY AND MOTIONMANAGEMENT IN RADIOTHERAPHY **9**

Method to emulate and compensate breathing motion during radiation therapy, Image-based motion correction, Detection and prediction of radiotherapy errors, Treatment delivery validation - recent advancements in radiotherapy application through machine learning.

UNIT V HEMATOLOGICAL CYTOLOGY APPLICATIONSTHROUGH MACHINE LEARNING **9**

Automatic analysis of microscopic images in haematological cytology applications, Methods to detect, classify and measure objects in hematological cytology, Fully automated blood smear analysis system, Recent advances of main automated analysis steps in hematological cytology applications.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Learners are able to

- Explain the history, algorithm types, languages for machine learning
- Describe machine learning cycle with different data parameters
- Outline the decision trees and Bayesian networks
- Investigate the knowledge of machine learning in radiotherapy
- Summarize the methods to detect, classify and measure objects in hematological cytology.

TEXT BOOKS:

1. Issam E I Naqa., "Machine Learning in Radiation Oncology - Theory and Applications", Springer,1stedition, 2015.
2. Jason Bell, "Machine Learning for Big Data: Hands on for Developers and Technical Professionals", John Wiley & Sons, 1stedition,2014.

REFERENCES:

1. Kenneth R Foster, Robert Koprowski, Joseph D Skufca.,"Machine learning, medical diagnosis, andbiomedical engineering research – commentary", Journal of Biomedical Engineering, 2014.

2. Koprowski R, Zieleźnik W, Wróbel Z, Małyszek J, Stepien B, Wójcik W., “Assessment of significance offeatures acquired from thyroid ultrasonograms in Hashimoto's disease”, Journal of BiomedicalEngineering Online, 2012.
3. David A. Rubenstein, Wei Yin, Mary D. Frame., “Machine Learning and Data mining: Introduction toPrinciples and Algorithms”, Horwood Publishing Ltd, 1stedition, 2007.
4. Cyran KA, Kawulok J, Kawulok M, Stawarz M, Michalak M, Pietrowska M, Polańska J., “SupportVector Machines in Biomedical and Biometrical Applications. In Emerging Paradigms in MachineLearning”, Vol.13, Springer, 2013
5. Shan Suthaharan, Machine Learning Models and Algorithms for Big Data Classification, Springer publication.

U20BM706 BRAIN COMPUTER INTERFACE AND ITS APPLICATIONS L T P C
3 0 0 3

Pre-requisite: Basic Knowledge of Brain Computer Interface and it’s medical application.

OBJECTIVE:

- Understand the basic concepts of brain computer interface.
- Study the various signal acquisition methods.
- Learn about the signal processing methods used in BCI.
- Understand the various machine learning methods of BCI.
- Learn the various applications of BCI.

UNIT I INTRODUCTION TO BCI 9

Concept of BCI – Invasive and Non-invasive Types – EEG Standards – Signal Features –Spectral Components – EEG Data Acquisition – Pre-processing – Hardware and Software – Artifacts – Methods to Remove – Near Infrared BCI

UNIT II BCI APPROACHES 9

Mu Rhythm – Movement Related EEG Potentials – Mental States – Visual Evoked Potential Based – P300 component.

UNIT III EEG FEATURE EXTRACTION METHODS 9

Time/Space Methods – Fourier Transform – Wavelets – AR models – Band pass filtering –PCA – Laplacian Filters – Linear and Non-linear Features.

UNIT IV EEG FEATURE TRANSLATION METHODS 9

LDA – Regression – Memory Based – Vector Quantization – Gaussian Mixture Modelling –Hidden Markov Modelling.

UNIT V CASE STUDY 9

Case Study of Problems in BCI Competition III (2005) – Dataset I, II, III, IV and V –Solutions. Case Study of Brain Actuated Control of Khepera Mobile Robot.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Learners are able to

- Learn EEG Data Acquisition, Pre-processing, Hardware and Software and Artifacts.
- Learn the Movement Related EEG Potentials and Mental States and Visual Evoked Potential Based – P300 component.
- Learn Laplacian Filters their Linear and Non-linear Features
- Vector Quantization and Gaussian Mixture Modeling.
- Study the Case Study of Brain Actuated Control of Khepera Mobile Robot.

TEXT BOOKS:

1. Special Issue on Brain Control Interfaces, IEEE Transactions on Neural Systems and Rehabilitation Engineering, Vol 14, June 2006.
2. Andrew Webb, “Statistical Pattern Recognition”, Wiley International, Second Edition, 2000

REFERENCES:

1. R.Spehlmann, “EEG Primer”, Elsevier Biomedical Press, 1981.
2. Arnon Kohen “Biomedical Signal Processing”, Vol I and II, CRC Press Inc, ocaRato ,Florida.
3. Bishop C.M, “Neural Networks for Pattern Recognition”, Oxford, Clarendon Press, 1995
4. TorstenFelzer, “On the possibility of Developing a Brain Computer Interface”, Technical Report, Technical University of Darmstadt, Germany,2001.
5. Wolpaw J.R, N.Birbaumer et al, “Brain control interface for Communication and control”, Clinical Neurophysiology, 113, 2002.
6. Jose del R.Millan et al, “Non-invasive brain actuated control of a mobile robot by human EEG”, IEEE Transactions on biomedical Engineering, Vol 51, No.6, 2004 June.
7. S.Coyle, T.Ward et al, “On the suitability of near infra-red systems for next generation Brain Computer interfaces”, Physiological Measurement, 25, 2004.
8. Carlo Tomasi, “Estimating Gaussian Mixture Densities with EM – A Tutorial”, Duke University, 2000.
9. R.Dugad, U.B Desai, “A Tutorial on Hidden Markov Modelling”, Signal Processing and Artificial Neural Networks Laboratory, IIT Bombay, 1996.

U20BM707 NUCLEAR IMAGING L T P C
3 0 0 3

Pre-requisite: Basic Knowledge of Nuclear medicine and it’s safety procedure.

COURSE OBJECTIVES:

- To know the techniques used for visualizing various sections of the body.
- To learn the principles of different radio diagnostic equipment in Imaging
- To discuss the radiation therapy techniques and radiation safety.

UNIT I INTRODUCTION TO NUCLEAR MEDICINE 9

Radioactive decay: radioactive law, radioactive process, Decay process: units of radioactivity measurement and successive decay equations, Statistics of counting and interaction of radiation with matter, Methods of radionuclide production: nuclear reactor, medical cyclotron and radionuclide generators, Spectra of commonly used radio nuclides and problems in radiation measurements.

UNIT II DETECTOR AND APPLICATION 9

Types detector : pulse current mode operation, Gas Filled detector: basics principle and ionizing chamber, Scintillation Detectors: Inorganic crystalline scintillator in Radiology, Solid state detector and scintillation counting system, Gamma Ray Spectrometry and radionuclide dose calibrator, Properties of detectors, In Vitro techniques: Introduction, single and double isotope method, radioimmunoassay and RIA counting system , In vivo techniques: general principle, uptake monitoring system, rectilinear, computer interface and performance parameter.

UNIT III NUCLEAR MEDICINE IN IMAGING 9

Planar nuclear imaging: introduction to anger scintillation camera, Design and principles of operation: anger scintillation camera and principle of image formation, Design factors determining. Performance, Effect of scatter and attenuation on projection image, operation and routine quality controls, System spatial resolution and efficiency, Computer in nuclear imaging: Image acquisition, frame mode acquisition and list mode acquisition.

UNIT IV EMISSION TOMOGRAPHY TECHNIQUES AND CLINICAL APPLICATIONS 9

Introduction, principles and applications of SPECT, Principles and applications of PET, System performance parameters and quality control functions , Introduction to hybrid modalities: PET/CT, SPECT/CT , Clinical applications: clinical applications of PET, SPECT and hybrid modalities in cardiology, neurology and oncology

UNIT V RADIOPHARMACEUTICALS AND RADIATION SAFETY 9

Introduction to ideal radiopharmaceuticals and methods of radio labelling, Internal radiation dosimetry: absorbed dose calculations to target and non-target tissues, Medical Internal Radiation Dose (MIRD) methodology, Radiation safety: natural and artificial radiation exposure , External and internal radiation hazard and methods of minimizing external and internal exposure , Evaluation of external and internal hazard , Radioactive management and radioactive waste management and ethics in nuclear medicine

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Learners are able to

- Knowledge of technological similarities and differences between the different modalities and choice of equipment for different clinical applications.
- Interpret the technique used for visualizing various sections of the body using magnetic resonance imaging
- Knowledge of ionizing radiation related risks and radiation protection principles in medical imaging.
- Knowledge of new applications and technology trends for the different modalities.
- Knowledge on how to analyse and assess a scientific article.

TEXT BOOKS:

1. Steve Webb, —The Physics of Medical Imaging‖, Adam Hilger, Philadelpia, 1988 (Units I, II, III & IV).
2. R.Hendee and Russell Ritenour —Medical Imaging Physics‖, Fourth Edition William, Wiley-Liss, 2002.

REFERENCE:

1. Gopal B. Saha —Physics and Radiobiology of Nuclear Medicine - Third edition Springer, 2006.
2. B.H.Brown, PV Lawford, R H Small wood, D R Hose, D C Barber, — Medical physics and Biomedical Engineering, - CRC Press, 1999.
3. Myer Kutz, — Standard handbook of Biomedical Engineering and design, McGraw Hill, 2003.
4. P.Ragunathan, — Magnetic Resonance Imaging and Spectroscopy in Medicine Concepts and Techniques, Paperback – Import, 2007.
5. Khandpur R S, — Handbook of Biomedical Instrumentation‖, Tata McGraw Hill, New Delhi, 2003.

U20BM708 CONTINUUM MODELS IN BIOMEDICAL ENGINEERING L T P C
3 0 0 3

Pre-requisite: Basic Knowledge of Biomechanics and Physiological model.

COURSE OBJECTIVES:

- To elucidate the relationship between continuum physics and mathematics.
- To governing equations for all branches of continuum physics
- Focus on application to biological and biomedical processes

UNIT I BASIC CONCEPTS OF PHYSIOLOGICAL SYSTEM 9

Introduction to physiological system and mathematical modelling of physiological system The technique of mathematical modelling, classification of models-black box & building block, characteristics of models. Purpose of physiological modelling and signal analysis, linearization of nonlinear models. Engineering system and physiological system, System variables & properties-Resistance, Compliance & their analogy. Time invariant and time varying systems for physiological modelling.

UNIT II EQUIVALENT CIRCUIT MODEL 9

Electromotive, resistive and capacitive properties of cell membrane, change in membrane potential with distance, voltage clamp experiment and Hodgkin and Huxley's model of action potential, the voltage dependent membrane constant and simulation of the model, model for strength-duration curve, model of the whole neuron.

UNIT III LINEAR MODEL 9

Respiratory mechanics & muscle mechanics, Huxley model of isotonic muscle contraction, modelling of EMG, motor unit firing: amplitude measurement, motor unit & frequency analysis. Modelling of Blood flow and Urine formation: Electrical analog of blood vessels, model of systematic blood flow, model of coronary circulation, transfer of solutes between physiological compartments by fluid flow, counter current model of urine formation, model of Henle's loop Linearized model of the immune response: Germ, Plasma cell, Antibody, system equation and stability criteria..

UNIT IV COMPARTMENTENTAL MODEL 9

Cardio-Pulmonary Modelling: Cardiovascular system and pulmonary mechanics modelling and simulation, Model of Cardiovascular Variability, Model of Circadian Rhythms Eye Movement Model: Types of Eye movement, Eye movement system and Wetheimer's saccade eye model. Robinson's Model, Oculomotor muscle model, Linear Reciprocal Innervations Oculomotor Model.

UNIT V SIMULATION OF PHYSIOLOGICALSYSTEMS9

Simulation of physiological systems using Open CV / MATLAB software, MIMMICS. Biological receptors: - Introduction, receptor characteristics, transfer function models of receptors, receptor and Perceived intensity. Neuromuscular model, Renal System, Drug Delivery Model.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Learners are able to

- Understand the requirements for the development of mathematical and computational models in the analysis of physiological process/ biological systems
- Select and apply appropriate analytical and numerical tools to solve ordinary differential equation models of biological problems.
- Integrate electrical, electrochemical, physiological and mechanical phenomena into the design of models to assess their inter-dependencies.
- Break down a complex physiological system into the function of its component subsystems, and then build an engineering model based on subsystems.

TEXT BOOKS:

1. Endarle, Blanchard &Bronzino, Introduction to Biomedical Engg. , Academic press.
2. Suresh.R.Devasahayam, Signals & Systems in Biomedical Engineering, Kluwer Academic/ Plenum Publishers.
3. V.Z. Marmarelis, Advanced methods of physiological modeling, Plenum Press.
4. L.Stark, Neurological Control System, Plenum Press.
5. R.B. Stein, Nerve and Muscle, Plenum Press

REFERENCES:

1. Michel C Khoo, Physiological Control Systems -Analysis, simulation and estimation, Prentice Hall of India, 2001.
2. Joseph D, Bronzino, "The Biomedical Engineering Handbook", CRC Press, 3rd edition, 2006.
3. Modeling and Simulation in Medicine and the Life Sciences (2nd Edition), by F.C. Hoppensteadt and C.S.Peskin, Springer 2002.
4. John D. Enderle, "Model of Horizontal eye movements: Early models of saccades and smooth pursuit", Morgan &Claypool Publishers, 2010.

U20BM709 NEUROPHYSIOLOGY AND NEURAL ENGINEERING L T P C
3 0 0 3

Pre-requisite: Basic Knowledge of Neurophysiology and it's Evaluation.

COURSE OBJECTIVES:

- To discuss the physiological concepts of nerve impulse generation and Electromyography
- To discuss about EEG and its various applications
- To Explore Evoked potentials and its importance in medicine
- To introduce various techniques to study central and peripheral nerve function
- To discuss the electrophysiological evaluation in special situation.

UNIT I BASICS OF NEURON 9

Types of neurons and their functions. Synthesis, storage, & release of neurotransmitters. Neurotransmission: chemical electrical signal transmission, and Postsynaptic potentials Neurotransmission in neurological disease Action of neurotransmitters in peripheral nervous system, Potentials and Signaling — rapid signal transmission Fundamentals of electrical circuits Current around a circuit . Cell membrane circuit Equivalent neuron properties resting membrane potential Membrane currents Passive properties of neurons, Action potential, Action potentials in muscle Chemical and electrical synapses, Nerve-muscle synapse, Post-synaptic potentials, Ionotropic and metabotropic receptors

UNIT II REFLEXES 9

Spinal Reflexes — basic neural circuits ,Control strategies , Tendon organs and muscle spindles ,afferent reflexes , Modulation of spinal reflexes , Reflexes and muscle fatigue ,Reflexes and spinal cord injury, Automatic behaviours — actions that do not involve the motor cortex , Biomechanics of locomotion , Neural control of locomotion , Central pattern generators , Sensory input , Cortical control of the spinal locomotor system , Voluntary Actions — generating the motor commands , Motor system , Reaching and pointing , Muscle strength.

UNIT III ELECTROENCEPHALOGRAPHY AND EVOKED POTENTIALS 9

Electroencephalography (EEG): General Principles and Clinical Applications, Neonatal and Paediatric EEG, EEG Artefacts and Benign Variants, Video EEG monitoring for epilepsy Evoked Potentials and Related Techniques: Visual Evoked potentials (VEPs), Electroretinography and other diagnostic approaches to the Visual System, VEPs in infants and children, Brainstem Auditory Evoked Potentials (AEPs), Brainstem AEPs in infants and children, Somatosensory evoked potentials, Diagnostic and therapeutic role of Magnetic stimulation in neurology.

UNIT IV FUNCTIONAL NEUROIMAGING AND COGNITION 9

Historical and physiological perspective, Functional neuroimaging methods: PET and fMRI, Network analyses, Functional neuroimaging of: Attention, Visual recognition, Semantic memory, Language, Episodic memory, Working memory, Cognitive aging, Neuro-psychologically impaired patient.

UNIT V ELECTROPHYSIOLOGICAL EVALUATION IN SPECIAL SITUATIONS 9

Electrophysiological evaluation of sacral function: Bladder, bowel and sexual function, Vestibular laboratory testing, Polysomnographic evaluation of sleep disorders, Electrophysiologic evaluation of: brain death, patients in the intensive care unit, patients with suspected neurotoxic disorders.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Learners are able to

- Understand the physiology behind generation of nerve impulses.
- Describe various techniques that are used to evaluate the functioning of central and peripheral nervous system.
- Differentiate between a normal and abnormal signal coming from a healthy and a diseased nervous system respectively.
- Know about the electrophysiological evaluation in neuro therapy
- Describe experimental neuroscience data and to study the spiking properties of single neurons within the brain.

TEXT BOOKS:

1. Michael J. Aminoff, et. al., —Aminoff‘s electrodiagnosis in Clinical Neurology, Sixth Edition, Elsevier Saunders, 2012.
2. Kim E. Baretteet. al., —Ganong‘s review of Medical Physiologyǁ, 23rd Edition, McGraw Hill Medical, 2010.

REFERENCES:

1. Eric R. Kandelet. al., —Principles of Neural Scienceǁ, McGraw-Hill, New York, 2012.
2. R. Cooper, et. al, —Techniques in Clinical Neurophysiology: A Practical Manual , Elsevier, Amsterdam, The Netherlands, 2005.
3. Holodny, Andrei I., et al, —Functional neuroimaging: a clinical approachǁ. Informa Health Care, 2008

U20BM710 MEDICAL ETHICS AND STANDARDS L T P C
3 0 0 3

Pre-requisite: Basic Knowledge of Medical Standards.

COURSE OBJECTIVES:

- To achieve familiarity with some basic ethical framework& understand how these ethical frameworks can help us to think through contemporary questions in medical ethics.
- To know about the legal and ethical principles and application of these principles in health care settings
- To gain knowledge about the medical standards that to be followed in hospitals

UNIT I INTRODUCTION TO MEDICAL ETHICS 9

Definition of Medical ethics, Scope of ethics in medicine, American medical Association code of ethics, CMA code of ethics- Fundamental Responsibilities, The Doctor and the Patient, The Doctor and the Profession, Professional Independence, The Doctor and Society

UNIT II TIME DOMAIN ANALYSIS 9

Theories-Deontology & Utilitarianism, Casuist theory, Virtue theory, The Right Theory. Principles Non- Maleficence, Beneficence, Autonomy, Veracity, Justice. Autonomy & Confidentiality issues in medical practice, Ethical Issues in biomedical research, Bioethical issues in Human Genetics & Reproductive Medicine

UNIT III MEDICAL STANDARDS AND HOSPITAL ACCREDITATION 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 Accreditation - JCI Accreditation & its Policies. Patient centered standards, Healthcare Organization management standards -Indian Perspective

UNIT IV HOSPITAL SAFETY STANDARDS 9

Life Safety Standards- Protecting Occupants, Protecting the Hospital From Fire, Smoke, and Heat, Protecting Individuals From Fire and Smoke, Providing and Maintaining Fire Alarm Systems, Systems for Extinguishing Fires Environment of Care Standards-Minimizing EC Risks, Smoking Prohibitions, Managing Hazardous Material and Waste, Maintaining Fire Safety Equipment, Features, Testing, Maintaining, and Inspecting Medical Equipment

UNIT V MEDICAL EQUIPMENT SAFETY STANDARDS 9

General requirements for basic safety & essential performance of medical equipment. IEC 60601standards- Base Standard-general requirement of electrical medical devices, Collateral Standards EMC radiation protection & programmable medical device system, Particular Standards-type of medical device

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Learners are able to

- Apply HCE theory and methods to major topics and issues in contemporary healthcare ethic
- Provide ethical leadership in diverse settings, with the knowledge, skills, competencies and character traits to provide ethics services
- Integrate academic learning with experiential learning in clinical or organizational rotations as a function of service-learning and development as a HCE professional.
- Illustrate the concepts of ethical theories and moral principles for the health professions
- Recommend the suitable principles of medical equipment safety standards in hospitals

TEXT BOOKS:

1. Johnna Fisher, “Biomedical Ethics: A Canadian Focus.” Oxford University Press Canada 2009.
2. Ben Mepham,”Bioethics-—An Introduction for the biosciences”,Oxford, 2008.
3. Domiel A Vallero, “Biomedical Ethics for Engineers”, Elsevier Pub.1st edition, 2007

REFERENCES:

1. Joint Commission Accreditation Standards for Hospitals, 2nd edition 2003.
2. Nils Hoppe and Jose Miola, “Medical law and Medical Ethics”, Cambridge University Press2014.
3. Robert M Veatch,” Basics of Bio Ethics”, Second Edition. Prentice- Hall,Inc, 2003
4. Physical Environment Online: A Guide to The Joint Commissions Safety Standards, HCPro, Inc.2010
5. Mohan Bansal, “Medical informatics”, Tata Mc Graw Hill Publishing Ltd, 2003.

U20BM803 ARTIFICIAL ORGANS AND IMPLANTS L T P C
3 0 0 3

Pre-requisite: Basic Knowledge of materials and it’s Implants Process

COURSE OBJECTIVES:

- To have an overview of artificial organs & transplants
- To describe the principles of implant design with a case study

- To explain the implant design parameters and solution in use
- To study about various blood interfacing implants
- To study about soft tissue replacement and hard tissue replacement

UNIT I ARTIFICIAL ORGANS & TRANSPLANTS 9

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

UNIT II PRINCIPLES OF IMPLANT DESIGN 9

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

UNIT III IMPLANT DESIGN PARAMETERS AND ITS SOLUTION 9

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

UNIT IV BLOOD INTERFACING IMPLANTS 9

Neural and neuromuscular implants, heart valve implants, heart and lung assist devices, artificial heart, cardiac pacemakers, artificial kidney- dialysis membrane and artificial blood.

UNIT V IMPLANTABLE MEDICAL DEVICES AND ORGANS 9

Gastrointestinal system, Dentistry, Maxillofacial and craniofacial replacement, Soft tissue repair, replacement and augmentation, recent advancement and future directions.

TOTAL :45 PERIODS

COURSE OUTCOMES:

Learners are able to

- Gain adequate knowledge about artificial organs & transplants
- Get clear idea about implant design and its parameters and solution
- Have in-depth knowledge about blood interfacing implants
- Explain different types of soft tissue replacement and hard tissue replacement

TEXT BOOKS:

1. Kopff W.J, Artificial Organs, John Wiley and sons, New York, 1st edition, 1976.
2. Park J.B., ―Biomaterials Science and Engineering‖, Plenum Press, 1984.

REFERENCES BOOKS:

1. J D Bronzino, Biomedical Engineering handbook Volume II, (CRC Press / IEEE Press), 2000
2. R S Khandpur, Handbook of Biomedical Instrumentation, Tata McGraw Hill, 2003 3. Joon B Park, Biomaterials – An Introduction, Plenum press, New York, 1992.
3. Yannas, I. V, ―Tissue and Organ Regeneration in Adults‖, New York, NY: Springer, 2001.
4. Yadin David, Wolf W. von Maltzahn, Michael R. Neuman, Joseph.D, Bronzino, ―Clinical Engineering‖, CRC Press, 1st edition,2010.
5. Standard Handbook of Biomedical Engineering & Design – Myer.

U20BM804 MEDICAL INFORMATICS L T P C

3 0 0 3

Pre-requisite: Basic Knowledge of medical data storage and it's standards.

COURSE OBJECTIVES:

- To learn ICT applications in medicine with an introduction to health informatics.

- To understand the theories and practices adopted in Hospital Information Systems in the light of medical standards, medical data formats and recent trends in Hospital Information Systems.

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 - Dialogue with the computer

UNIT II MEDICAL DATA STORAGE AND AUTOMATION 9

Evolution of Medical Standards – IEEE 11073 - HL7 – DICOM – IRMA - LOINC – HIPPA – Electronics Patient Records – Healthcare Standard Organizations – JCAHO (Joint Commission on Accreditation of Healthcare Organization) - JCIA (Joint Commission International Accreditation) - Evidence Based Medicine - Bioethics

UNIT III MEDICAL DATA STORAGE AND AUTOMATION 9

Representation of Data, Data modelling Techniques, Relational Hierarchical and network Approach, Normalization techniques for Data handling - 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

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: 45 PERIODS

COURSE OUTCOMES:

Learners are able to

- Explain the function of Hospital Information Systems
- Analyze medical standards
- Know about the data acquisition and storage
- Apply the virtual instrumentation
- Know about the various recent trends health informatics.

TEXT BOOKS

1. R.D.Lele, “Computers in medicine progress in medical informatics”, Tata McGraw Hill Publishing Ltd, 2005.
2. Mohan Bansal, “Medical informatics”, Tata McGraw Hill Publishing Ltd, 2003.

REFERENCES

1. Orpita Bosu and Simminder Kaur Thukral, “Bioinformatics Databases, Tools and Algorithms”,
   Oxford University press, 2007.
2. Yi Ping Phoebe Chen, “Bioinformatics Technologies”, Springer International Edition, New Delhi, 2000

U20BM805 HOME MEDICARE TECHNOLOGY L T P C
3 0 0 3

Pre-requisite: Basic Knowledge of Medicare technology.

COURSE OBJECTIVES:

- To be eligible for Medicare reimbursement,
- To home health care services must be deemed medically necessary by a physician and provided to a home-bound patient
- To improve function and live with greater independence

UNIT I INTRODUCTION TO HOME MEDICARE 9

Home health care, purpose, legal and ethical aspects, Organization of homecare system, Historical development of home care, Environmental influences on home care, Home care organization, Home care nursing practice, Role of home care nurse and orientation strategies, Infection control in home, Patient education in home

UNIT II WORKING WITH USERS 9

Basic human needs, communication and interpersonal skills, Caregiver observation, recording and reporting, Confidentiality, Working with elderly, aged, Working with children, need for home care, Mobility transfers and ambulation, range of motion exercises, Skin care and comfort.

UNIT III MEDICAL INSTRUMENTS AND DEVICES AT HOME 9

Medical devices at home and its implementation , Scope of market for home medical devices, Unique challenges to the design & implementation of high-tech home care devices , Infant monitors, Medical alert services, Activity monitors.

UNIT IV DIGITAL HOME CARE 9

Video communication to support care delivery to independently living seniors, Establishing an infrastructure for telecare, Implementation of mobile computing in home care programs, Home Medicare management by videophone, Continuous home care through wireless bio-signal monitoring system

UNIT V ADVANCES IN MEDICAL TECHNOLOGIES 9

Dynamic configuration of home services, personalized ambient monitoring, Support for mental health at home, Multi model interaction and technologies for care at home, User centered design of technologies to support care at Home.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Learners are able to

- Summarize the organization and the need for home medicare system
- Identify the skills required for home medicare for the elderly and the children
- Review the biomedical instruments that can be used at home
- Associate digital technical advancements with home medicare
- Comprehend the advances in healthcare technologies and wireless technology related to healthcare system.

TEXT BOOKS:

1. Robyn Rice, “Home care nursing practice: Concepts and Application”, Elsevier, 4th edition, 2006.
2. Lodewijk Bos, “Handbook of Digital Homecare: Successes and Failures”, Vol.3, Springer, 2011.

REFERENCES:

1. Yadin David, Wolf W. von Maltzahn, Michael R. Neuman, Joseph.D,Bronzino, “Clinical Engineering”,CRC Press, 1st edition,2010.
2. KenethJ. Tumer, “Advances in home care technologies”, AT research series,Vol 31,1st edition, IOSpress, 2012.

U20BM806 BODY AREA NETWORKS AND MOBILE HEALTHCARE L T P C
3 0 0 3

Pre-requisite: Basic Knowledge of mobile health care and it’s Networks

OBJECTIVE:

- Learn about body area networks’ and different hardwares related to it
- Provide knowledge in the applications of Body Area Networks.

UNIT I BAN INCEPTION 9

BAN and healthcare, Technical challenges- sensor design, Biocompatibility, energy supply, energy scavenging methods, Optimal node placement, number of nodes, networks for BAN, System security andreliability, standards, BAN Architecture.

UNIT II HARDWARE FOR BAN 9

Processor-Low Power MCUs, mobile computing MCUs, Integrated processor with radio transceiver, memory types and Ranges, Antenna types , PCB antenna, wire antenna, ceramic antenna external antenna, Sensor interface, power sources- batteries and fuel cells for sensor nodes.

UNIT III WEARABLE SENSORS AND STANDARDS FOR BAN 9

Wearables fundamentals and role of wearable sensors, Attributes of wearables, flexible electronics, meta-wearables, Future of wearables, research road map, Wireless personal area network technologies- IEEE 802.15.1,IEEEP802.15.13, IEEE 802.15.14,Zigbee, coexistence issues with BAN.

UNIT IV MOBILE DEVICES FOR HEALTHCARE 9

Wearable system for ECG monitoring, Evaluation of night time performance, smart phone based health care monitoring system, Phone based fall risk prediction, RFID based personal mobile medical assistance, Secure medical sensor network.

UNIT V MOBILEHEALTH TECHNOLOGIES AND APPLICATIONS 9

Mobile nutrition tracking -case study, Accessing existing virtual electronic patient record, mobile personal health records, Monitoring hospital patients, sensing vital signs and transmission using wireless networks, Context aware healthcare applications with Case study.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Learners are able to

- Comprehend technical information and challenges in body area networks (BAN)
- Describe the hardware requirements of BAN
- Review the wearable sensors and standards for BAN
- Describe the medical devices that are available for health care
- Summarize the possible and latest applications of mobile healthcare.

TEXT BOOKS:

1. Annalisa Bonfiglio, Danilo De Rossi, “Wearable Monitoring Systems”, Springer, 1st edition, 2011.
2. Philip Olla, Joseph Tan, “Mobile Health solutions for Biomedical applications”, Medical Information science reference, Hershey New York, IGI Global 2009.

3. Mehmet R. Yuce, JamilY.Khan, “Wireless Body Area Networks Technology, Implementation, and applications”, Pan Stanford Publishing Pvt. Ltd, Singapore, 1st edition, 2012.

REFERENCES:

1. Zhang, Yuan-Ting, “Wearable Medical Sensors and Systems”, Springer, 1st edition, 2013.
2. Guang-ZhongYang(Ed.), “Body Sensor Networks”, Springer, 1st edition, 2006.
3. Konstantina S.Nikita, James C. Lin, Dimitrios, Maria Teresa, “Wireless mobile communication and healthcare”, Second International ICST conference, Mobihealth 2011, Springer, 1st edition, 2011.
4. Ullah, Sana, et al. “A review of wireless body area networks for medical applications”,
5. Patel, Shyamal, et al. “A review of wearable sensors and systems with application in rehabilitation”, Journal of Neuroengineering Rehabilitation. 9.12 (2012): 1-17

U20BM807 REGENERATIVE BIOLOGY L T P C
3 0 0 3

Pre-requisite: Basic Knowledge of Tissue engineering

COURSE OBJECTIVES:

- To understand tissue engineering and regenerative medicine
- To deal with the basic and clinical aspects of stem cell research
- To understand the knowledge on the potential of stem cells for the regeneration of a wide range of tissues and organs.

UNIT I INTRODUCTION 9

Introduction to tissue engineering: Basic definition; current scope of development; use in therapeutics, cells as therapeutic agents, cell numbers and growth rates, measurement of cell characteristics Morphology, number viability, motility and functions. Measurement of tissue characteristics, appearance, cellular component, ECM component, mechanical measurements and physical properties.

UNIT II TISSUE ARCHITECTURE 9

Tissue types and Tissue components, Tissue repair, Engineering wound healing and sequence of events, Basic wound healing Applications of growth factors: VEGF/angiogenesis, Basic properties, Cell-Matrix and Cell-Cell Interactions, telomeres and Self-renewal, Control of cell migration in tissue engineering.

UNIT III BIOMATERIAL 9

Biomaterials: Properties of biomaterials, Surface, bulk, mechanical and biological properties. Scaffolds and tissue engineering, Types of biomaterials, biological and synthetic materials, Biopolymers, Applications of biomaterials, Modifications of Biomaterials, Role of Nanotechnology.

UNIT IV BASIC BIOLOGY OF STEM CELLS 9

Stem Cells: Introduction, hematopoietic differentiation pathway Potency and plasticity of stem cells, sources, embryonic stem cells, hematopoietic and mesenchymal stem cells, Stem Cell markers, FACS analysis, Differentiation, Stem cell systems- Liver, neuronal stem cells, Types & sources of stem cell with characteristics: embryonic, adult, haematopoetic, fetal, cord blood, placenta, bone marrow, primordial germ cells, cancer stem cells induced pleuripotent stem cells.

UNIT V CLINICAL APPLICATIONS 9

Stem cell therapy, Molecular therapy, In vitro organogenesis, Neurodegenerative diseases, spinal cord injury, heart disease, diabetes, burns and skin ulcers, muscular dystrophy, orthopaedic applications, Stem cells and Gene therapy Physiological models, issue engineered therapies, product characterization, components, safety, efficacy. Preservation –freezing and drying. Patent protection and regulation of of tissue-engineered products, ethical issues.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Biomaterials, artificial organs and Tissue engineering, Larry L. Hench, Julian.R Jones, Wood head publishing Ltd, 2005.
2. Principle of Tissue Engineering, Robert P.Lanza, Robert Langer William L.Chick. Academic Press, 2004.

REFERENCES:

1. Tissue Engineering, by Palsson and Bhatia (eds.), Published by Pearson Prentice Hall, 2004
2. E-L Winnacker., From genes to clones: pp 634. VCH Verlagsgesellschaft, Weinheim, FDR. 1987.
3. T.A.Brown, “Gene Cloning“, VCH Publication, 1997..
4. R.W.Old and S.B.Primrose , “Principles of Gene Manipulation” Blackwell Scientific Publication, Sixth Edition, 2002
5. Yannas, I. V, “Tissue and Organ Regeneration in Adults”, New York, NY: Springer, 2001.