DEPARTMENT OF BIOMEDICAL ENGINEERING

B.TECH. BIOMEDICAL ENGINEERING

CURRICULUM STRUCTURE & SYLLABI

(2023-2027 BATCH ONWARDS)

SCHOOL OF ENGINEERING AND TECHNOLOGY
MODY UNIVERSITY OF SCIENCE AND TECHNOLOGY
LAKSHMANGARH

Component	Credits	Courses	
1. University Core (4 Courses)	08	UC 23.101 Human Values & Professional Ethics UC 23.102 Pragmatic English Communication UC 23.201Introduction to Management & Leadership UC 23.202 Entrepreneurship Development	
2. University Elective (2 Courses)	06	Mody university Elective I Mody University Elective II	
3. Basic Science (09 Courses)	25	MA 23.105 Basic Mathematics CY 23.101 Engineering Chemistry CY 23.111 Chemistry Laboratory CY 23.102 Environmental Sciences MA 23.102 Applied Mathematics I	PY 23.101 Engineering Physics PY 23.111 Physics Laboratory MA 23.201 Applied Mathematics-II BM 23.101 Biology for Engineers
4. Engineering Science (10 Courses)	23	EC 23.101 Basics of Electronics Engineering EC 23.111 Electronics Laboratory ME 23.111 Computer Aided Engineering Drawing EE 23.101 Basics of Electrical Engineering EE 23.111 Electrical Laboratory	CS 23.101 Programming for Problem Solving I CS 23.111 Programming Laboratory I ME 23.111 Mechanical Workshop CS 23.205 General Purpose Programming CS 23.255 General Purpose Programming laboratory
5. Program Core (30 Courses)	69	BM 23.201 Human Anatomy and Physiology BM 23.203 Biomedical Transducers and Sensors BM 23.202 Monitoring and Diagnostic Equipment BM 23.204 Microbiology and Pathology BM 23.206 Biomedical Signals and Systems EC 23.201 Electronic Devices and Circuits EC 23.202 Digital Electronics EC 23.204 Integrated Circuits and Applications EC 23.301 Microprocessor and Microcontroller BM 23.301 Biomaterials BM 23.303 Biomedical Imaging Systems BM 23.305 Biomedical Signal Processing BM 23.302 Therapeutic and Surgical Equipment BM 23.304 Medical Image Processing BM 23.306 Biomechanics BM 23.308 Biocontrol System BM 23.310 Hospital Planning and Engineering	BM 23.221 Human Anatomy and Physiology Laboratory BM 23.223 Biomedical Transducer and Sensors Laboratory BM 23.222 Monitoring and Diagnostic Equipment Laboratory BM 23.224 Microbiology and Pathology Laboratory EC 23.221 Electronic Devices and components Laboratory EC 23.224 Digital Electronics Laboratory EC 23.222 Integrated Circuits and Applications EC 23.325 Microprocessor and Microcontroller Laboratory BM 23.221 Biomaterials Laboratory BM 23.225 Biomedical Signal Processing Laboratory BM 23.322 Therapeutic and Surgical Equipment Laboratory BM 23.324 Medical Image Processing Laboratory BM 23.312 Data Analysis in Healthcare
6. Program Elective / MOOCs (5 Courses)	15	MOOC – 01 Program Elective – 04	
7. Project / Summer Internship/ Colloquium (7 Courses)	17	Summer Internship Project – 02 Colloquium – 01	Project – 02 Capstone Project – 02
8. Proficiency (Non-Credit / Non-Graded) (6 Courses)	00	SEFS – 06	
Total	160	63 Courses	

First Year

Common to

B. Tech. Biomedical Engineering / Bioengineering / Biotechnology (All Specialization)

First Year - Autumn Semester										
Course Code	Course Title	Contact Hours Per Week			Credits	ETE Duration (Hours)	Weightage			
		L	T	P			CW	MTE	PBL	ETE
UC 23.101	Human Values & Professional Ethics	2	0	0	2	3	10	40		50
MA 23.105	Basic Mathematics	3	1	0	4	3	10	40		50
CY 23.101	Engineering Chemistry	3	0	0	3	3	10	40		50
BM 23.101	Biology for Engineers	3	0	0	3	3	10	40		50
EC 23.101	Basics of Electronics Engineering	3	1	0	4	3	10	40		50
ME 23.111	Computer Aided Engineering Drawing	0	0	4	2	2	20	20	20	40
CY 23.111	Chemistry Laboratory	0	0	2	1	2	20	20	20	40
EC 23.111	Electronics Laboratory	0	0	2	1	2	20	20	20	40
CY 23.10	Environmental Sciences	2	0	0	2	3	10	40		50
SF 101	Personal Grooming and Fine Dinning (Non Credit)	0	0	2	1	1	50			50
	Total	16	2	10	**22**					

First Year - Spring Semester										
Course Code	Course Title	Contact Hours Per Week			Credits	ETE Duration	Weightage			
		L	T	P			CW	MTE	PBL	ETE
UC 23.102	Pragmatic English Communication	2	0	0	2	3	10	40		50
MA 23.106	Applied Mathematics-I	3	1	0	4	3	10	40		50
PY 23.101	Engineering Physics	3	0	0	3	3	10	40		50
EE 23.101	Basics of Electrical Engineering	3	1	0	4	3	10	40		50
CS 23.101	Programming for Problem Solving I	3	0	0	3	3	10	40		50
CS 23.111	Programming Laboratory I	0	0	4	2	2	20	20	20	40
PY 23.111	Physics Laboratory	0	0	2	1	2	20	20	20	40
EE 23.111	Electrical Laboratory	0	0	2	1	2	20	20	20	40
ME 23.112	Mechanical Workshop	0	0	2	1	2	20	20	20	40
SF 102	Social Grooming, Home & Décor and Business Communication (Non Credit)	0	0	2	1	1	50			50
	Total	14	2	12	**21**					

Semester	I	II	III	IV	V	VI	VII	VIII	Total
Credit	22	21							43

Second Year- Autumn Semester										
Course Code	Course Title	Contact Hours Per Week			Credits	ETE Duration (Hours)	Weightage			
		L	T	P			CW	MTE	PBL	ETE
UC 23.201	Introduction to Management & Leadership	2	0	0	2	3	10	40		50
MA 23. 205	Applied Mathematics-II	3	1	0	4	3	10	40		50
CS 23.205	General Purpose Programming	3	0	0	3	3	10	40		50
EC 23.201	Electronic Devices and Circuits	3	0	0	3	3	10	40		50
BM 23.201	Human Anatomy and Physiology	3	0	0	3	3	10	40		50
BM 23.203	Biomedical Transducer and Sensors	3	0	0	3	3	10	40		50
CS 23.255	General Purpose Programming laboratory	0	0	2	1	2	20	20	20	40
EC 23.221	Electronic Devices and Circuits Laboratory	0	0	2	1	2	20	20	20	40
BM 23.221	Anatomy and Physiology Laboratory	0	0	2	1	2	20	40		40
BM 23.223	Biomedical Transducer and Sensors Laboratory	0	0	2	1	2	20	20	20	40
SF 201	Personal Grooming Fine Dining and Home Safety (Non Credit & Grade)	0	0	2	1	2	50			50
	Total	17	3	10	22					

Second Year – Spring Semester										
Course Code	Course Title	Contact Hours Per Week			Credits	ETE Duration (Hours)	Weightage			
		L	T	P			CW	MTE	PBL	ETE
UC 23.202	Entrepreneurship Development	2	0	0	2	3	10	40		50
	University Elective-I	3	0	0	3	3	10	40		50
EC 23.202	Digital Electronics	3	0	0	3	3	10	40		50
EC 23.204	Integrated Circuits and Applications	3	0	0	3	3	10	40		50
BM 23.202	Monitoring and Diagnostic Equipment	3	0	0	3	3	10	40		50
BM 23.204	Microbiology and Pathology	3	0	0	3	3	10	40		50
BM 23.206	Biomedical Signals and Systems	3	1	0	4	3	10	40		50
EC 23.224	Digital Electronics Laboratory	0	0	2	1	2	20	20	20	40
EC 23.222	Integrated Circuits and Applications Laboratory	0	0	2	1	2	20	20	20	40
BM 23.222	Monitoring and Diagnostic Equipment Laboratory	0	0	2	1	2	20	20	20	40
BM 23.224	Microbiology and Pathology Laboratory	0	0	2	1	2	20	40		40
SF 202	Social Grooming and Professional Skills (Non-credit, Non Grade)	0	0	2	1	2	50			50
		20	1	10	25					

Semester	I	II	III	IV	V	VI	VII	VIII	Total
Credit	22	21	22	25					90

Third Year Autumn Semester									
Course Code	**Course Title**	**Contact Hours Per Week**			**Credits**	**ETE Duration (Hours)**			
		L	**T**	**P**			**CW**	**MTE**	**ETE**
EC 23. 301	Microprocessor and Microcontroller	3	0	0	3	3	10	40	50
BM 23.301	Biomaterials	3	0	0	3	3	10	40	50
BM 23.303	Medical Imaging Systems	3	0	0	3	3	10	40	50
BM 23.305	Biomedical Signal Processing	3	0	0	3	3	10	40	50
	Program Elective-1*	**0**	0	0	3	-	Based on MOOC Course Examination Grading		
EC 23.325	Microprocessor and Microcontroller Laboratory	0	0	2	1	2	10	40	50
BM 23.321	Biomaterials Laboratory	0	0	2	1	2	10	40	50
BM 23.325	Biomedical Signal Processing Laboratory	0	0	2	1	2	10	40	50
BM 23.331	Summer Internship – I**	0	0	0	2		100		
BM 23.333	Project I	0	0	4	2		50		50
SF 301	Civility and Ethics Business and Professional Grooming, Corporate Dinning Etiquettes (Non Credit)	0	0	2	1	2	50		50
	Total	15	0	12	22				

Third Year -Spring Semester									
Course Code	**Course Title**	**Contact Hours Per Week**			**Credits**	**ETE Duration (Hours)**			
		L	**T**	**P**			**CW**	**MTE**	**ETE**
BM 23.302	Therapeutic and Surgical Equipment	3	0	0	3	3	10	40	50
BM 23.304	Medical Image Processing	3	0	0	3	3	10	40	50
BM 23.306	Biomechanics	3	0	0	3	3	10	40	50
BM 23.308	Physiological Control System	3	0	0	3	3	10	40	50
BM 23.310	Hospital Planning and Engineering	3	0	0	3	3	10	40	50
BM 23.312	Data Analysis in Healthcare	3	0	0	3	3	10	40	50
BM 23.322	Therapeutic and Surgical Equipment Laboratory	0	0	0	1	2	10	40	50
BM 23.324	Medical Image Processing Laboratory	0	0	0	1	2	10	40	50
BM 23.332	Colloquium	0	0	2	1		100		
BM 23.334	Project II	0	0	4	2		50		50
SF 302	Soft Skills and Interview Skills (Non Credit)	0	0	2	1	2	50		50
	Total	15	1	10	23				

Semester	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**Total**
Credit	22	21	22	25	22	23			135

*The course may be taken through MOOC. NPTEL/SWAYAM/Coursera will be the authorized platform for MOOC course. A minimum 8 week duration is required to earn 3 credits. After successful completion of this MOOC course, the student shall provide the successful completion status/certificate to the University (COE) through HOD/NPTEL/Coursera coordinator."

**Summer Internship-I must be carried out during the summer vacation, specifically between the end of the second year and the start of the third year.

Fourth Year Autumn Semester									
Course Code	**Course Title**	**Contact Hours Per Week**			**Credits**	**ETE Duration (Hours)**			
		L	**T**	**P**			**CW**	**MTE**	**ETE**
	University Elective-II	3	0	0	3	3	10	40	50
	Program Elective-2	3	0	0	3	3	10	40	50
	Program Elective-3	3	0	0	3	3	10	40	50
BM 23.421	Summer Internship –II*	0	0	0	2		100		
BM 23.423	Capstone Project-I	0	0	4	2		100		
	Total	9	0	4	**13**				

*Summer Internship-II must be during the summer vacation, specifically between the end of the third year and the start of the fourth year.

Fourth Year Spring Semester									
Course Code	**Course Title**	**Contact Hours Per Week**			**Credits**	**ETE Duration (Hours)**			
		L	**T**	**P**			**CW**	**MTE**	**ETE**
	Program elective-4	3	0	0	3	3	10	40	50
	Program elective-5	3	0	0	3	3	10	40	50
BM 23.422	Capstone Project-II	0	0	0	6		100		
	Total				12				

Semester	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**Total**
Credit	**22**	**21**	**22**	**25**	**22**	**23**	**13**	**12**	**160**

Credit Distribution across all Components								
Semester	**UC**	**UE**	**BS**	**ES**	**PC**	**PE**	**Proj/SIP**	**Total**
First	02	X	12	07	X	X	X	**22**
Second	02	X	08	11	X	X	X	**21**
Third	02	X	04	04	12	X	X	**22**
Fourth	02	03	X	00	20	X	X	**25**
Fifth	X	X	X	X	15	03	04	**22**
Sixth	X	X	X	X	20	X	03	**23**
Seventh	X	03	X	X	X	06	04	**13**
Eighth	X	X	X	X	X	06	06	**12**
Total	**08**	**06**	**24**	**22**	**68**	**15**	**17**	**160**

UC	University Core	**BS**	Basic Science	**PC**	**Program Core**
UE	University Elective	**ES**	Engineering Science	**PE**	**Program Elective**
Proj/SIP	Project/Summer Internship				

List of Electives

Program Elective	Code	Courses
Program Elective -1		MOOC
Program Elective -2	BM 23.411	Telemedicine
	BM 23.413	Bioinformatics
	BM 23.415	Bio-fluid Mechanics
	BM 23.417	Nanotechnology in Medicine
Program Elective -3	BM 23.412	Tissue Engineering
	BM 23.414	Analytical Instrumentation and Techniques
	BM 23.416	Transport Phenomena in Biological Systems
	BM 23.418	Medical Radiation safety
Program Elective -4	BM 23.419	Rehabilitation Engineering
	BM 23.421	Artificial Organs and Implants
	BM 23.423	Data Mining And Machine Learning for Biomedicine
	BM 23.425	BioMEMS
Program Elective -5	BM 23.422	Fiber Optics and LASER in Medicine
	BM 23.424	Design & Development of Medical Devices
	BM 23.426	Bioethics, IPR and Regulatory affairs

UC 23.101 **Human Values and Professional Ethics** **Total Lectures: 26**
2-0-0-2

Objectives: To create an awareness on professional ethics and human values,
To instill moral and social values and loyalty and to appreciate the rights of others.

Pre-requisite: Nil

1. **Introduction to Human Values:** Morals, Values and Ethics – Happiness & Prosperity Truth, Rights Conduct (Righteousness), Love, non-violence and peace, Humility and character. Core areas of ethics: Social ethics, Personal ethics Integrity and Trustworthiness, Honesty, Loyalty, Courage, Prudence, Confidence, Confidentiality. **[5]**
2. **Understand the Harmony:** Understanding the harmony as co-existing of self and body. Understanding my self, harmony in the family and society harmony in nature. **[4]**
3. **Professional Ethics:** Introduction, meaning of work ethics, professional ethics for Journalists, Physicians, Lawyers, Engineers and Accountants. Intellectual property Rights, scope of ethics, code of conduct, business values and inner consciousness, Ethics at the workplace cybercrime, plagiarism, misconduct, fraudulent use of institutional resources, etc. **[7]**
4. **Corporate Social Responsibility:** Evolution of Corporate Social Responsibility (CSR) in India, CSR models, CSR to different stakeholders, Corporate Social Responsibility Initiatives of Major Companies of India, Promoting value based governance in organization. Whistle blower policy. **[6]**
5. **Ethics and Environment:** Introduction to environmental Issues- Industry and Environmental Pollution, Ethics of Controlling environmental pollution – Impact of environmental pollution on human health – Rights, Duties and care in environmental protection - Sustainable development. **[4]**

Outcome: The students will understand the basic perception of profession, professional ethics, various moral issues and uses of ethical theories.

Text Books:
1. B.N Ghosh “Business Ethics and Corporate Governance”, McGraw Hill Education, Chennai, 2016
2. John R Boatright, “Ethics And The Conduct Of Business”, Pearson Education, New Delhi, 2013.

Reference Books:
1. Raju Ramachandran, “Professional Ethics: Changing Profession and Changing Ethics”, LexisNexis, Butterworths, 2nd Edition 2014.
2. Andrew Crane and Dirk Matten, “Business Ethics”, Oxford University Press, 2nd Edition, 2015.
3. S.K Mandal “Ethics in Business and Corporate Governance” McGraw Hill Education, New Delhi, 2013.
4. R. Subramanian “Professional Ethics”, Oxford University Press, 2015.

MA 23. 105 **Basic Mathematics** **Total Lectures: 40**

Prerequisite: Nil **Credit: 3-1-0-4**

Objective (s): To acquire fundamental knowledge of higher Mathematics and apply in science and engineering disciplines.

1.	**Algebra:** Basic needs of matrices, different types of matrices, addition , multiplication and inverse of matrices, rank of matrix, system of equation using rank of matrix, eigenvalues and eigenvectors of matrix, determinants (second and third order) properties of determinants.	9
2.	**Differential Calculus:** Limits and continuity, derivatives of a standard functions, derivatives of product of two functions, derivatives of quotient of two functions, different chain rules, Mean value theorem, partial derivatives, maxima and minima of functions of single variables.	9
3.	**Integral Calculus**: Definite and indefinite integrals, partial fractions, integration by substitution, integration by parts, definite integral and properties, Multiple Integral (double and triple with constant limits).	9
4.	**Differential Equations I:** Introduction and definition of differential equation, order and degree of differential equation, differential equations of first order and first degree (Variable separable, linear form),	7
5.	**Differential Equations II:** Linear differential equations with constant coefficients (second order), different form of complimentary function and particular integral, Euler Cauchy equation.	6

Outcomes: After completion of the course, students would be able to apply knowledge of algebra and calculus to solve of real word problems related to biomedical engineering

Text Books:

1. Ramana B.V., Higher Engineering Mathematics, McGraw Hill Education, July, 2017.
2. Babu Ram, Engineering Mathematics 1st edition Pearson Education, 2009.

Reference Books:

1. Kreyszig, Erwin, Advanced Engineering Mathematics, 9th edition, New York :Wiley, 2011
2. AICTE Module for Bridge course in Mathematics.

CY 23.101 **Engineering Chemistry** **Total Lectures: 39**

3-0-0-3

Prerequisite(s): NIL

Objective(s):

- To purify the most valuable natural resource of the future-water.
- To understand one of the most versatile Engineering Materials: Polymers their preparation, properties and uses.
- To develop the basics of protecting engineering materials from the natural forces.
- To understand the present day up-to-date knowledge of the contemporary energy sources.
- To build up the basis of the future Engineering materials like superconductors, conducting organic polymers, Nano materials etc.

1. **Water treatment:** Hardness, types of hardness, degree of hardness and its estimation (EDTA methods). Numerical problems on degree of hardness. Boiler troubles: sludge and scale formation, Prevention of sludge and scale formation in boilers. Softening of hard water (Lime-Soda, Permutit, Ion Exchange and calgon methods). Numerical problems based on water treatment (Lime-Soda process). [8]

2. **Polymers and Phase Rule:** Industrial applications of Inorganic and organic polymers. Phase Rule and its application to water and Sulfur system. [8]

3. **Electrochemistry and Corrosion:** Electrochemical Changes, Electrochemical cell and its classifications (Galvanic cell, electrolytic cell). Types of electrodes. Origin of electrode potential, Electrochemical Series. Electromotive force, Nernst equation of electrode potential. [8]
Corrosion: Definition and its significance, Theories of corrosion, Mechanism of corrosion, types of corrosion, Corrosion control (Corrosion inhibitors, Cathodic protection - sacrificial anodic and impressed current cathodic protection).

4. **Fuels and Lubricants:** Introduction - Importance of fuels in Industries. Classifications of fuels, Comparison of solid, liquid & solid fuels, Calorific value of a fuel. Determination of calorific value by Bomb calorimeter. Refining and cracking of petroleum, knocking. Octane Number and Cetane Number. L.P.G., Coal gas and Producer gas. [9]
Lubricants: Introduction and Classification of Lubricants. Properties of Lubricants, Lubricant Oil, Grease, Emulsions.

5. **New Engineering Materials:** Introduction: Superconductors, high and low temperature superconductors, organic electronic materials, Fullerenes and Nano materials, Industrial applications of fullerenes and Nano materials. [6]

Outcome(s): The student will be able to understand the basis of the future Engineering materials like of lubricants, superconductors, conducting polymers, Nano materials etc and purification of the most valuable natural resource of the future-water.

Text Books:

1. Jain and Jain, "Engineering Chemistry," 16th Edition, Dhanpat Rai Publishing Company, 2015.
2. S.S. Dara, "A Text Book of Engineering Chemistry," 12th Edition, S. Chand & Company Limited, 2014.

Reference Books:

1. Peter Atkins, Julio de Paula, and James Keeler, "Atkins' Physical Chemistry" Eleventh Edition, Oxford University Press, 2017.
2. William D. Callister, "Materials Science and Engineering: An Introduction, Eighth Edition, John Wiley & Sons, Inc., 2010.

BM 23.101 **Biology for Engineers** **Total Lectures: 40**

Prerequisite: Nil **Credit: 3-0-0-3**

Objective: This course aims to provide students with a comprehensive understanding of fundamental concepts in cell biology, biochemistry, molecular biology and genetics, recombinant DNA technology, and the organization of the human body. Students will learn about the origin of life, cell structure and function, biomolecules, gene regulation, genetic inheritance, DNA technology, and the structure and function of human body systems.

6. **Basics of Cell Biology**: Origin of life, Cell theory, Cell Structure and function, Biomolecules, Cell cycle and cell division, Biological Organization. **[06]**
7. **Fundamentals of Biochemistry**: Covalent and Hydrogen bonds, Macromolecules: lipids, carbohydrates, nucleic acid, Proteins. Enzymes and ATP, Respiration and Fermentation, Chemiosmotic principle. **[08]**
8. **Fundamentals of Molecular Biology and Genetics:** DNA and RNA structure, DNA replication, transcription, translation, Gene regulation and the lac operon. Mendel's Laws, Linkage and Recombination, Genetic Maps, Gene interaction, Epistasis, Meiosis and Mitosis, Pedigrees. **[10]**
9. **Fundamentals of Recombinant DNA**: Development of Recombinant DNA, Basic Mechanics of Cloning, CDNA Libraries and Expression Libraries, Agarose Gel Electrophoresis, DNA Sequencing, PCR. **[08]**
10. **Organization of Human Body**: Levels of structural organization and body systems, Sub cellular structure and morphology, Transport across cell membranes and membrane potentials. Structure, Classification & function of tissue. Structure & function of skin. **[08]**

Outcomes:

1. Students will be able to explain the basic principles of cell biology and demonstrate knowledge of cell structure and function.
2. Students will understand the fundamental concepts of biochemistry, including macromolecules, enzymes, respiration, and thermodynamics.
3. Students will demonstrate an understanding of molecular biology and genetics, including DNA structure and replication, gene regulation, and genetic inheritance.
4. Students will gain knowledge of recombinant DNA technology, including cloning, DNA sequencing, and polymerase chain reaction (PCR).
5. Students will understand the organization of the human body, including levels of structural organization, tissue classification, and the transport across cell membranes.

Text Books:

1. Thyagarajan S, Selvamurugan N, Rajesh M. P, Nazeer, Richard Thilagaraj R. A, Barathi. W.S and. Jaganthan. M. K “Biology for Engineers”, Tata McGraw-Hill, New Delhi, 2012.
2. Jeremy M, Berg John.L, Tymoczko and Lubert Stryer, “Biochemistry”, W.H. Freeman and Co. Ltd., 2010.

Reference Books:

1. Robert Weaver, “Molecular Biology”, McGraw-Hill, 5th Edition, 2012.
2. E. N. Marieb, “Essentials of Human Anatomy & Physiology”, Pearson, 2018.

EC 23.101 **Basics of Electronics Engineering** **Total Lectures: 40**

3-1-0-4

Prerequisite Basic Knowledge of Engineering and Applied Physics

Objective: To learn the fundamental principle and applications of electronics and communication engineering and devices.

1. **Introduction:** Brief history of major inventions in ECE, Electronic test and measurement equipment's, Specifications for electronic components. **[3]**

2. **Semiconductors**: Material and its properties, Formation of energy band diagram, Currents in semiconductors, Fermi-Dirac energy distribution, Types of semiconductors – Intrinsic and Extrinsic, Mass action law, Hall effect. **[7]**

3. **Diodes**: Introduction, Characteristic of ideal and real diode, Current components in diode, load characteristics, Breakdown in diode, Zener diode, Varactor diode, Tunnel diode, Clippers and Clampers, Rectifiers – Half and Full-wave rectifiers. **[10]**

4. **Transistors:** Introduction to pnp and npn transistors, current components, active, cutoff and saturation regions, CC, CB and CE configuration, Operating point, Biasing circuits, Bias Stability, Thermal runway and thermal stability. **[10]**

5. **Introduction to Signals and Communication Systems**: Definition, Classification of signals – Analog and Digital, Deterministic and Random signals, Power and Energy of signals, Bandwidth, Bit and Baud rate. Block representation of communication system, Modulation – Definition, Need of modulation, Types of modulation. **[10]**

Outcome: After completion of this course, students would be able to :

1. Distinguish between conductors, semiconductors and insulators based on energy band theory and classify different types of semiconductors.
2. Employ the concept of Energy Band Theory and Fermi Levels to explain the operating principle of semiconductors.
3. Demonstrate the operating principle and characteristics of p-n junction diodes, different diode circuits and Transistors.
4. Understand various types of communication signals and its characteristics parameters.
5. Understand the basic concepts of communication system and modulation techniques..

Text Books:

1. George Kennedy, Bernard Davis, "Electronics Communication Systems", Tata McGraw-Hill, 3rd Edition, 2007.
2. Behrouz Forouzan, "Data Communication and Networking", McGraw-Hill, 4th Edition, 2006.

Reference Books:

1. David A. Bell, "Electronics Devices and Circuits", PHI, 4th edition, 2008.
2. Wayne, Tomasi, "Advanced Electronic Communication Systems", PHI, 6th edition, 2013.
3. Robert L. Boylestad, Louis Nashelsky, "Electronics Devices and Circuits Theory", Prentice Hall, 10th Edition, 2009.

ME 23.111 **Computer Aided Engineering Drawing** **Total Hours: 26**
0-0-4-2

Objective:

- To improve the visualization skills.
- To enable the students with various concepts like dimensioning, conventions and standards related to working drawings, projections in order to become professionally efficient.
- To impart the knowledge on understanding and drawing of simple engineering products.

1. **Introduction to Computer Aided Sketching:** Introduction, Drawing Instruments and their uses, BIS conventions, Lettering, Dimensioning and free hand practice. Board Drawing vs. Computer- Aided Drawing. Introduction to Solid works Environments. Computer screen, layout of the software, standard tool bar/menus and description of most commonly used tool bars, navigational tools. Co-ordinate system and reference planes. Definitions of HP, VP, RPP &LPP. Creation of 2D/3D environment. Selection of drawing size and scale. Commands and creation of Lines, Co-ordinate points, axes, dimensioning, line conventions, material conventions and lettering. [8]
2. **Orthographic Projections** : Horizontal planes, Vertical planes, Front view, Top view, Side view, Projections, First and Third angle of projection, Projections of points, Principles of orthographic projections, Sketching of different views of given objects. Introduction to sketching in Solid works : 2-Dimenional Sketching, Sketching in Solid works, poly-lines, square, rectangle, polygons, splines, circles, ellipse, text, move, copy, off-set, mirror, rotate, trim, extend, break, chamfer, fillet, curves, constraints viz. tangency, parallelism, inclination and perpendicularity. [12]
3. **Projections of Lines, Planes and Solids:** Lines inclined to both the principal planes, projection of Lamina inclined to both principal planes, Projections of solids: Axis inclined to both the reference planes and Intersection of solids. Introduction to part module in Solid works: Extrude, Revolve, Sweep, Hole, Filleting, and Chamfering features. [12]
4. **Sections of solids and sectional orthographic views:** Sectional orthographic projections - Full, Half, Partial, revolved and removed surfaces. Introduction to drawing module in Solid works: Standard 3 views, Auxiliary view, Section View, Projected view. [12]
5. **Isometric Projection:** Terminology, Isometric scale, Box method, Coordinate or offset method, Four-center method, isometric projection of arcs. Solid models practice using Solidworks part module. [8]

Outcomes:

1. Students will be able to improve their visualization skills so that they can apply these skills in developing new products.
2. Students will be able to know and understand the conventions and the methods of engineering drawing using Solid works.
3. Students will be able to prepare simple drawings of engineering products.

Text Books:

1. N.D. Bhatt, "Engineering Drawing", Charotar Publishing House, 2013.
2. Prof. Sham Tickoo, Sandeep Prem Dass “Solid works 2013 for Engineers and Designers” Wiley Publication, 2013.

Reference Books:

1. Randy H. Shih, “Solid works 2013 and Engineering Graphics: An Integrated Approach”, SDC Publications. 2013

CY 23.111 **Chemistry Laboratory** **Total Hours:26**
0-0-2 - 1

Prerequisite(s): NIL

Objective(s):

- To introduce students to water chemistry and purify the most valuable natural resource of the future-water.
- To understand one of the most versatile Engineering Materials: Polymers, lubricants, fuel and their properties and uses.

LIST OF EXPERIMENTS

Choice of 10-12 experiments from the following

1. To determine the temporary and permanent hardness in the given water sample by complexometric titration using EDTA as standard solution.
2. To determine the percentage of Available Chlorine in the given sample of Bleaching powder. Iodometrically.
3. To determine the alkalinity of water sample.
4. To prepare urea formaldehyde resin.
5. To determine the strength of given HCl solution by titrating it against NaOH solution using pH meter.
6. To determine the strength of given acid solution by titration it against sodium hydroxide solution using conductometer.
7. To determine molecular weight of a polymer using Ostwald viscometer.
8. Determination of viscosity of given lubricating oil by Redwood viscometer.
9. Determination of cloud and pour point of given lubricating oil.
10. Determination of the flash and fire point of given lubricating oil.
11. Determination of phase diagram of water system.
12. To determine the calorific value (HCV) of a sample of fuel.

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Outcomes The students will learn to:

- Estimate the Hardness of water, alkalinity of water.
- Familiar with the important practical applications of electrochemistry, lubricants, solids, their properties and applications, and the polymer materials.

EC 23.111 **Electronics Laboratory** **Total Hours: 26**

0-0-2-1

Objective:

- To gain practical knowledge by applying the experimental methods to correlate with the theory of Electronics Engineering.
- To apply the analytical techniques and graphical analysis to the experimental data.
- To enable the students to simulate and test the Electronics circuits using Multisim software.

Prerequisite: Basic Understanding of Engineering Physics and Electronics

Practical to be performed on Hardware:

1. Familiarity of Soldering/de-soldering process, Component identification, testing and their verification using multimeter.
2. To plot V-I characteristics of junction diode and Zener diode.
3. To design a half wave rectifier with and without filter circuit and find the ripple factor.
4. To design a full wave rectifier with and without filter circuit and find the ripple factor.
5. Study of clipper and clamper circuits and their implementation on breadboard.
6. To plot the characteristics of Transistor under Common Emitter configuration

Practical to be performed using Multi-Sim Software:

7. To verify Ohm's law and Kirchhoff's law
8. To Simulate half wave and full wave bridge rectifier.
9. To plot V-I characteristics of p-n junction diode.
10. To plot V-I characteristics of Zener diode.
11. Study of Clipper circuit and its implementation on Multisim.

Outcome: After performing the above experiments, Student will be able to :

1 Identify and describe basic electronic components used in circuits.
2 Build and configure basic electronic circuits using breadboards.
3. Analyze the voltage-current characteristics of p-n junction diodes , Zener diodes and Transistor.
4 Develop clipper and clamper circuits to achieve desired voltage waveforms.
5 Utilize Multisim software to simulate and validate circuit designs.

CY 23.102 **Environmental Sciences** **Total Lectures: 26**
2-0-0-2

Objective:
- To teach the principal resources, renewable energy systems and biosphere.
- To explore the environmental impact of various energy sources and also the effects of different types of pollutants.

Pre-requisite: Nil

1. **Basic concepts of Environmental Studies:** Definition, scope and importance**,** Multidisciplinary nature of environmental studies, Need for public awareness. Role of an individual in conservation of natural resources. Equitable use of resources for sustainable lifestyles. [4]
2. **Natural Resources:** Renewable and non-renewable resources. **Mineral resources:** Use and exploitation, environmental effects of extracting and using mineral resources, case studies. **Forest resources:** Use and over exploitation, deforestation, case studies. **Land resources:** Land as a resource, land degradation, man induced landslides, soil erosion and desertification. **Food resources:** World food problems, changes caused by agriculture and overgrazing, effects of modern agriculture, fertilizer-pesticide problems, [6]
3. **Ecosystems & Biodiversity:** Concept and Structure and function of an ecosystem. Producers, consumers and decomposers. Energy flow and nutrient cycling in the ecosystem. Food chains, food webs and ecological pyramids.
   Biodiversity and its conservation: Introduction – Definition, genetic, species and ecosystem diversity. Threats to biodiversity: habitat loss, illicit poaching, man-wildlife conflicts. [5]
4. **Environmental Pollution:** Definition, cause, effects and control measures of: Air pollution, Water pollution, Soil pollution, Noise pollution, Thermal pollution, Nuclear Radiation.
   Solid waste Management: Causes, effects and control measures of urban and industrial wastes. Pollution case studies. Disaster management: floods, earthquake, cyclone and landslides. [6]
5. **Social Issues, Population and impacts of Environmental impacts:**Urban problems related to energy, Resettlement and rehabilitation of people, Global Climate Change, global warming, acid rain, ozone layer depletion. Wasteland reclamation. Population growth, variation among nations. Population explosion, Environment and human health. Human Rights. Value Education. Women and Child Welfare. Role of Information Technology in Environment and human health. Case Studies. Environment Protection Acts. [5]

Outcome: At the end of this course, students will demonstrate the ability to
- Evaluate local, regional and global environmental topics related to resource use and management
- Propose solutions to environmental problems related to resource use and management.
- Describe threats to global biodiversity, their implications and potential solutions.

Text Books:
1. Erach Bharucha “Environmental Studies”, University Grants Commission, 2004.
2. Anubha Kaushik, C P Kaushik “ Perspectives In Environmental Studies” New Age International Publishers. 2018

Reference Books:
1. C. William, P. Saigo, B Woodworth, “Environmental Science: A Global Concern”, Sixth Edition McGraw-Hill Higher Education, 2001.
2. Botkin, and Keller, “Environmental Science” Wily Publication, 2012.
3. R.T. Wright, D.F. Boorse, “Environmental Science” 11th Edition, PHI, 2010.

UC 23. 102 **Pragmatic English Communication** **Total Lectures: 26**
2-0-0-2

Objective: This course aims to develop and enhance the linguistic and communicative competence of the students. The students will be exposed to various forms of personal and professional communication. The self-learning tasks designed will facilitate to enhance effective communication skills.

Pre-requisite: Basic knowledge of English grammar.

1. **Sentence Structure:** Elements of a sentence (Subject, verb, object, complement and adjunct) [7]
Correct Usage of Language: Tenses (Present, Past and Future, Modals (can, could, will, would, shall, should, may, might, must, ought to, need).

2. **Listening and Reading Skills:** Developing effective listening and reading. [6]
Writing Skills: Theme (Paragraph) writing, Letter (formal letters) and application writing, report writing, résumé writing

3. **Idioms and Phrasal Verbs:** Understanding idioms, collocations, introduction to phrasal [5]

4. **Common Errors:** How to avoid common sentence – structural errors, vocabulary and pronunciation [3]

5. **Technology-based Communication:** Effective e-mail messages; power-point presentation; enhancing editing skills using computer software. [5]

Outcome: The students will learn the essentials of English Grammar, analyze, identify and rectify the common errors in speech and writing. Student can read and write with ease and fluently, enrich vocabulary and enjoy reading and writing.

Text Books:
1. Wren & Martin: English Grammar & Composition, S. Chand & Co, Delhi (Latest edition)
2. Raman, M., & Singh, P. (2017). Business Communication (2nd edition.). New Delhi: Oxford University Press.

Reference Books:
1. Prasad, H. M. How to Prepare for Group Discussion and Interview. New Delhi: Tata McGraw-Hill Publishing Company Limited
2. Bonet, Diana. The Business of Listening: Third Edition. New Delhi: Viva Books, 2004.
3. Hornby A.S.: A Guide to patterns and usage, Oxford University Press, Delhi, 1954.
4. Lesikar, Raymond V and Marie E. Flatley. Basic Business Communication: Skills for Empowering the Internet Generation: Ninth Edition. New Delhi: Tata McGraw-Hill

MA 23. 106 **Applied Mathematics -1** **Total Lectures: 40**

Prerequisite: Nil **Credit: 3-1-0-4**

Objective: To acquire fundamental knowledge of higher Mathematics and apply in science and engineering disciplines.

1.	**Calculus of Finite Differences**: Forward, Backward and Shift operators and their relationship, related problems and applications, constructions of forward and backward difference tables, calculation of missing terms in observe data for equal intervals.	9
2.	**Interpolation for Equal Intervals:** Construction of forward and backward difference tables, missing term problems, Newton's forward and backward interpolation formulae, related problems and applications.	7
3.	**Numerical Integration:** Introduction and basic concepts of numerical integration , Trapezoidal rule, Simpson one third and three eighth rule of integrations	9
4.	**Algebraic and Transcendental Equations:** Approximations of one real root of equation using Bisection, Regula – Falsi (method of false position) and Newton Raphson method.	8
5.	**Ordinary Differential Equations:** Numerical solutions of initial value problems, Euler's method and Runge Kutta method of fourth order.	7

Outcomes: After completion of the course, students would be able to apply knowledge of Numerical technique to solve of real word problems related to biomedical engineering.

Text Books:

1. S. S. Sastry, Introductory Methods of Numerical Analysis, PHI Learning Private Limited, Fifth Edition,2012
2. Babu Ram, Numerical Methods, Pearson Publication, 2010

Reference Books:

1. Steven C. Chapra and Raymond P. Canale,Numerical Methods for Engineers, McGrow Hill Education, Seventh Edition,2015.
2. G Haribaskaran, Numerical Methods, Laxmi Publicalion, Second Edition, 2008.

PY 23.101 **Engineering Physics** **Total Lectures: 40**

3-0-0-3

Pre-requisite: Fundamental knowledge of Basic Physics

Objective:
1. To provide students with a basic understanding of the Physics that may be required by engineers in the course of their careers
2. To enhance knowledge related to lasers and its different components to make it suitable for various purposes
3. To introduce the learners to the basics of modern physics and Quantum Mechanics

1. **Modern Physics**: Introduction to Black body radiation spectrum, Photo-electric effect, Compton effect. Wave particle Dualism. de Broglie hypothesis – de Broglie wavelength. Davisson and Germer Experiment. Matter waves and their Characteristic properties, Phase velocity, group velocity and Particle velocity, Relation between phase velocity and group velocity, Relation between group velocity and particle velocity. **[8]**
2. **Quantum Mechanics:** Heisenberg's uncertainty principle and its physical significance. Application of uncertainty principle (Non-existence of electron in the nucleus, explanation for decay and kinetic energy of electron in an atom). Wave function, Properties and physical significance of wave function, Probability density and Normalization of wave function. Setting up of one-dimensional time independent Schrodinger wave equation. Eigen values and Eigen functions. Application of Schrodinger wave equation – Energy Eigen values for a free particle. Energy Eigen values and Eigen functions for a particle in a potential well of infinite depth. **[7]**
3. **Electrical Conductivity in Metals**: Free–electron concept. Classical free-electron theory – Assumptions. Drift velocity, Mean collision time and mean free path. Relaxation time. Expression for drift velocity. Expression for electrical conductivity in metals. Effect of impurity and temperature on electrical resistivity of metals. Quantum free-electron theory – Assumptions. Fermi – Dirac Statistics. Fermi-energy, Fermi factor. Density of states (No Derivation). Expression for electrical resistivity / conductivity. Temperature dependence of resistivity of metals. electron in a periodic potential, origin of the energy gap, band theory of solids, distinction of solids into metals, semi-conductors and insulators. **[8]**
4. **Dielectric & Magnetic Properties of Materials**: Dielectric constant and polarization of dielectric materials. Types of polarization. Equation for internal field in liquids and solids (one dimensional). Ferro and Piezo electricity. Frequency dependence of dielectric constant. Important applications of dielectric materials. Classification of dia, para and ferro-magnetic materials. Hysterisis in ferromagnetic materials. Soft and Hard magnetic materials. Applications. **[7]**
5. **Lasers and Optical Fibers**: Einstein's coefficients (expression for energy density). Requisites of a Laser system. Condition for laser action. Principle, Construction and working of CO2 laser and semiconductor Laser. Applications of Laser – Laser welding, cutting and drilling. Propagation mechanism in optical fibers. Angle of acceptance. Numerical aperture. Types of optical fibers and modes of propagation. Attenuation. Applications–Block diagram discussion of point to point communication. **[10]**

Outcome: After completion of this course, students will be able to :

1. Understand the experimental evidence supporting the de Broglie hypothesis and the wave-particle duality of matter.
2. Explain fundamentals of quantum mechanics and apply to one dimensional motion of particles.
3. Describe the band theory of solids.
4. Understand material properties to use in engineering applications and studies.
5. Illustrate the working of lasers and optical fibers.

Text Books:

1. S. O. Pillai, “Solid State Physics”, New Age International, Sixth Edition, 2009
2. V. Rajendran, “Engineering Physics,” TMH, Fifth Edition , 2013

Reference Book:

1. G. K. Shivkumar, “Engineering Physics,” Prism Book Pvt. Ltd.
2. Stephen T. Thornton, “Modern Physics for Scientists and Engineers”,Cengage Learning, 4th ed.,2013

EE 23.101 **Basics of Electrical Engineering** **Total Lectures: 40**
3-1-0-4

Objective: This course facilitates the students to get a comprehensive exposure to various concepts and devices of electrical engineering.

Pre-requisite: Nil

1. **DC Circuits:** Electrical circuit elements (R, L and C), voltage and current sources, Ohm's law, Kirchhoff current and voltage laws, analysis of simple circuits with dc excitation using mesh and nodal method. Network Theorems - Superposition, Thevenin, Norton and Maximum power transfer Theorems. Time-domain analysis of first-order RL and RC circuits. Star-Delta Conversion [8]
2. **AC Circuits:** Basic terminologies, representation of sinusoidal waveforms, average, rms and peak values of a.c. quantities, phasor representation, real power, reactive power, apparent power, power factor. Analysis of single-phase ac circuits consisting of R, L, C, RL, RC, RLC combinations (series and parallel). [8]
3. **Three Phase A.C. Circuits:** Three phase supply, phase sequence, star connection, delta connection, relationship between phase and line quantities in 3-phase circuits, measurements of three phase power under balanced condition. [6]
4. **Transformers:** Magnetic materials, BH characteristics, ideal and practical transformer, equivalent circuit, Transformer testing: open circuit and short circuit test, losses in transformers, regulation and efficiency. Basics of auto-transformer and three-phase transformer connections. [10]
5. **Electrical Machines:** DC Machines – construction, functions of each part, working principle, EMF and torque equations, types of dc machines. Single Phase AC machines, AC machines – classification (Split phase machines, universal machines), construction, operating principles of ac machines. [8]

Outcome: At the end of this course, students will demonstrate the ability to

- To understand and analyse basic electric and magnetic circuits.
- To study the working principles of electrical machines.

Text Books:

1. Kothari, D. P., and I. J. Nagrath, "Theory and Problems of Basic Electrical Engineering," PHI Learning Pvt. Ltd., 1998.
2. Fitzgerald, Arthur Eugene, David E. Higginbotham, and Arvin Grabel, "Basic electrical engineering," McGraw-Hill Series in Electrical Engineering, Auckland: McGraw-Hill, 1981, 5th ed.(1981).

Reference Books:

1. H.Cotton, "Advanced Electrical Technology," CBS Publication. 1967.
2. Vincent Del Toro, "Electrical Engineering Fundamentals," 2nd Edition PHI Publication. 1972.
3. Smarajit Ghosh, "Fundamentals of Electrical and Electronics Engineering", PHI Publication, 1st Edition, 2007.

CS 23.101 **Programming for Problem Solving-I** **Total Lectures: 40**

3-1-0-4

Prerequisite(s): NIL

Objective(s):
1. To learn principles of programming by the structured native language 'C'.
2. To comprehend the rudiments, constructs, syntax, and statements with essentials of efficient compiling, running and debugging processes.

1. **Introduction:** The role of programming languages, programming paradigms, language description and syntax structure, basics of structured and object-oriented programming, functional programming, logic programming, concurrent programming. [5]
2. **Fundamentals of 'C' language**: Character set, variables data types constants, arithmetic, relational and logical operators, type conversion,increment,decrement, bitwise and assignment operators, conditional expressions, statements and blocks, *if-else*, *switch*, loops-*do-while*, *while*, *for*; *break, continue* and *goto* statements, labels. [10]
3. **Functions, pointers and Arrays**: Basics of functions, storage classes, scope rules, and header files, recursion and C preprocessor, arrays, pointers and addresses, types of pointers, pointers and arrays address arithmetic, character pointers and functions, pointer arrays, pointers to functions, function returning pointer, pointer to array, array of pointers, and multidimensional arrays, command line arguments, dynamic memory allocation-malloc(), calloc(), realloc(), free() [13]
4. **Structures and unions:** Basics of structures and functions, arrays of structures, pointers to structures, passing structure to function, function returning structure, union, self-referential structures. [6]
5. **I/O and File Processing:** Concept of files, standard input and output, formatted output, file access in different modes, reading from and writing to a file, random access file operations. [6]

Outcome(s): Students would be able to apply learning and knowledge of C language analytically, critically and logically to solve mathematical, scientific and real-life problems in an efficient manner.

Text Books:
1. Brain W. Kernighan and Dennis M. Ritchie, The C Programming Language, Second edition, Pearson Education.
2. Ravi Sethi & K.V.Viswanatha, Programming Languages-Concepts, and Constructs, Second edition, Pearson Education,

Reference Books:
1. Herbert Schildt, C: The Complete Reference, Fourth Edition, McGraw-Hill Education,
2. E Balagurusamy, Programming in ANSI C, Tata McGraw - Hill Education,

CS 23.111 **Programming Laboratory- I** **Total Hours: 26**

0-0-4-2

Objective:
- To make students familiar with syntax and structure of C-programming.
- To learn problem solving techniques using C programs implementation.

Prerequisite: Nil

1. Implement the logic of Data Types & Operators.
2. Implement the logic of Type Conversions.
3. Implement the logic of Arithmetic, Relational, and logical operators.
4. Implementation of Bitwise, unary, assignment operators.
5. Implementation of Increment and Decrement operators.
6. Implementation of Conditional operators.
7. Implement the logic of Increment and Decrement operators.
8. Implement programs in order to cover Control Structure, If-Else statements, Nested If-Else statements, Switch-case statement, Loops- For, While, Do-While, Break Continue, Go-To Statements, and Labels.
9. Implement programs in order to cover processing an array, passing arrays to functions, Multidimensional arrays.
10. Implement programs to cover all possible String operations.
11. Implement programs in order to cover Function prototypes and passing arguments to a function, Recursion.
12. Implement programs in order to cover Pointers declaration, operations on pointers, Array of pointers, pointers to arrays.
13. Implementation of structure and union programs.
14. Implement the use of Storage classes in C programming.
15. Implement programs for Reading and writing from/to a file.
16. Implement random access file operation

Outcome: On completion of this course student will be able to:
- Apply learning and knowledge of C language analytically, critically and logically to solve mathematical, scientific and real-life problems in an efficient manner

PY 23.111 **Physics Laboratory** **Total Hours: 26**
0-0-2-1

Pre-requisite: Nil

Objective:
1. To gain practical knowledge by applying the experimental methods to correlate with the Physics theory.
2. To apply the analytical techniques and graphical analysis to the experimental data.

List of Experiments:

1. To study of material constant, temperature coefficient of current and planck's constant.
2. To determine the specific resistance of a given wire by using the Carey Foster's bridge.
3. To measure the numerical aperture of an optical fiber.
4. To measure the cylindrical object of diameter with help of Screw gauge and Vernier caliper.
5. To study the variations of resistivity with temperature and hence determines the energy band gap of the given semiconductor with help of four probe method.
6. To convert a galvanometer into a voltmeter of a given range.
7. To convert a galvanometer into an ammeter of a given ranges.
8. To plot graph showing the variation of magnetic field with distance along the axis of a circular coil carrying current and to estimate from it the radius of the coil.

Outcome:
1. Students will be convergent with operation of equipment and verify the principle of Physics by doing the experiments.
2. Understand the concepts and principles related to material constants, temperature coefficients, and Planck's constant.
3. Analyze the collected data to determine the specific Resistance using Carey Foster's Bridge.
4. Perform measurements and data analysis to determine the numerical aperture of the optical fiber accurately.
5. Gain hands-on experience in measuring and plotting the magnetic field variation along the axis of a circular coil carrying current.
6. Develop the ability to convert a galvanometer into an ammeter and voltmeter.

EE 23.111 **Electrical Laboratory** **Total Hours: 26**

0-0-2-1

Objective: The objective is to provide a basic exposure of installation and operation of electrical equipment.

Prerequisite: Nil

Perform any ten of the list.

1. To Study of the various apparatus used in Electrical Engineering.
2. To perform residential house wiring using fuse, indicator, switch, Socket, plug and lamp.
3. To design a Stair case wiring for illuminating three lamps.
4. To conduct the open circuit tests on the given single phase transformer and to determine equivalent circuit parameters.
5. To conduct the short circuit tests on the given single phase transformer and to determine equivalent circuit parameters.
6. To construct a fluorescent tube and to measure voltage across tube rod, voltage across choke and current.
7. To conduct the polarity test on the given transformer.
8. To control the speed of DC machine by field current control method.
9. To control the speed of DC machine by Armature Voltage control method.
10. To measure three phase power by using two wattmeter methods.
11. To verify Superposition Theorem using resistive circuit.
12. To verify Thevenin's Theorem using resistive circuit.

Outcome: Students will be convergent with installation and operation of electrical equipment.

ME 23.112 **Mechanical Workshop** **Total Hours:26**
0-0-2-1

Objectives:

1. Practice on manufacturing of components using workshop trades including fitting, carpentry, sheet metal and welding.
2. Identify and apply suitable tools for machining processes including turning, facing, thread cutting and tapping.
3. Study and practice on machine tools and their operations.

List of Jobs:

1. **Fitting Shop:** Prepare job that contain various fitting operation like filing, marking, measuring, cutting, drilling etc.
2. **Carpentry Shop:** Prepare job that contain various carpentry operations and making of carpentry joint (T joint).
3. **Sheet Metal Shop:** Prepare job that contain various sheet metal operations and making job from sheet (funnel, tray etc).
4. **Machine Shop:** Perform various operations like, turning, step turning, facing, chamfering, knurling etc. on Lathe.
5. **Welding Shop:** Prepare a weld bead using arc welding process.

Outcomes:

At the end of the course, the student will be able to:

1. To acquire skills in basic engineering practice.
2. To identify the hand tools and instruments.
3. To acquire measuring skills.
4. To provides the knowledge of job materials in various shops.
5. Students will be able to analyze the material on the basis of their properties and thus assigning different weight age to their use for technical purposes.

Text Books:

1. Hajara Chaudhary, Workshop Technology Vol I & II, Media Promoters and Publishers PVT. LTD, Mumbai.
2. B.S. Raghuvanshi, Workshop Technology, Dhanpat Rai & Sons. New Delhi.

Reference Books:

1. H S Bawa, Workshop Technology, TMH. New Delhi.

Second Year

B. Tech. (Biomedical Engineering)

UC23.201 **Introduction to Management and Leadership** **Contact Hours: 26**
2-0-0-2

Objectives: This course introduces students to the principles of leadership and management practices. It will consider how one manages oneself, others, and resources in the pursuit of a well-defined purpose. It acquaints students with the methods managers use to: assess the environment in which the organization operates; design, build, and implement the organization's capacity to serve; make decisions; and evaluate the efficacy of those decisions.

1 **Introduction to Management**: Meaning and importance, Concept of industrial management, Levels of management, Management theories- classical, neo-classical and modern, Managerial roles (Mintzberg), Managerial competencies, Managers and environment. **[5]**

2 **Management Functions**: ***Planning*** – Concept, types, Strategic planning, Types of strategy, Decision making, Techniques for individual and group decision-making; ***Organizing*** **–** Concept, Design of organization structures, Departmentalization, Power and authority, Conflict and coordination; ***Staffing*** – Concept, Human resource planning, Recruitment and selection. **[6]**

3 **Contemporary Issues in Management**: Management challenges of the 21st Century, Factors reshaping and redesigning management purpose, Performance and reward perceptions, Internationalization, Digitalization, Entrepreneurship, Values and Ethics. **[5]**

4 **Introduction to Leadership**: Concept, Leadership theories (Trait, Behavioral, Situational), Leadership styles, Leadership behavior, Women as leaders, Leadership development, Leadership and change, Leadership and innovation (Audience analysis and engagement). **[5]**

5 **Emerging Challenges to Leadership**: Leadership in changing workplace, Leader's role in fostering teamwork, Methods to enhance creative problem solving, Leadership practices for innovation, Ethical leadership development, Cultural sensitivity, Global leadership skills. **[5]**

Outcome Students will describe the various levels of management and applicability of management Principles, demonstrate various types of authority, delegation and decentralization in authority, demonstrate various types of leadership styles and identify the motivation techniques used by leaders, and discuss the impact of emerging issues in management.

Text Books
1. L.M. Parasad, "Principles & practice of management", Sultan Chand & Sons, New Delhi, (Latest edition).
2. Stephen P.Robbins "Organizational Behavior" Pearson Education, New Delhi (Latest edition).

Reference Books
1. T.N. Chhabra, "Business Organization and Management", Sun India Publications. New Delhi.
2. P.C. Tulsian, and V. Pandey, "Business Organization & Management", Pearson Education, India.

Course Code: **MA 23. 205** | **Applied Mathematics -1I** | **Total Lectures: 40**

Prerequisite: Nil | **Credit: 3-1-0-4**

Objective: To acquire fundamental knowledge of higher Mathematics and apply in science and engineering disciplines

1. **Probability:** General Introduction, addition and multiplication law of probability, conditional probability, related problems and applications. 9
2. **Random variables and Distributions:** Discrete and continuous random variables, basic idea of Binomial, Normal and Poisson distributions, mean, variance and standard deviations. 8
3. **Sampling and Testing of Hypothesis:** General introduction of sampling, large and small sampling, testing of hypothesis, null and alternate hypothesis, related problems. 8
4. **Statistics and Linear Regression:** Mean, Median and Mode of frequency distribution, Fitting of least square straight line, correlation, different form, Karl Pearson coefficient of correlation. 8
5. **Complex Analysis:** Introduction of complex numbers, representation of complex numbers on argand plane, modulus and argument, complex variable, function of complex variables, analytic function, Cauchy Integral theorem , Cauchy integral formula, Taylor's and Laurent's series, Residue theorem. 9

Outcomes: After completion of the course, students would be able to apply knowledge of Numerical technique to solve of real word problems related to biomedical engineering.

Text Books:

1. Ramana B.V., Higher Engineering Mathematics, McGraw Hill Education, July, 2017.
2. Babu Ram, Engineering Mathematics 1st edition Pearson Education, 2009.

Reference Books:

1. Kreyszig, Erwin, Advanced Engineering Mathematics, 9th edition, New York :Wiley, 2011
2. Pal and Bhunia, Engineering Mathematics, Oxford University Press, 2015.

Course Code: **CS 23. 205** | **General Purpose Programming** | **Total Lectures: 40**

Prerequisite: CS 23.101 (Programming for Problem Solving –I) | **Credit: 3-0-0-3**

Objective: This course aims to provide students with a comprehensive understanding of Python programming. It covers the basic elements, data types, control structures, functions, modules, object-oriented programming, testing, debugging, and advanced topics like regular expressions, plotting, multithreaded programming, GUI, and introduction to machine learning and deep learning.

1. **Introduction**: The basic elements of python, python syntax, python operators, basic input, branching programs, control structures, data types, strings, tuples, lists, sets, dictionaries, bytes, bytearray and input iteration, Mutability with different types, ranges and iterators [7]
2. **Functions and Module**: Functions and scoping flow of execution, specifications, recursion, global variables, variable arguments, default arguments, system functions and parameters, input and output, modules , making your own module, importing modules, decorators, generators, command line argument. [7]
3. **Classes and Object-Oriented Programming**: Abstract data types and classes, class attribute, instances, object overhead, constructor, self, inheritance, encapsulation and information hiding, polymorphism, getter & setter, abstract class, duck typing, monkey patching, operator overloading, method overloading using multiple dispatch decorator. [8]
4. **Testing and Debugging**: Exceptions and assertions, types of testing – black-box and glass-box, debugging, handling exceptions, assertions. [6]
5. **Advance Python:** Regular expressions – REs and Python, plotting using matplotlib and Multithreaded Programming, GUI & event handling programming using Tkinter & pygame. Introduction to machine learning and deep learning [12]

Outcomes: Upon completion of this course students will be

- Familiar with Python syntax.
- Able to use python to implement a given logic

Text Books:

1. John V Guttag, Introduction to Computation and Programming using Python, Prentice Hall of India, 2nd Edition, 2013.
2. Martin C. Brown, Python: The Complete Reference,Mc Graw Hill, 2018

Reference Books:

1. Zed A. Shaw ,Learn Python the hard way: a very simple introduction to the terrifyingly beautiful world of computers and code, 3rd edition, 2014.
2. Richard L. Halterman,Learning to Program with python, 2011.
3. Allen Downey ,Think Python How to Think Like a Computer Scientist, Version 2.0.17, Green Tea Press Needham, Massachusetts,2012.

EC 23.201	**Electronic Devices and Circuits**	**Total Lectures: 40** **3-0-0-3**

Objective To acquire fundamental knowledge of operation, design and application of various Electronic devices and circuits.

Pre-requisite Basic Electronics and Physics of electron.

1.	**Junction Diode:** Junction breakdown**,** Current components in a p-n diode, Quantitative analysis of p-n diode characteristics and equivalent circuit, diode resistance, interconnections of diodes, transition and diffusion capacitance.	[6]
2.	**Transistors**: Operation of transistor, transistor current components, transistor circuit configurations, transistor biasing schemes and operating point stabilization, hybrid-pi model of BJT, low and high frequency models of JFET.	[11]
3.	**Small Signal Amplifiers at Low Frequency:** Coupling schemes for multistage amplifiers, frequency response of coupled amplifier, RC coupled transistor amplifier, transformer coupled transistor amplifier, cascode circuits, Differential amplifier, Darlington amplifier.	[7]
4.	**Power Amplifiers:** Power amplifier circuits, class-A, class-B, class-AB, class-C, push pull amplifiers- class-A, class-B, Class- AB.	[10]
5.	**Oscillators:** Classification criterion for oscillation, tuned collector, Hartley, Colpitts, RC phase shift, Wien bridge and crystal oscillators.	[6]

Outcome: After completion of this course, students would be able to understand the working phenomena and applications of various electronic devices and circuits.

Text Books:

1. Robert L. Boylestad & Louis Nashelsky, Electronic Devices and Circuit Theory, Pearson Education, 11th Edition, 2013.
2. Thomas L. Floyd, Electronic Devices, Pearson Education, 10th Edition , 2018.

Reference Books:

1. Bell, David A., Operational Amplifiers & Linear ICS, Prentice Hall of India, 3rd Edition, 2018.
2. J. Millman & C. C. Halkias, Electronic Devices and Circuits, McGraw Hill

BM 23.201 **Human Anatomy & Physiology** **Total Lectures: 40**

Prerequisite: Nil **Credit: 3-0-0-3**

Objective: The objective of the course is to provide engineering students with a comprehensive understanding of the structure and function of the human body. The course aims to familiarize students with the anatomical and physiological principles relevant to engineering applications, enabling them to develop a strong foundation in the biological sciences.

1. **Musculoskeletal System**: Types of muscles their structure & function, Properties of muscles, Gross anatomy of skeletal muscle tissue, Mechanism of muscle contraction and relaxation. Skeleton system and its classification, Bones, Types of Bones, Bone Formation, Growth & remodeling, Bone fracture, Joint & its classifications, Common terminologies used for body Position & movements. **[8]**

2. **Cardiovascular System**: Composition & functions of blood, Blood cell formation, Blood Groups, Physiology of Blood Clotting. Anatomy of the heart, Properties of cardiac muscles, Heart valves and circulation of blood, Heart sound, Blood vessels, Structural difference in arteries, veins & capillaries, Cardiac cycle, Cardiac output, Conduction system, Electrocardiogram, Regulation of Heart rate, Blood Pressure. **[12]**

3. **Respiratory, Lymphatic & Endocrine System:** Functional anatomy of the respiratory system, Mechanism of breathing, Lung volume capacities, External respiration, Internal respiration & gases transport, Regulation of respiration. Structure and function of lymphatic system, Immunity & body defense mechanism, Different types of their gland & their functions. **[8]**

4. **Digestive System & Excretory System:** Anatomy of the digestive system, Digestion and absorption of carbohydrates, Proteins and fats, Role of pancreas and liver. Structure & function of kidney and urinary tracts, Nephron & urine formation. **[6]**

5. **Nervous System & Special Senses**: Structure and function of nervous tissue, Functional anatomy of the brain & spinal cord, Autonomic nervous system & its functions, Sense organ for sight and hearing. **[6]**

Outcomes: Student will able to understand and identify structures, position and orientation of various organ systems. [C1] They will also understand the various functional mechanisms involved with cellular level to system level in human body. [C1]

Text Books:

1. E. N. Marieb, "Essentials of Human Anatomy & Physiology", Pearson, 2018
2. A. C. Guyton, "Text Book of Medical Physiology", Elsevier Saunders, 2016.

Reference Books:

1. Gerard J. Tortora and Bryan Derrickson, "Principle of Anatomy and Physiology", John Wiley, 2012.
2. K. Sembulingam, J.P Brothers, "Essentials of Medical Physiology", Jaypee Brothers, 2012.
3. A. J. Vander, J.H Sherman and D.C. Lucian, "Human Physiology", Mcgraw Hill, 2001.

Course Code: **BM 23.203** | **Biomedical Transducers and Sensors** | **Total Lectures: 40**

Prerequisite: Nil | **Credit: 3-0-0-3**

Objective: To attain adequate knowledge about the various sensors and measuring instruments used for measurement and detection of physical quantities.

1. **Introduction:** Generalized Medical Instrumentation System, Static characteristics and dynamic characteristics, Errors in measurements: sources of errors, types of errors. **[3]**
2. **Transducers**: Potentiometers, Strain gauges, Bridge circuits, Variable inductance and LVDT; Capacitive type; Piezoelectric transducers; Optical measurement, Temperature measurement: Thermistor, thermocouple, resistive temperature detector; IC-based temperature measurement; Radiation sensors, Hall effect transducers. **[12]**
3. **Biopotentials**: Origin of biopotential, Resting potential, Action potential, Different type of the bioelectric signals, their origin, characteristics & Recoding (ECG, EEG, EMG, Evoked Potentials etc.). **[6]**
4. **Biopotential Electrodes**: Half Cell Potential, , polarization, polarizable and non-polarizable electrodes, Electrode electrolyte interface, Electrode-skin Interface and Motion Artifact, Body-Surface Recording Electrodes, Internal Electrodes, Electrode Arrays, Microelectrodes. Electrodes for Electric Stimulation of Tissue. **[11]**
5. **Biochemical Measurement and Biosensors:** Blood gas & acid base physiology, Electrodes for Measurement of pH, pO2 and pCO2, Ion selective Field Effect Transistor (ISFET), Immunologically sensitive FET (IMFET), Blood glucose sensors. **[8]**

Outcomes: After attending this course student will able to

1. Describe the origin of bio potential and its measurements using different type of electrodes.
2. Explain the basics of measurements and the errors associated with measurement.
3. Describe the working principles of passive transducers.
4. Demonstrate the various sensors used in medical diagnosis.

Text Books:

3. John G. Webster: Medical Instrumentation Application & Design Haughton Mifflin, Co. Boston. USA, 2010.
4. R. S. Khandpur: Hand Book of Biomedical Instrumentation. Tata McGraw Hill, Third Edition, 2018.

Reference Books:

1. Joseph J. Carr & Joseph M. Brown: Introduction to Biomedical Equipment Technology. Pearson, Fourth edition, 2019.
2. Andrew G. Webb: Principles of Biomedical Instrumentation. Cambridge University Press, 2018.

CS-23.255 **General Purpose Programming Laboratory** **Total Hours:26**
Credit:0-0-2-1

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Prerequisite: (CS 23.111) Programming Laboratory-I

Objectives: The objective of this course is to:

- Become comfortable with Python programming, starting from basics of data types to deep learning.
- Provide the foundation of to explore any expansions of Python whether it is machine learning, deep learning, web development or gaming. It will also put focus to learn various skills to design object-oriented software.

Contents:

- Code different data types and operations on list, tuple, dictionaries, sets, String etc
- Code basic programs like factorial, fibonacci etc. to understand functions and recursions.
- Implement different built-in functions in Python like eval, exec,lambda, map reduce, filter etc.
- Implement the concept of class, objects, inheritance and polymorphism.
- Implement constructor and self
- Code programs to implement exceptions and assertions
- Implement regular expressions
- Implement a small gaming application using Pygame
- Implement user interface and event handling using TKinter
- Code programs to implement the logic for machine and deep learning
- Implement multithreading

Outcomes: Upon completion of this course, students will be:

- Able to develop application in Python
- Able to develop scientific applications for machine learning
- Able to use python to implement a given logic.
- Able to use various Python IDE like Anaconda, Pycharm etc.

EC 23.221 **Electronics Devices and Circuits Laboratory** **Total Hours: 26**
0-0-2-1

Objective: To acquire fundamental knowledge of operation, design and application of various Electronic devices and circuits by doing the experiments.

Pre-requisite: Electronics Laboratory

1. To plot the diode characteristics and its dynamic resistance and cut-in Voltage.
2. Plot the characteristics of a Zener diode and find its dynamic resistance under reverse biased condition. Plot the Line-Regulation and Load-Regulation curve using Zener diode.
3. To implement a diode clipper circuit which clips the positive peak of the input voltage (i) By 1V and (ii) negative peak by 1.5V? (For given sinusoidal input $V_{pp} = 4V, 1kH$).
4. To implement a diode clamper circuit which clamps the positive peak of the input voltage $1V$ and the negative peak of the input voltage 1.5V. (For given square wave input $V_{pp} = 10V, 1kHz$)
5. To plot the frequency response of a emitter follower.(For given sinusoidal input $V_{pp} = 3V, 1kH$.
6. Design a Half Wave Rectifier circuit with and without capacitor filter, measure the rms and Dc values of output voltage and calculate the ripple factor for given sinusoidal input $V_{pp} = 10V, 1kH$.
7. To plot the input and output characteristics of a transistor in CE Configuration.
8. Design a two stage RC coupled transistor amplifier and calculate the gain. (for given sinusoidal input $V_{pp} = 200mV, 1kHz$).
9. To plot the Transfer characteristics (for$V_{DS} = 5V$) and Drain (for $V_{GS} = -1V$) characteristics of a JFET inCS Configuration.

Outcome: After completion of this lab course, students would be able to demonstrate the working phenomena and applications of various electronic devices and circuits. Knowledge gained from this course would also be utilized to design different electronic circuits and devices.

Course Code: **Anatomy & Physiology Laboratory**
BM 23.221
Prerequisite: **Credit: 0-0-2-1**

Objective: To acquire fundamental knowledge of recording and analyzing physiological parameters.

1. Study of skeletal system
2. Study of anatomy of different organs in body
3. Determination of bleeding time
4. Determination of clotting time
5. Measurement of Blood Pressure
6. Total R.B.C. Counting
7. Total W.B.C. Counting
8. Total Platelets Counting
9. Detection of Blood group
10. Preparation of blood film & staining
11. Estimation of Hemoglobin
12. Cardiopulmonary resuscitation Technique
13. Injection Techniques
14. Electrophysiological recording of Heart
15. Electrophysiological recording of Muscles
16. Electrophysiological recording of Brain

Outcomes: After completion of this lab course, students would be able to perform Haematology experiments, measurement of blood pressure & bone identification in skeletal system.

Reference Books: Lab manual

Course Code: **Biomedical Transducer and Sensor Laboratory**
BM 23.223
Prerequisite: Nil **Credit: 0-0-2-1**

Objective: This course aims to provide students with practical experience in measuring and recording various physiological signals, including blood pressure, electrical activity of muscles, heart, and brain, PCG signal analysis, spectrophotometry for light intensity measurement, and understanding lead configurations and respiratory signal waveforms.

Suggested List of Experiments: (A minimum of eight experiments must be conducted.)

1. Measurement of blood pressure using sphygmomanometer.
2. Recording & measurement of electrical activity of muscles.
3. Recording & measurement of electrical activity of Heart.
4. Recording & measurement of electrical activity of Brain.
5. Recording & measurement of PCG signal and analyze the PCG signal sound.
6. To study and measure the intensity of light by spectrophotometer.
7. To study LEAD I, LEAD II & LEAD III of standard Bipolar lead configuration.
8. To study AVR, AVF & AVL lead of standard augmented Uni-polar leads configuration.
9. To study chest lead of standard Uni-polar leads configuration.
10. To measure and observe the normal and abnormal respiratory signal waveform
11. To study working of Plethysmograph.
12. To determine characteristics of thermistor.
13. Characteristics of LVDT.
14. Characteristics of Strain gauge.

Outcomes:

1. Students will be able to effectively measure and record physiological signals using appropriate instruments and techniques.
2. Students will demonstrate proficiency in analyzing and interpreting physiological signals, such as PCG and respiratory waveforms.
3. Students will gain knowledge of different lead configurations used in electrocardiography and understand their significance.
4. Students will be able to operate and interpret data from instruments such as plethysmographs, spectrophotometers, thermistors, LVDTs, and strain gauges.
5. Students will develop practical skills in experimental design, data acquisition, analysis, and reporting in the field of biomedical instrumentation.

Reference Books: Lab manual

UC23.202 **Entrepreneurship Development** **Contact Hours: 26**
2-0-0-2

Objectives: This course is intended to provide engineering students with a solid foundation in terms of the vital role played by entrepreneurs and entrepreneurship in the 21st century global economy.

1. **Entrepreneurship**: Definition and concept of entrepreneurship, Entrepreneur Characteristics, Classification of Entrepreneurs, Role of Entrepreneurship in Economic Development, Start-ups. **[5]**

2. **Idea Generation and Project Formulation**: Ideas in entrepreneurships, Sources of new ideas, Techniques for generating ideas, Guidelines for report preparation, Project appraisal techniques, EDP organizations - MDI, EDII, Industrial Sickness and Role of BIFR. **[6]**

3. **Institutions Supporting and Taxation Benefits**: Central level institutions - NABARD, SIDBI, KVIC, State Level Institutions – DICs, SFC, Government policy for MSMEs, Tax incentives and concessions. **[5]**

4. **Small Scale Industries (SSI)**: Concept, Evolution, Role, Problems and prospects, Policies governing SSIs, Organizational structure, Ownership pattern, Export potential of SSIs. **[5]**

5. **Project Identification and Financial Analysis**: Meaning of project, project identification, formulation, feasibility analysis, Economic analysis, Financial analysis, Market analysis. **[5]**

Outcome By the end of the course, students should be able to:

- Recognize the entrepreneurial potential within self and others in their environment.
- Identify the ways in which entrepreneurship manifests itself, including start-up contexts, corporate contexts, social contexts, public sector contexts, and others;
- Appraise the nature of creative new business concepts that can be turned into sustainable business ventures;

Identify the financial, marketing, legal, human resource, operations, and general management skills that are necessary to successfully launch and operate a successful new venture.

Text Books

1. Khanna, S. S., Entrepreneurial Development, S. Chand, New Delhi.
2. Hisrich D. Robert, Michael P. Peters, Dean A. Sheperd, Entrepreneurship, McGraw-Hill.

Reference Book

1. Kuratko, F. Donald, Richard M. Hodgetts, 'Entrepreneurship: Theory, Process, Practice', Thomson, 7ed.
2. Gupta, C B. and Shrinivasan, N.P., 'Entrepreneurship Development in India', Sultan Chand & Sons, New Delhi.

EC 23.202 **Digital Electronics** **Total Lectures: 40**

Objective: The aim of this course is to present the principles and techniques of combinational and sequential digital logic design and optimization at a gate level. The use of transistors for building gates is also introduced. **3-0-0-3**

Pre-requisite: Basics of Electronics Engineering

1. **Number Systems and Boolean Algebra:** Introduction to number systems, weighted and non-weighted codes, 1's complement, 2's complement, complement arithmetic, Postulates and theorems of Boolean algebra, Boolean functions, canonical and standard form, simplification of Boolean function using Boolean laws and theorems. [5]

2. **Logic Gates and Simplification of Boolean Functions:** Basic Logic gates, Universal gates, K-map representation, incompletely specified functions, simplification realization with gates, Quine-Mc Cluskey method. [5]

3. **Combinational Logic:** Analysis and design of combinational circuits, half adder and full adder, half subtractor and full subtractor, binary serial and parallel adder, BCD adder, binary multipliers, magnitude comparator, decoders, encoders, multiplexers, de-multiplexers. [10]

4. **Sequential Circuits:** Latches, flip-flops, triggering of the flip-flops, master-slave flip-flop, excitation tables, conversion of the flip-flops, analysis and design of clocked sequential circuits, shift registers, counters. [12]

5. **Programmable Logic & Introduction to Verilog HDL:** ROM, ASIC, PAL, PLA, FPGA, Verilog as HDL, An overview of VHDL, Role of VHDL in system design. [8]

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

1. Gain fundamental knowledge of the basic logic gates such as AND, OR, NAND NOR, EX-OR and their implementation in Logic Circuits.
2. Design multipliers, Combinational Circuits and registers.

Text Books:

1. M. M. Mano and M. D. Ciletti, Digital Design, Pearson Education, 4th Edition, 2009.
2. T. L. Floyd and R.P. Jain, Digital Fundamental, Pearson Education, 8th Edition, 2009.

References

1. V. K. Puri, Digital Electronics: Circuits and Systems, Tata McGraw-Hill, 4th Edition, 2001.
2. R. P. Jain, Modern Digital Electronics, Tata McGraw-Hill, 4th Ed, 2003.

EC 23.204 **Integrated Circuits and Applications** **Total Lectures: 40**

3-0-0-3

Objective: To acquire fundamental knowledge of Mathematics and apply in engineering disciplines.

Pre-requisite: Electronics Devices and Circuits

1. **Differential Amplifier:** Operational amplifier, bipolar and FET differential amplifiers, constant current source, current mirror, level translator, block diagram of operational amplifier, frequency response and stability, operational amplifier parameters, offset compensation techniques. [4]

2. **Application of Op-amp:** Inverting and non-inverting amplifiers, voltage follower, integrator and differentiator circuits, instrumentation amplifier, current to voltage converter and voltage to current converter, voltage to frequency conversion. [8]

3. **Oscillators and Active Filters:** Barkhausen's criteria, Quadrature, square wave, triangular wave, saw tooth wave and voltage controlled oscillator, Low pass, high pass, band pass and band reject filters. [8]

4. **ICs and Applications:** Clipping and clamping circuits, comparator, LM-311 comparator, schmitt trigger, log and antilog amplifiers, half and full wave rectification, IC-8038, IC LF-398, IC-555. [10]

5. **Voltage Regulator and PLL:** Voltage regulator IC-723, switching regulators, regulator IC series 78xx, 79xx, building blocks of PLL, IC-565 and its applications, four-quadrant multiplier and its applications. [10]

Outcomes: After completion of the course, students would be able to apply mathematical knowledge in engineering and solve curriculum problems.

Text Books:

1. R. A. Gayakwad, Op-Amps and Linear Integrated Circuits, PHI, New Delhi, 3rd Edition.
2. B. P. Singh and Rekha Singh, Electronic Devices and Integrated Circuit", Pearson Education, 2003.

Reference Books:

1. R. F. Coughlin and F. F. Driscoll, Operational Amplifiers & Integrated Circuits, Pearson Education, 5th Edition, 2001.
2. S. Franco, Design with Operational Amplifiers and Analog Integrated Circuits, Pearson Education, 3rd Edition, 2003.

BM 23.202 **Monitoring and Diagnostic Equipment** **Total Lectures: 40**

Prerequisite: BM 23. 201, BM 23. 203 **Credit: 3-0-0-3**

Objective: This course aims to provide students with a comprehensive understanding of various biomedical measurements and instruments. It focuses on blood pressure and blood flow measurements, biomedical recorders, monitoring systems, respiration system measurements, and clinical laboratory instruments. Students will learn about the principles, techniques, and applications of these instruments in diagnosing and monitoring physiological conditions.

1. **Blood Pressure & Blood Flow Measurements**: Measurement of Blood Pressure using Direct & Indirect Measurement Techniques, Cardiac output Measurement, Heart Sounds, Phonocardiography, Electromagnetic flow meter, Ultrasonic flow meter, Electrical Impedance Plethysmography, Photo-plethysmography **[8]**

2. **Biomedical Recorders:** ECG Lead Configuration, Microprocessor based ECG machine, Electrocardiograph, Electroencephalograph, 10-20 electrode placement system, Evoked potentials Electromyography, Phonocardiogram etc. **[10]**

3. **Monitoring Systems:** Central Monitoring System, Bedside Monitoring System, Arrhythmia Monitor, Ambulatory Monitoring Instruments, Endoscopy, Foetal Monitoring Systems. **[8]**

4. **Respiration System Measurements**: Pulmonary Function Measurements, Spirometery, Pneumotachometers, Pulmonary Function analysers, Respiratory Gas Analysers **[6]**

5. **Clinical Laboratory Instruments:** Colorimeters, Spectrophotometer, Clinical Flame Photometer, Automated Biochemical Analysers, Blood Cell Counters, Chromatography, Gas-Liquid Chromatographs, Electrophoresis **[8]**

Outcomes: Students will be able to

1. Demonstrate proficiency in measuring blood pressure, blood flow, and cardiac output using different measurement techniques and instruments.
2. Gain practical skills in biomedical recording, including ECG, lead configuration, electrode placement, and the use of cardiac monitors and other bedside monitoring systems.
3. Acquire knowledge and understanding of various monitoring systems used in clinical practice, enabling them to effectively utilize and interpret data obtained from these systems.
4. Familiar with respiratory system measurement techniques and instruments, such as spirometry, pulmonary function analyzers, and respiratory gas analyzers.
5. Gain knowledge about clinical laboratory instruments, including colorimeters, spectrophotometers, biochemical analyzers, blood cell counters, and chromatography and electrophoresis equipment used in clinical diagnostics and research.

Text Books:

1. John G. Webster: Medical Instrumentation Application & Design Haughton Mifflin, Co. Boston. USA, 2010.
2. R. S. Khandpur: Hand Book of Biomedical Instrumentation. Tata McGraw Hill, Third Edition, 2018.

Reference Books:

1. Joseph J. Carr & Joseph M. Brown: Introduction to Biomedical Equipment Technology. Pearson, Fourth edition, 2019.
2. Andrew G. Webb: Principles of Biomedical Instrumentation. Cambridge University Press, 2018.

BM 23. 204 **Microbiology & Pathology** **Total Lectures: 40**

Prerequisite: BM 23.201 **Credit: 3-0-0-3**

Objective: To impart the basic knowledge of biochemistry, microbiology and tissue processing methods. To understand the defense and repair processes which are commonly used by the body when a malfunction of a cell occurs. To understand the various microscopic diagnostic methods of medical applications.

1 **Clinical Biochemistry I**: Carbohydrates: function, classification & properties of carbohydrates, digestion, absorption & metabolism of carbohydrates. Proteins: classification & properties of proteins, types of proteins, Amino acids, absorption & metabolism of amino acids. Lipids: classification of lipids, digestion, absorption & metabolism of lipids. Liver function test, Kidney function test. **[10]**

2 **Instrumentation in Biochemistry**: Glassware, Clinical laboratory instruments – Balances, Hot plate and magnetic stirrer, centrifuges, Hot air oven, Incubator, Colorimetry and photometry, Spectrophotometers, pH meters, Electrophoresis, Water distillation apparatus, Automation – semi & fully automated analyzer. **[8]**

3 **Clinical Microbiology:** Introduction to bacteriology, classification & morphology of bacteria, Sources & transmission of bacteria, Gram positive & Gram negative bacteria, Identification methods, Staining methods – Gram staining, Acid-fast staining, Albert's staining. Sterilization & disinfection. Light Microscopy. **[10]**

4 **Clinical Hematology:** Hematopoietic system of the body, Erythropoiesis, Leukopoiesis, Thrombopoiesis, Synthesis of hemoglobin, Complete blood count, Anticoagulants, Blood transfusion. **[6]**

5 **Histopathology Techniques:** Introduction, Equipments & instruments, Histopathological examination of tissues, Fixation, Decalcification, Automatic tissue processor, Cryostat, Staining Procedure, Electron Microscopy. **[6]**

Outcomes: After completing this course student would able to know various tissue processing techniques, different types of instruments. They would also know the microscopic techniques and identification of bacterial and virus contamination in biological samples.

Text Books:

1. Praful B. Godkar, Darshan P. Godkar, "Textbook of Medical Laboratory Technology", 3rd Ed, Bhalani Publishing House, 2018.
2. Christopher J. Woolverton, Joanne Willey, and Linda Sherwood, "Prescott's Microbiology", 10th Ed, Wiley, 2017.

Reference Books:

1. Gerard J. Tortora, "Microbiology: An Introduction", 9th Ed, Pearsons, 2008.
2. David L. Nelson, Michael M. Cox, "Lehninger Principles of Biochemistry", 7th Ed, Macmillan, 2017.

BM 23.206 **Biomedical Signals & Systems** **Total Lectures: 40**

Prerequisite: MA 23. 105 **Credit: 3-1-0-4**

Objective: To acquire knowledge for analyzing the continuous time discrete time signals & systems and its biosignal applications.

6. **Classification Of Signals And Systems:** Representation of signals, Basic operation on signals, classification of signals-Deterministic and random signal, periodic and Non-periodic, Energy and power signal, causal and Non-causal signal, Even and Odd signal. Classification of systems- static and dynamic system, casual and non-causal system, linear and non-linear system, time variant and time invariant system, stable and unstable system. **[8]**

7. **Fourier Analysis of Signals:** Introduction to Fourier series, Continuous-Time Fourier Transform (CTFT), Dirichelet's conditions, Magnitude and phase response the discrete Spectrum, limitations of Fourier series. The direct and inverse Fourier transform, continuous spectrum, Existence and properties of Fourier transform, Parseval's theorem, Limitations of Fourier transform. Discrete-time Fourier transforms, Properties, Inverse discrete-time Fourier transform, Comparison between CTFT and DTFT. **[10]**

8. **Convolution and Correlation**: Continuous-time convolution, Convolution sum, Correlation between signals: Cross correlation, Autocorrelation, Energy spectral density, Power spectral density. **[4]**

9. **System Analysis using Laplace transforms:** Relation between Laplace and Fourier transforms, Properties, Inverse Laplace transform, Solution of differential equations using Laplace transform, Region of convergence, Stability analysis. **[9]**

10. **System Analysis using z-Transform:** Z-transform, Properties, s-plane to z-plane mapping, Inverse z-transform, Solution to difference equations using z-transform, Region of convergence, Stability analysis. **[9]**

Outcomes: After attending this course student will able to

- Classify the continuous time signals and systems and discrete-time signals and systems.
- Compute the convolution and correlation of discrete time systems.
- Understand the concepts of z-transform and discrete Fourier transform.

Text Books:

3. Allan V. Oppenheim, Alan S. Willsky and S. Hamid, "Signals and systems", Prentice Hall of India Pvt. Ltd, 2nd edition, 1997.
4. A. Anand Kumar, "Signals and systems", PHI learning Pvt. Ltd., 3rd edition, 2015.

Reference Books:

1. Simon Haykin and Barry Van Veen, "Signals and systems", John Wiley & Sons, 2nd Edition, 2001, Reprint 2002.
2. Suresh R, Devashayam, "Signals and Systems in Biomedical Engineering", Springer US, 2nd edition, 2013.

EC-23.224 **Digital Electronics Laboratory** **Total Hours: 26**
0-0-2-1

Objective: This lab course develops skills for implementing and analyzing digital electronic circuits, with applications to electronics design. It is also designed to enhance problem solving ability through steadily increasing problem complexity.

Pre-requisite: Basics of Electronics Engineering

1 To study the use of General Purpose Digital Trainer and familiarization with the digital IC Data-Books.

2 To study AND, OR. NOT, NAND, NOR, EX-OR gates and their specified experiments.

3 To set up a 4-bit Binary Counter (74LS93) to demonstrate its sequence of Counting.

4 To design and test 4-bit Adder and Subtractor circuits.

5 To compare the magnitude of two 4-bit Binary Numbers A and B.

6 Design a combinational circuit with 4 inputs and 4-outputs that converts a 4-bit Gray Code to an equivalent 4-bitBinary number.

7 Design and implement a BCD to Seven Segment Decoder / Driver.

8 To design and implement a 2 to 1 multiplexer.

9 To design and implement a 1:2 & 1:4 de multiplexer.

10 To investigate the operation of various flip flops SR, JK, T and D using gates and FF ICs.

11 To design and implement Adders and Subtractors using Verilog HDL

12 To design and implement Multiplexers/De-Multiplexers using Verilog HDL

13 To design and implement Filp-Flops using Verilog HDL

Outcomes:

1. The background provided in this laboratory may effectively be utilized for the understanding of advanced courses such as VLSI Design and for the designing of complex circuitry.
2. Gain a hands-on experience in carrying out key operations needed to assemble circuits on breadboard.
3. This subject is directly applicable to industrial IC design and provides a strong background for more advanced courses.
4. This lab will be useful in the designing of hardware projects using Verilog HDL

EC-23.222 **Integrated Circuits & Applications Laboratory** **Total Hours: 26**
0-0-2-1

Objective: This lab course develops skills for implementing and analyzing electronic circuits, with applications to electronics design. It is also designed to enhance problem solving ability through steadily increasing problem complexity.

Pre-requisite: Electronic Devices and Circuits

1. To measure the following parameters of IC-741-
(a) Slew rate (b) CMRR

2. Implement the circuits to show the application of op-amp as-
(a) Summing amplifier (inverting)
(b) Difference amplifier (c) Algebraic adder

3. (a) Design an ideal inverting integrator to integrate a square wave of frequency, f ≥ 1KHz.
(b) Design a non-ideal non-inverting differentiator to differentiate a triangular wave of frequency, f ≥ 1KHz.

4. To plot the frequency response of - 1st order Low-Pass active filter

5. To plot the frequency response of - 1st order High-Pass active filter

6. Design the following circuit using IC 555 timer-
(a) Monostable Multivibrator to generate a pulse of 0.11 ms.
(b) Astable Multivibrator with 50% duty cycle.

7. Design op-amp based circuits to realize Wein Bridge oscillator.

8. To study application of IC 555 as-
(a) VCO (b) Schmitt-trigger circuit for square wave generator

9. To measure free running frequency, lock range and capture range of the given PLL circuit using IC-565.

10. Verify the line regulation and load regulation using IC 723.

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

1. Design Band pass and Band Stop filters for the given specifications
2. Design Oscillators and Multivibrators

Course Code: **BM 23 .222**

Monitoring and Diagnostic Equipment Laboratory

Prerequisite: BM 23. 203, BM 23.201 **Credit: 0-0-2-1**

Objective: To gain the practical knowledge of recording of various biomedical parameters and get familiar with the functioning of the various types of biomedical diagnostic and monitoring equipment.

Suggested List of Experiments: (A minimum of eight experiments must be conducted.)

1. Multi-parameter monitor
2. ECG Amplifier
3. EEG Amplifier with Simulator
4. EMG Amplifier with Simulator
5. Arrhythmia Simulator
6. DC Defibrillator Demo Kit
7. Audiometer
8. Pulmonary function test
9. Multi-parameter monitor
10. X-Ray Imaging System
11. CT Scan Imaging System
12. Ultrasound Imaging System
13. Spectrophotometer.
14. Blood cell counter

Outcomes: After this course students will able to

1. measure and analyze the pulmonary function.
2. measure heart parameter like heart rate and detect abnormalities like Tachycardia, Bradycardia etc.
3. record and analyze various biomedical signals like EMG, EEG, PCG.
4. understand spectrophotometric technique of measurement.
5. to perform direct blood cell counting and their classification.

Course Code: **Microbiology and Pathology Laboratory**

BM 23.224

Prerequisite: Nil **Credit: 0-0-2-1**

Objective: To attain the practical knowledge about the various pathological and Microbiological test techniques for application in medicine.

Suggested List of Experiments: (A minimum of eight experiments must be conducted.)

1. Study of morphology of blood cells
2. Preparation of different types of agar
3. Preparation of blood film smear
4. Isolation of bacteria on nutrient agar
5. To stain bacteria in a culture by Gram Staining Method.
6. Staining of sputum smear for the detection of Mycobacterium tuberculosis by AFB Staining Method.
7. Antibiotic sensitivity test
8. Measurement of glucose, cholesterol and protein
9. pH measurement and calibration of pH meter
10. preparation of Buffer
11. working principle of centrifuge
12. Examination of urine and sputum
13. Determination of blood hemoglobin
14. Tissue Processing
15. Study of Freeze drying & Cryostat
16. Culture and Sensitivity study of Urine, Blood, Pus and other body specimens

Outcomes: After completion of this lab course students would able to understand pathological and microbiological test for blood, renal system, bacteria identification test and tissue biopsy for cancer identification.

Reference Books: Lab manual

Third Year

B. Tech. (Biomedical Engineering)

EC 23.301 **Microprocessor and Microcontroller** **Total Lectures: 40**

Prerequisite: Digital Electronics **Credit: 3-0-0-1**

Objective: To develop an in-depth understanding of the operation of microprocessors and microcontrollers,machine language programming & interfacing techniques.

1. **The 8086 Microprocessor Architecture :** Architecture, details of sub-blocks such as EU, BIU; memory segmentation and physical address computations, pin diagram and description of various signals, minimum and maximum mode of operations, supporting chips viz. 8284, 8288 and memory mapping [8]
2. **Programming of 8086:** Addressing modes of 8086, instruction set of 8086, assembly language programming, counters and time delays, stack structure of 8086 and subroutine. [7]
3. **Interfacing of 8085 / 8086 with Programmable Chips:** Interfacing of 8255 Programmable peripheral interface, 8251 USART, 8253/8254 Programmable Interval Timer and Direct Memory Access Controller 8237/8257 DMA, 8259 Programmable Interrupt Controller. [8]
4. **Introduction to Microcontrollers, Architecture and Memory Interfacing:** Overview of the 8051 family, 8051 Microcontroller's Architecture, Pin configuration, Common memory types and Tradeoffs,External Memory interfacing. [7]
5. **Programming and Interfacing of 8051:** Addressing modes of 8051, instruction set of 8051, assemblylanguage programming of 8051, stack structure of 8085, delays, and subroutines, Applications of interrupts, timer/counter and serial port, Components of Integrated Development Environment for software development, Interfacing of 8051 with sensors, ADC, DAC, Stepper Motor, Introduction to ARM processors. [10]

Outcomes: Upon completion of this course, the student will be able to:
1. The student will learn the internal organization of some popular microprocessors and microcontrollers.
2. The student will learn hardware and software interaction and integration and memory.

Text Books:
1. Ramesh S. Gaonkar, Microprocessor Architecture, Programming and Application with the 8085, Penram International Publishing, 6th Edition, 2013.
2. M. A. Mazidi, The 8051 Microcontroller & Embedded Systems, Pearson Education, 2nd Edition, 2006.

Reference Books:
1. Scott McKenzie and Raphael C.W. Phan, The 8051 Microcontroller, Pearson Education, 4th Edition, 2007.
2. D. V. Hall, Microprocessors and Interfacings; TMH, 3rd Edition, 2012

Course Code: **BM 23.302** | **Therapeutic and Surgical Equipment** | **Total Lectures: 40**

Prerequisite: BM 23.201, BM 23.203 | **Credit: 3-0-0-3**

Objective: The course aims to provide students with a comprehensive understanding of various medical devices and equipment used in cardiac care, respiratory care, electrotherapy, heart-lung machines, dialysis machines, and surgical equipment. Students will learn about the principles, types, functionalities, and applications of these devices, as well as safety considerations and relevant techniques associated with their operation.

1. **Cardiac Pacemakers & Defibrillators:** Need for a Pacemaker, Types- Asynchronous, Synchronous, External and implantable. Asynchronous pacemakers, Synchronous / Demand Pacemaker, Implantable Pacemaker. D.C. Defibrillator, Need for Synchronous Defibrillators, Types of electrodes and their features, External Defibrillators (AED), Implantable defibrillators. Cardioverters. **[10]**

2. **Respiratory Care:** Ventilators: Artificial Ventilation, Types of ventilators, Modern Ventilators, High frequency Ventilators, Humidifiers, Nebulizers and Aspirators. Anaesthesia Machine: Need of Anaesthesia, Anesthesia Equipment, Gas delivery System, Capnography, Baby Incubator. **[8]**

3. **Electrotherapy Equipment:** Short wave diathermy, Microwave diathermy and Ultrasonic diathermy, Nerve Muscle stimulator, Functional Electrical Stimulator etc. **[6]**

4. **Heart Lung Machine & Dialysis Machine:** Heart Lung Machine: Governing principles, Qualitative requirements, Functional details of Bubble, Thin Film and membrane-type of blood oxygenators. Haemodialysis: Artificial Kidney, Dialyzers, Membranes for Haemodialysis, Haemodialysis Machine, Portable Kidney Machines. **[8]**

5. **Surgical Equipment:** Electro surgical Unit, Principles of Cutting and Coagulation, Spark gap, valve and solid state generators, safety features, Laparoscope, Bronchoscope, Lithotripters. **[6]**

Outcomes:

1. Students will be able to explain the types and functionalities of different cardiac pacemakers, defibrillators, and cardioverters, and understand their applications in treating cardiac conditions.
2. Students will demonstrate knowledge of various respiratory care equipment such as ventilators, anaesthesia machines, and understand their principles, functionalities, and usage in patient care.
3. Students will gain proficiency in operating electrotherapy equipment like short wave diathermy, microwave diathermy, and nerve muscle stimulators, and understand their therapeutic applications.

4. Students will acquire a comprehensive understanding of heart-lung machines, dialysis machines, and their components, and demonstrate knowledge of their functioning, indications, and limitations.
5. Students will develop skills in handling surgical equipment like electro surgical units, laparoscopes, bronchoscopes, and lithotripters, and understand the principles of cutting, coagulation, and safety measures associated with their usage in surgical procedures.

Text Books:

1. John G. Webster: Medical Instrumentation Application & Design Haughton Mifflin, Co. Boston. USA, 2010.
2. R. S. Khandpur: Hand Book of Biomedical Instrumentation. Tata McGraw Hill, Third Edition, 2018.

Reference Books:

1. Joseph J. Carr & Joseph M. Brown: Introduction to Biomedical Equipment Technology. Pearson, Fourth edition, 2019.
2. Andrew G. Webb: Principles of Biomedical Instrumentation. Cambridge University Press, 2018.

BM 23.304 **Medical Image Processing** **Total Lectures: 40**
3-0-0-3

Prerequisite: MA 23.105, MA 23.106

Objective: The student should be made to learn digital image fundamentals & be exposed to simple image processing, image compression and segmentation techniques.

1 **Digital Image Processing Fundamentals:** Fundamentals of Image formation, components of image processing system, image sampling and quantization, relationships between pixels , Nature of Biomedical images, Objectives of biomedical image analysis and Difficulties in biomedical image acquisition. **[8]**

2 **Image Enhancement:** Basic gray-level transformation, histogram processing, arithmetic and logic operators, basic spatial filtering, smoothing and sharpening spatial filters, image enhancement in frequency domain. **[8]**

3 **Image Segmentation:** Detection of discontinuities, Point detection, Line detection, Edge detection, Gradient operators, Laplacian, Edge linking and Boundary detection, Thresholding, Region based segmentation. **[8]**

4 **Image Compression:** Image Compression Fundamentals, Image Compression Models, Lossless and Lossy Compression Techniques, image compression standards, JPEG. **[8]**

5 **Image Representation, Description & Recognition:** Representation, Boundary descriptors, Regional descriptors, Principal component analysis, Recognition based on decision theoretic & structural methods. **[8]**

Outcomes: At the end of the course, the student should be able to discuss digital image fundamentals and apply the basic image processing techniques.

Text Books:

1. Rafel C. Gonalez and Richard E. Woods, "Digital Image Processing", Pearson Education, Forth Edition 2017.
2. A. K. Jain, "Fundamentals of Digital Image Processing", Pearson Education India, 2015.

Reference Books:

1. Geoff Dougherty, "Digital Image Processing for Medical Application", Cambridge University Press, 2011.
2. Rafael C. Gonzalez, Richard E. Woods, Steven L. Eddins, "Digital Image Processing Using MATLAB", Third Edition Tata McGraw Hill Pvt. Ltd., 2016.
3. G. R. Sinha & B. C. Patel, "Medical Image processing Concepts & Applications", PHI Learning, 2014.

BM 23.306 **Biomechanics** **Total Lectures: 40**
3-0-0-3

Prerequisite: Mathematics , Human Anatomy and Physiology

Objective: To make the students familiar with principles of mechanics and learn the mechanics of physiological systems. To make the students familiar with the mathematical models used in the analysis of biomechanical systems.

1	**Application of Statistics to Biomechanics:** Skeletal joints, Skeletal muscles, basic consideration, basic assumptions and limitations, mechanics of the elbow, mechanics of the shoulder, mechanics of the spinal column, mechanics of the hip, mechanics of the knee, mechanism of the ankle. Deformable body mechanics – Stress & Stain, Uniaxial, Biaxial Triaxial Tension Test, Stress & Stain curve, work energy, Torsion & Bending, combine loading.	**[08]**
2	**Properties of biological tissues:** Mechanical Properties of collagen, elastin, bone, cartilage, tendons, ligaments, muscles and synovial fluid. Muscle models. Evaluation tests for mechanical properties of biological tissues. Features of viscoelasticity, constitutive equations and uses of viscoelastic models. Bio-viscoelestic solids and fluids.	**[09]**
3	**Cardiovascular mechanics:** Forces involved in blood flow, Generalized Bernoulli‘s equation, Wind kessel model, Stresses in the ventricular wall, Pressure -Volume loop. Hagen-Poiseuille Law-derivation and applications, steady laminar flow in elastic tube, Wave propagation in blood vessels, Reflection and transmission of waves at arterial junctions, Rheology of blood & blood flow in veins, microcirculation.	**[09]**
4	**Pulmonary mechanics:** Mechanism of air flow, Respiratory cycle, Lung Ventilation model, Methods of determining pressure, flow-rate and volume - Spirometry, Respiratory plethysmography, Diagnostic significance of the lung - ventilation model, static and dynamic respiratory mechanics tests.	**[07]**
5	**Orthopedic implants:** Design process of an orthopedic implant, typical specifications for an prosthetic joint, Biocompatibility, Requirements of a biomaterial, Characteristics of different types of biomaterials, manufacturing process of implants, fixation of implants - Mechanical fixation, cements and adhesives, porous materials.	**[07]**

Outcomes: At the end of the course, the student should be able to explain the mechanics of physiological systems & analyze biomechanical systems.

Text Books:

1. Nihat Ozkaya and Margareta Nordin, "Fundamentals of Biomechanics", Springer, 2nd Edition, 2013.
2. Y.C. Fung, "Bio-Mechanics- Mechanical Properties of Living Tissues", Springer, 2013.

Reference Books:

1. K. B. Chandran, S. E. Rittgers & A. P. Yoganathan, "Biofluid Mechanics: The Human Circulation", CRC Press, 2nd Edition, 2012.
2. Donald R. Peterson & J. D. Bronzino, "Biomechanics Principles & Practices", CRC Press, 2014.
3. Hall & Susan J Hall, "Basic Biomechanics", McGraw Hill Education, 7th Edition, 2015.

BM 23.308 **Physiological Control System** **Total Lectures: 40**

Prerequisite: BM 23.206 **Credit: 3-0-0-3**

Objective:
- To study the concept and different mathematical techniques applied in analyzing any given system in time domain and frequency domain.
- To study the concept of state space representation.

1 **Basics of Control System:** Open and closed loop systems, Mathematical models of physical systems, Transfer functions: Block diagram reduction technique, Signal flow graph, conversion of block diagram to signal flow graph. **[6]**

2 **Time response Analysis:** Transient and steady state response analysis of first and second order Systems-Time response specifications, Stability-definition, Routh's stability criterion, Root locus plots - Rules for construction -Stability analysis using root locus. **[10]**

3 **Frequency Response Analysis:** Bode plot-gain margin and phase margin, determination of transfer function using Bode plots. Polar plot-gain margin and phase margin, Nyquist Plot, Nyquist stability criterion. **[12]**

4 **Types Of Physiological Control Systems:** Difference between general control systems and physiological control systems, Examples of positive and negative feedback physiological control systems; Body temperature Regulation; Blood glucose regulation, Pupil Control System, Visual Fixation System, Oculo-motor System, Muscle stretch reflex, Skeletal muscle Servo-mechanism **[8]**

5 **Cardiovascular Control Systems:** Regulation of heart rate, Blood pressure and cardiac output, Respiratory Control System, Chemical regulation of ventilation. **[4]**

Outcomes: The learner will be able to analyze the time and frequency domains of the given system using different mathematical techniques.

Text Books:
1. Michael C K Khoo, “Physiological Control Systems”, IEEE Press, PHI, 2018.
2. L. J. Nagrath, M. Gopal “Control Systems Engineering”, Tata McGraw Hill, 2016.

Reference Books:
1. John Enderle Susan Blanchard, Joseph Bronzino “Introduction to Biomedical Engineering”, Third Edition, Academic Press, 2012.
2. L. Stark, “Neurological Control System”, Plenum Press, 2012.

BM 23.310 **Hospital Planning & Engineering** **Total Lectures: 40**

Prerequisite: Biomedical Instrumentation **Credit: 3-0-0-3**

Objective: This course provides a comprehensive understanding of hospital planning, accreditation protocols, information systems, engineering services, support services, sterilization, safety, and adherence to codes and standards in healthcare settings.

1. **Hospital Planning & Accreditation:** Role of Hospitals in Health Care, Distinction between Hospital and Industry, Fundamentals of Planning & Design of Hospital, Hospital Accreditation Protocols - ISO standards, NABH and JCI Certification. **[07]**
2. **Hospital Information System:** Requirements of computerization in Hospital. Networking, DBMS in hospital, Electronic Health record system (EHR), Information security, HL7, Medical Support System. **[07]**
3. **Engineering in Hospital:** Biomedical Engineering Services in Hospitals - Role & responsibilities. Biomedical equipment Procurement procedure - (CMC and AMC), Selection Testing and Calibration & Installation, Maintenance & Repair of Medical Equipment. **[08]**
4. **Support Services:** Basics of Air Conditioning and Refrigeration. Air filtering & sterility – Concept of Clean Room with Air Handling Unit (AHU), Hospital gas supply Systems- Oxygen, Nitrous Oxide & Vacuum, Operation theatre table & lighting, Biomedical Waste Management. **[10]**
5. **Sterilization And Hospital Safety:** Disease transmission, Central sterile services department (CSSD), Sterilization and disinfection methods, **Electrical Safety**: physiological effects of electricity, macro-shock and micro-shock hazards, electrical safety codes and standards, Radiation Safety, disposal of biological waste **[08]**

Outcomes:
1. Students will understand the role of hospitals in the healthcare system and the fundamentals of planning and designing a hospital.
2. Students will gain knowledge of hospital accreditation protocols such as ISO standards, NABH, and JCI certification.
3. Students will acquire skills in implementing hospital information systems, including networking, database management, electronic health record systems, and information security.
4. Students will grasp the duties of biomedical engineering services in hospitals, encompassing equipment procurement, testing, installation and maintenance.
5. Students will gain knowledge of hospital support services such as air conditioning, sterilization,, waste management, and equipment maintenance.

Text Books:
1. Kunders G.D, "Hospitals: Facilities Planning and Management", TMH, 16th Ed, 2017.
2. Cesar A. Caceres, "The Practices of Clinical Engineering", Academic Press, 2012.

Reference Books:
1. Sanjiv Singh, Sakthikumar Gupta, Sunil Kant, "Hospital infection control guidelines, principles and practice", Jaypee Brothers Medical Publishers Pvt Ltd, First edition, 2012.
2. K. Willson et al, "Medical Equipment Management", CRC Press, 2014.

BM 23.312 **Data Analysis in Healthcare** **Total Lectures: 40**

Prerequisite: BM 23.201, BM 23.203 **Credit: 3-0-0-3**

Objective: In this course, the students will learn the principles and methods of statistical analysis, but will also put them into practice using a range of real-world data sets. The objective of the course is to provide a basic understanding of data analysis using statistics and to use computational tools on problems of applied nature. Applications of data science techniques such as machine learning, deep learning and their applications in biological data.

1 **Data preprocessing and visualization:** Types of data, dealing with missing data, data visualization: Scatter Plot, histogram, group plots, box plots etc., dimensionality reduction. **[10]**

2 **Data analysis:** Statistical analysis, hypothesis testing, significance of p-value, chi-square, T-test, ANOVA, Bayesian Probability. **[8]**

3 **Mining Frequent Patterns:** Associations and Correlations, Classification. **[6]**

4 **Machine learning:** Supervised, unsupervised, logistic regression, SVMs, decision trees, clustering and model evaluation. **[8]**

5 **Artificial neural networks:** Types of ANN, case studies for the application of deep learning in biology and health care research. **[8]**

Outcomes: On completion of this course, students will be able to gain insights such as correlation and basic analysis using data visualization. Students can present their research results in probabilistic terms using statistical significance. Students can build and train machine learning models and evaluate them; get accustomed with deep learning techniques and their applications in biological and healthcare data.

Text Books:

1. Introduction to Machine Learning using Python, Jeeva Jose, Khanna Publishing House, 2019.
2. Data Mining: Concepts and Techniques by Jiawei Han, Jian Pei, Micheline Kamber, Elsevier; Third edition 2007.
3. Deep Learning by Ian Goodfellow, Yoshua Bengio, MIT Press 2017.

Reference Books:

1. Data Visualization – A Practical Introduction by Kieran Healy, Princeton University Press 2019.
2. Deep Learning – Rajiv Chopra, Khanna Publishing House, 2019

BM 23.322 **Therapeutic and Surgical Equipment Laboratory**

Prerequisite: BM 23.203 **Credit: 0-0-2-1**

Objective: The objective of this course is to make familiar with various medical devices used in clinical, diagnostic and therapeutic purpose and their troubleshoot techniques.

Suggested List of Experiments: (A minimum of eight experiments must be conducted.)

1. Ventilator machine
2. Anesthesia machine
3. Heart Lung Machine
4. Dialysis Machine
5. Stress Test using TMT Machine
6. Multichannel EEG Recoding & Analysis
7. Study of the Electrosurgical Unit
8. DC Defibrillator Machine
9. Short Wave Diathermy
10. Ultrasound Diathermy
11. DC Defibrillator
12. Electrical stimulation technique
13. Transcutaneous electrical nerve stimulation

Outcomes: After completion of this course, students would be able to understand the design aspects, measurement requirements & application of various diagnostic, surgical & therapeutic equipments.

Reference Books: Laboratory Manual

BM 23.324 **Medical Image Processing Laboratory** **0-0-2-1**

Prerequisite: BM 23.206

Objective: To attain the practical knowledge of various Image Processing & Analysis techniques.

Suggested List of Experiments: (A minimum of eight experiments must be conducted.)

1. Image Acquisition Technique using Ultrasound Imaging System.
2. Study of X-Ray Imaging System and Acquisition Technique.
3. Study of CT-Scan Imaging System and Acquisition Technique.
4. Write Program to read any image, resize it to 256 × 256. Apply square mask shown in following figure so that only middle part of the image is visible.
5. Write a program to compute the histogram of a given input image. Program for calculation and equalisation of the histogram.
6. Write and execute program for geometric transformation of image (a) Translation (b) Scaling (c) Rotation (d) Shrinking (e) Zooming
7. Write a program for the edge detection using Roberts, Prewitt, Sobel edge detectors.
8. Write a program to convert RGB colour model into HSV colour model apply on given image.
9. Write a program to calculate different morphological features (Area, perimeter, major axis, minor axis) of an object in a given image.
10. Write a program to add salt and paper noise than apply median filter and comment on result.
11. Design a GUI and add following functionality
    (a) A button for load an image
    (b) A brightness adjustment bar
    (c) A contrast adjustment bar
12. Processing of CT Image.
13. Processing of MRI Image.
14. Write analysis low pass and high pass wavelet filter coefficients for Daubechies-2, 4 and 8 wavelets.
15. Write a program to image segmentation based on region growing approach.

Outcomes: After completion of this laboratory course students would be able to use Image Processing Techniques like Segmentation, Image Enhancement, Morphological Applications & Image Analysis in various Software Like MATLAB, Python etc. for Biomedical Applications.

Reference Books: Lab Manual

BM 23. 301 **Biomaterials** **Total Lectures: 40**

Prerequisite: BM 23.201 **Credit: 3-0-0-3**

Objective: To provide an understanding of different biomaterials and their applications in implantable medical devices and organs.

1. **Introduction:** Basic concepts of materials Science, Definition of biomaterials, requirements of biomaterials, classification of biomaterials, Comparison of properties of some common biomaterials. Surface properties of materials, physical properties of materials, mechanical properties. **[05]**

2. **Metallic Biomaterials:** Stainless steel, Co-based alloys, Ti and Ti-based alloys etc. Importance of stress-corrosion cracking. Hard tissue replacement implant: Orthopedic implants, Dental implants. Soft tissue replacement implants: Percutaneous and skin implants, Vascular implants, Heart valve Implants. **[07]**

3. **Polymeric Materials:** Molecular structure of polymers, common polymeric biomaterials, Polyethylene, PMMA, PLA, PGA, PCL, biodegradable polymers, silicon's rubber, Hydrogel & Nanopolymers. Viscoelastic behavior: creep-recovery, stress relaxation, strain rate sensitivity. Biomedical applications **[07]**

4. **Ceramic & Composite Materials:** General properties of ceramics & classifications, common types of bioceramics, Composite Materials: Mechanics of improvement of properties by incorporating different elements. Composite theory of fiber reinforcement (short and long fibers, fibers pull out). Polymers filled with osteogenic fillers (e.g. hydroxyapatite). Host tissue reactions, Biomedical applications. **[09]**

5. **Biocompatibility & Testing of Biomaterials:** Definition of biocompatibility, blood compatibility and tissue compatibility. Testing of biomaterials/Implants: In vitro testing (Mechanical testing): tensile, compression, wears, fatigue, corrosion studies and fracture toughness. In-vivo testing (animals): biological performance of implants. Ex-vivo testing: in vitro testing simulating the in vivo conditions. Standards for testing and Manufacturing of biomaterials. Sterilization techniques: ETO, gamma radiation, autoclaving. Effects of sterilization on material properties. **[12]**

Outcomes: Student would have basic knowledge of biomaterials, biocompatibility issues and preparation techniques of biomaterials for medical applications.

Text Books:

1. Bikramjit Basu, "Biomaterials Science & Tissue Engineering: Principles & Methods" Cambridge-IISC Press, 2017.
2. Buddy D. Ratner, Allan S. Hoffman, "Biomaterials Science - Introduction to Materials in Medicine", 3rd Ed, Academic Press Elsevier, 2013

Reference Books:

1. Joon Park and R S Lakes, "Biomaterials an Introduction", Springer, 2007.
2. Jonathan Black, "Biological Performance of materials", Marcel Decker, 1991.

BM 23.303 **Medical Imaging Systems** **Total Lectures: 40**

Prerequisite: BM 23.201 **Credit: 3-0-0-3**

Objective: This course aims to provide students with a comprehensive understanding of medical imaging techniques, including X-ray imaging, computed tomography (CT), magnetic resonance imaging (MRI), nuclear imaging, and ultrasound imaging. Students will learn the principles, instrumentation, image formation, and clinical applications of these imaging modalities in diagnosing and monitoring medical conditions.

1	**X-Ray Imaging:** X- Ray: Atomic Structure, Physics of X-Ray, X-Ray Instrumentation, X-Ray Tube, Filtration, Restriction, Collimation, Power Supply, Interaction of X Ray with Biological Systems, X Ray dose, X-Ray Film, X-Ray Image Intensifier, Digital Radiography, Mammography, Fluoroscopy.	**[10]**
2	**Computed Tomography:** Principle of Hounsfield CT Scanner. CT Instrumentation, Hounsfield number, Different Generations of CT Scanner.	**[5]**
3	**Magnetic Resonance Imaging:** Fundamentals of Magnetic Resonance Imaging, Fourier spectrum of NMR signal, spin density, relaxation times, pulse sequences. MRI Instrumentation, Magnetic field gradient, the NMR coil/probe, the transmitter and the receiver. T1weighted, T2 Weight and Proton Density Image. Imaging Methods: Data Acquisition, Spin echo imaging, Gradient echo imaging, clinical use, biological effect & safety.	**[9]**
4	**Nuclear Imaging:** Nuclear Medicine Imaging: Principle of NMR, Radioactive decay, Radiotracers, planar scintigraphy, Instrumentation. Emission Computed Tomography: PET, SPECT, Instrumentation and Image formation.	**[9]**
5	**Ultrasound Imaging:** Physics of ultrasound, Interaction of ultrasound with biological matter, Ultrasound beam patterns and focusing. Instrumentation for ultrasound imaging system, Ultrasound transducer and probes, Pulse echo imaging, A Mode, B Mode and M Mode imaging. Doppler ultrasound imaging.	**[7]**

Outcomes:

1. Students will be able to explain the principles of X-ray imaging and its instrumentation.
2. Students will demonstrate knowledge of computed tomography (CT) principles and different generations of CT scanners.
3. Students will understand the fundamentals of magnetic resonance imaging (MRI) and various imaging methods.
4. Students will gain knowledge of nuclear imaging techniques, including emission computed tomography (PET and SPECT).
5. Students will demonstrate understanding of ultrasound imaging physics, instrumentation, and imaging modes.

Text Books:

1. Jerry L. Prince, Jonathan M., “Medical Imaging Signals and Systems”, Pearson Education, 2015.
2. Jerrold T. Bushberg, “The Essential Physics of Medical Imaging”, Wolters Kluwer, 2011.

Reference Books:

1. A. C. Kak & Malcom Slaney, "Principle of Computerized Tomography", IEEE Press New York, 2001.
2. William R. Hendee, E. Russell Ritenour “Medical Imaging Physics”, John Wiley, Fourth Edition, 2003.
3. Kristen M. Waterstram & Rich David Gilomre, “Nclear Medicine & PET/CT Technology & Technique”, Elsevier, Eight Edition, 2016.

BM 23.305 **Biomedical Signal Processing** **Total Lectures: 40**

Prerequisite: BM 23.206 **Credit: 3-0-0-3**

Objective: This course aims to introduce students to biomedical signals, their characteristics, and digital signal processing techniques. It covers Fourier analysis, wavelet analysis, IIR and FIR filter design, and analysis of ECG, PCG, EEG, and EMG signals.

1 **Introduction:** Brief introduction to biomedical signals (ECG, EEG, EMG , Evoked Potentials etc.), origin and characteristics, Concepts of Signal processing - Advantages of digital signal processing compared with analog processing Components of digital Signal Processing, Sampling theorem, Reconstruction of signal from its samples, effect of under sampling – Aliasing. **[06]**

2 **Frequency Domain Analysis of Continuous and Discrete Time Signals and Systems:** Fourier Series-Definition, properties and its limitation, Basics principles of DTFT & DFT: Definition and Properties, FFT-decimation in time algorithm, Decimation in Frequency algorithm. Basics of continuous and discrete wavelet. **[08]**

3 **IIR Filter Design:** Classification-Reliability constraints-IIR design-Butterworth and Chebyshev Filters, Bilinear Transform Method-Impulse Invariant Method-Step Invariance Method. **[09]**

4 **FIR Filter Design:** Characteristics of FIR filter, FIR filter design using windowing techniques- rectangular window, Hamming window, Hanning window, Blackmann window, Realization of FIR filters **[07]**

5 **Analysis of Biomedical Signal:** Analysis of ECG, Signals, QRS detection methods-Differentiation-based and template-based. Rhythm analysis and Arrhythmia detection, Data compression techniques, AZTEC, CORTES. Heart rate variability-time domain method and frequency domain methods. analysis of PCG, EEG signal and EMG signals. **[08]**

Outcomes: By the end of the course, students will be able to comprehend biomedical signals, apply signal processing techniques in the frequency domain, design IIR and FIR filters, analyze ECG signals for QRS detection and arrhythmia detection, perform data compression, analyze heart rate variability, and analyze PCG, EEG, and EMG signals

Text Books:

1. John G. Proakis and Dimitris G. Manolakis, Digital Signal Processing, Algorithms an Applications, PHI of India Ltd., New Delhi, 3rd Edition, 2000.
2. Rangaraj. M. Rangayyan, Biomedical signal processing, 2004.

Reference Books:

1. Sanjit K. Mitra ‘Digital Signal Processing’, A Computer Based Approach, Tata McGraw-Hill, New Delhi, 1998.

EC-23.325 **Microprocessor and Microcontroller Laboratory** **Total Hours: 26**

0-0-2-1

Objective: To introduce to students the basics of 8086 microprocessor, assembling language programming and interfacing with various modules.

Pre-requisite: Assembly language programming

1 **[a]** Write a program for 8085 microprocessor to move a eight bit number in register A, B, C and D. Verify the content of all the registers after execution of program.
Also find out the followings:
(i) Total number of bytes required for the program
(ii) Hex code of each instruction used in the program

[b] Load a eight bit number stored in memory location 4000H into register A. Now load the content of A in B and in memory location 5000H. Verify the contents of A, B and memory location 5000H.

2 **[a]** Write an assembly language program for 8086 microprocessor to find out the smallest number from a series of five eight bit numbers and store it at memory location 2000H: 2000H.

[b] Write an assembly language program for 8086 microprocessor to find out the largest number from a series of five eight bit numbers and store it at memory location 2000H: 2000H.

3 **[a]** Write a program to arrange the series of four eight bit numbers in ascending order.

[b] Write a program to arrange the series of four eight bit numbers in descending order.

4 Interface three LEDs with 8086 Kit to form traffic light control logic.

5 Interface a buzzer with 8086 microprocessor with the help of relay and write a program to control the ON-OFF sound from the buzzer.

6 Interface a DC motor with 8086 microprocessor and write a program to control its operation.

7 a) Introduction to Keil µVision Integrated Design Environment software.
b) Write an ALP for 8051 to move a block of five bytes stored from locations 30H to 40H of internal RAM.

8 a) Write an ALP for 8051 to move a block of five bytes stored from address 3000H of external data memory to address 40H of internal RAM.
b) Write an ALP for 8051 to move a block of five bytes stored from address 40H of internal RAM to address 3000H of external data memory.

9 Three 8 bit numbers are stored at internal RAM locations 30H, 31H and 32H. Find out the largest number and store it at internal RAM location 40H.

10 Three 8 bit numbers are stored at internal RAM locations 30H, 31H and 32H. Find out the smallest number and store it at internal RAM location 40H.

Outcome: After the basic knowledge of microprocessor and microcontroller interfacing and their applications, the student will be able to:

1. Analyze and apply working of 8086.
2. Compare the various interface techniques. Analyze and apply the working of 8255, 8279, 8259, 8251, 8257 ICs and design and develop the programs.
3. Learning the Communication Standards.

BM 22.321 **Biomaterials Laboratory** 0-0-2-1

Objective: The student should have practical knowledge of experimental techniques in Biomaterials identification, preparation and testing

Pre-requisite: None

List of Experiments

1. Identification of various materials
2. Study of various unit cells and crystals.
3. To determine the Impact toughness (strain energy) through Izod test.
4. To determine the tensile strength of specimen using Universal Testing Machine.
5. To find the modulus of rigidity using torsion testing equipment.
6. To find the values of bending stresses and Young's modulus of the material of a beam (say a wooden or steel) simply supported at the ends and carrying a concentrated load at the centre using Universal Testing Machine
7. To find the shear strength of given specimen using Universal Testing Machine.
8. To find the compressive strength of given specimen using Universal Testing Machine.
9. To determine the stiffness of the spring and modulus of rigidity of spring wire using spring testing machine.
10. Preparation of Polyvinyl alcohol hydrogel
11. Evaluation of swelling index of hydrogel
12. Preparation of drug loaded hydrogel

Outcome(s):

1. Students able to identify various materials
2. Understand the fundamental concepts of stress and strain and the relationship between both through the strain-stress equations in order to solve problems for simple tri-dimensional elastic solids.
3. Solve problems relating to pure and non-uniform bending of beams and other simple structures.
4. Solve problems relating to torsional deformation of bars and other simple tri-dimensional structures.
5. Able to prepare hydrogels

Fourth Year

B. Tech. (Biomedical Engineering)

Electives

Biomedical Engineering

BM 23.411 **Telemedicine** **Total Lectures: 40**

Prerequisite: Biomedical Instrumentation **Credit: 3-0-0-3**

Objective: This course aims to familiarize students with the concepts and applications of telemedicine. It covers the technology behind telemedicine systems, telecommunication and network basics, personal health monitors, and various telemedicine applications in fields such as radiology, surgery, pathology, cardiology, neurosciences, and emergency medicine.

1. **Introduction:** Introduction & evolution of telemedicine, Functional block diagram of telemedicine system, scope, benefits, application and limitations of telemedicine. Introduction to biotelemetry, physiological parameters adaptable to biotelemetry, the components of biotelemetry system. TeleHealth, mHealth, ubiquitous Health and eHealth, Setting up Telemedicine facility. **[06]**

2. **Telemedicine system Technology :** EMR, EHR, PHR, Standards for Medical data exchange, Health Level 7 (HL7), Transmission of Medical data (Text, Still, Video and Audio), DICOM **[9]**

3. **Telecommunication & Network:** Basics of communication system**,** Types of Communication and Network: PSTN, POTS, ISDN, Internet, Wireless Communication systems: GSM, satellite and Micro Wave. Modulation techniques & Antennas, Wi-Fi, WiMAX, Bluetooth, BLE, ZigBee, 6LoWPAN, Ultra Wideband Technology **[11]**

4. **Personal Health Monitors:** Portable Medical Devices (PMD), Design considerations for portable Medical Devices, System-On-Chip Architecture for PMD, Point of care Testing Instruments : BP Monitors, Blood Glucose Monitors, ECG Monitors, Pulse Oximeters, Smart Cloths, e-textiles , Wearable monitors , dry electrodes **[08]**

5. **Telemedicine Applications:** Teleradiology, Tele-surgery, Tele pathology, Picture Archiving and Communication System, Tele-cardiology, Tele-oncology, Telemedicine in neurosciences, Medical Emergencies and Disaster relief **[06]**

Outcomes: Student will able to

1. Understand the evolution, scope, benefits, and limitations of telemedicine.
2. Gain knowledge of telemedicine technology and standards.
3. Comprehend telecommunication and network technologies relevant to telemedicine.
4. Analyze and design personal health monitors and portable medical devices.
5. Understand telemedicine applications in teleradiology, tele-surgery, and tele-cardiology across medical field.

Text Books:

1. Wootton, R., Craig, J., Patterson, V. (Eds.), “Introduction to Telemedicine”, CRC Press, Second Edition, 2017.
2. R. S Khandpur “Telemedicine: Technology and Applications”, PHI Learning New Delhi, 2017.

Reference Books:

1. Olga Ferrer-Roca, M. Sosa Ludicissa, “Handbook of Telemedicine”, IOS press, 2002.
2. O'Carroll, P.W., Yasnoff, W.A., Ward, E., Ripp, L.H., Martin, E.L. (Eds), “Public Health Informatics and Information Systems”, Springer, 2003.

BM 23. 413 **Bioinformatics** **Total Lectures: 40**
3-0-0-3

Objective: The objectives of this course are to provide students with the theory and practical experience of the use of common computational tools and databases which facilitate investigation of molecular biology and evolution-related concepts as well as Apply disciplinary knowledge and transferable skills in areas related to biotechnology

Pre-requisite: None

1	**Introduction to Networking:** Computer Networks; Introduction to Internet and its applications; Importance of Unix and Linux systems and its basic commands; requirement of computational biology and bioinformatics, contribution of bioinformatics in biotechnology	06
2	**Biological Databases:** Introduction, Nucleotide and Amino Acid Sequence Databases: GenBank, EMBL, PDB, SWISSPROT, TREMBL, CATH, SCOP, KEGG, STRING: Understanding the structure of each source and using it on the web; database searching using SRS, ENTREZ	09
3	**Sequence alignment**: Pairwise and multiple sequence alignment; methods and tools for sequence alignment; BLAST; FASTA, Algorithm for sequence alignment; applications of sequence alignment	09
4	**Phylogeny:** Phylogenetic tree; methods of phylogenetic tree construction and application of phylogenetics	07
5	**Genome Annotation:** Gene structure**;** ORF, pattern and repeat finding; post translational modifications, CDS; Outline of sequence assembly; mutation/ substitution matrices	08

Course Outcome:

1. Remember the basic concepts and various tools of bioinformatics and their significance in molecular biology
2. Explain about biological data, their storage, alignment and phylogeny
3. Analyse the biological databases and their importance in biological research
4. Compare nucleotide and amino acid sequences employing bioinformatics tools
5. Apply bioinformatics tools for sequence alignment and evolution studies.
6. Build phylogenetic trees of nucleotide sequences using various algorithms

Textbooks

1. Lesk, A. M. (2002). Introduction to bioinformatics. Oxford: Oxford University Press.
2. Mount, D. W. (2001). Bioinformatics: Sequence and genome analysis. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
3. Ghosh Z. and Bibekanand M. (2008) Bioinformatics: Principles and Applications. Oxford University Press.
4. Pevsner, J. (2015). Bioinformatics and functional genomics. Hoboken, NJ.: Wiley- Blackwell.

Reference Books

1. Bourne, P. E., & Gu, J. (2009). Structural bioinformatics. Hoboken, NJ: Wiley-Liss.
2. Lesk, A. M. (2004). Introduction to protein science: Architecture, function, and genomics. Oxford: Oxford University Press.

BM 23. 415 **Bio-Fluid Mechanics** **Total Lectures: 40**

Prerequisite: Basic Mathematics, Basic Biology **Credit: 3-0-0-3**

Objective: To provide the students:

1. An understanding on the physiology and anatomy of studied systems,
2. A capability to analyse cardiac, respiratory, soft tissue and orthopedic mechanics

1. **Basics of Fluid Mechanics: Types of fluids , properties of fluids, Laminar and Turbulent flow,** Intrinsic fluid properties, Conservation Laws, Hagen Poiseuille Equation, Mass and Moment balance, Bernoulli equation, , effect of flow pulsatility, Boundary Layer Separation. **[06]**

2. **Cardiovascular Circulation:** Cardiac structure, Cardiac function, Systemic, Coronary and Pulmonary Circulation. Cerebral and renal Circulations, Regulation of Circulation, Atherosclerosis and its physiological implications. **[08]**

3. **Rheology of Blood:** Viscometry, Physical properties of Blood, Viscous behavior of blood, Pressure- flow relationship for non- Newtonian blood. Hemolysis and platelet activation with fluid dynamically induces stresses. Blood vessel mechanics. **[08]**

4. **Flow models:** Arterial stenosis and Aneurysms, cardiac Valve stenosis, Stents, Vascular Resistance, Estimation of entrance length, and its effect on flow development in arteries. Flow in collapsible vessel. Unsteady and Non-uniform models: Windkessel model for the human circulation, Continuum model for pulsatile flow dynamics, wave propagation in arterial system. Wall shear stress and its effects on endothelial cells **[10]**

5. **Engineering applications:** Fluid Mechanics of Other Body Fluids: Cerebral spinal Fluid, Synovial Fluid, Lymph etc. Engineering applications – Dialysis and Artificial kidney, Heart-Lung machines. **[08]**

Outcomes: At the end of the course, the student should be able to:

1. Discuss on Cardiovascular and pulmonary system in human body
2. Explain blood properties ,especially the anatomy and physiology of blood vessels

Text Books:

1. Krishnan B. Chandran, Stanley E. Rittgers, Ajit P. Yoganathan, "Biofluid Mechanics: The Human Circulation", CRC Press, Second Edition, 2012.
2. Clement Kleinstreuer, "Biofluid Dynamics: Principles and Selected Applications", CRC Press, 2016.

Reference Books:

1. Ronald L. Fournier Basic Transport Phenomena in Biomedical Engineering, CRC Press, Third Edition, 2011.
2. Kal R Sharma, "Transport Phenomena in Biomedical Engineering: Artificial organ Design and Development and Tissue Engineering", McGraw Hill Professional, 2010.

BM 23. 417 **Nanotechnology in Medicine** **Total Lectures: 40**

Prerequisite: BM 23.301 **Credit: 3-0-0-3**

Objective:
- To learn about basis of nanomaterial science, preparation method, types and application.
- To know about Drug delivery and tracking systems

1. **Synthesis and Application of Nano Material:** Bulk synthesis: Top down and bottom up approaches Inert gas condensation technique Arc plasma and laser ablation Chemical synthesis: sol gel processing, hydrothermal, precipitation, spray pyrolysis, Electro spraying and spin coating routes. **[10]**

2. **Characterization Technique:** Introduction to Nano scale phenomena, Nanoparticles determination and carbon nano tube, Nanomaterial characterization: Scanning electron microscope and Energy-dispersive X-ray Spectroscopy Analysis, Transmission electron microscopy analysis and Atomic force microscopy analysis, Scanning probe microscopy technique and Small-angle, X-ray scattering, Nano indentation technique. **[10]**

3. **Nanotechnology in Diagnostics:** Improved diagnosis for in vivo imaging, Detection of tumors, plaque and genetic defects, Nano-sized medical device, Cantilever Sensors. **[06]**

4. **Prosthetic and Medical Implants in Nanotechnology:** Neural implant, Ocular, cochlear and dental implants, Implants and prosthesis of skin, limb and bone, Artificial organ and organ transplant, Nanofiber scaffold technology. **[08]**

5. **Application of Nanotechnology:** Nano-bio conjugates and their significance, Nanoscaffolds and application, Magnetic nanoparticles synthesis and application, Multifunctional inorganic and CNT nano particle and its application, Organic nanoparticles and their biomedical applications. **[06]**

Outcomes:
- Will familiarize about the science of nanomaterials & nanomedicine.
- Will develop knowledge in characteristic nanomaterial

Text Books:
1. W. Gaddand, D. Brenner, S. Lysherski and G. J. Infrate (Eds.), "Handbook of Nano Science Engineering and Technology", CRC Press, 2013.
2. K. Barriham, D.D. Vvedensky, "Low dimensional semiconductor structure fundamental and device applications", Cambridge University Press, 2010.

Reference Books:
1. Cao G, "Nanostructures & Nanomaterials Synthesis: Properties &Applications", Imperial College Press, 2011.
2. Allen J Bard and Larry R Faulkner; Wiley, "Electrochemical Methods: Fundamentals and Applications", New York Chichester, 4th edition, 2009.

BM 23.412 **Tissue Engineering** **Total Lectures: 40**

Prerequisite: BM 23.301 **Credit: 3-0-0-3**

Objective: Introduce tissue engineering, cellular fate processes, tissue organization, cellular and molecular aspects, scaffold engineering, and application of tissue engineering in different fields. Discuss regulatory and ethical issues in tissue engineering.

1. **Introduction:** Basic definition, Introduction to tissue engineering, Cells as therapeutic agents with examples. Cellular fate processes, Cell differentiation, Cell migration – underlying biochemical process. **[6]**

2. **Structural and organization of tissues:** Tissue organization, Tissue Components, Tissue types, Functional subunits. Tissue Dynamics, Homeostasis in highly prolific tissues and Tissue repair. Angiogenesis. Epithelial, connective; vascularity and angiogenesis, basic wound healing, cell migration, current scope of development and use in therapeutic and in-vitro testing. **[8]**

3. **Molecular and cellular aspects:** Cell-extracellular matrix interactions - Binding to the ECM, Modifying the ECM, Malfunctions in ECM signaling. Cell signaling molecules, growth factors, hormone and growth factor signaling, growth factor delivery in tissue engineering, cell attachment: differential cell adhesion, receptor-ligand binding, and Cell surface markers **[10]**

4. **Scaffold:** Engineering biomaterials for tissue engineering, Degradable materials (collagen, silk and polylactic acid), porosity, mechanical strength, 3-D architecture and cell incorporation. Engineering tissues for replacing bone, cartilage, tendons, ligaments, skin and liver, Bioreactors for Tissue Engineering **[8]**

5. **Application and regulatory issues:** Case study of multiple approaches: cell transplantation and engineering for liver, musculoskeletal, cardiovascular, neural, visceral tissue engineering. Ethical, FDA and regulatory issues of tissue engineering. **[8]**

Outcomes: Students will understand the principles of tissue engineering, cellular and molecular interactions, tissue organization, and scaffold engineering. They will gain knowledge about applications in various fields and understand the ethical and regulatory considerations in tissue engineering

Text Books:

1. Bikramjit Basu, "Biomaterials Science & Tissue Engineering: Principles & Methods" Cambridge-IISC Press, 2017.
2. Bernhard Palsson & Sangeeta Bhatia, "Tissue Engineering", Pearson, 2009.

Reference Books:

1. Gordana Vunjak-Novakovic, R. Ian Freshney, "Culture of Cells for Tissue Engineering", WIS, 2006.
2. B. Palsson, J.A. Hubbell, R.Plonsey & J.D. Bronzino, "Tissue Engineering", CRC Press, 2003.

BM 22.414 **Analytical Instrumentation and Techniques** **Total Lectures: 40**
3-0-0-3

Course Objective:
1. To learn the basic fundamentals of analytical techniques and instrumentation involved
2. To identify the specific technique for the analysis of the biological samples

Pre-requisite: None

1	Microscopy Techniques: Principles of microscopy, light microscopy, electron microscopy, fluorescent microscopy and confocal microscopy	8
2	Spectroscopy Techniques: Ultra violet Visual spectroscopy, visible spectroscopy, Fluorescence Spectroscopy, Infrared Spectroscopy, Mass spectrometry, Nuclear Magnetic Resonance (NMR)	8
3	Chromatography and Electrophoresis Techniques: Introduction to Chromatographic techniques, Liquid chromatography, Gas chromatography, Applications of chromatography. Introduction to optical Techniques and their Working, turbidimetry, Nephelometry, Polarimetry, Refractometry Micro-arrays; Enzymatic assays; Immunoassays - Enzyme-Linked Immunosorbent Assay (ELISA), Radioimmunoassay (RIA), immunohistochemistry	10
4	Radioisotope techniques: Introduction to radioisotopes, detection, measurement and uses of radioisotopes, counting efficiency and autoradiography, biotechnological applications .	7
5	Centrifugation techniques: Introduction, Basic principle of sedimentation, Centrifuges and their uses, safety aspects in the use of centrifuges. Density gradient and analytical centrifugation	7

Course Outcome: Students will be able to
1. Apply basic principles of different analytical techniques in analytical work.
2. use spectroscopy and radioactivity in biotechnological applications
3. use microscopy, centrifugation and electrophoretic techniques.

Textbooks
1. J. Cazes, Analytical Instrumentation Handbook, CRC Press, Third Edition, 2004
2. R. Shobha, and M. Banani, Essentials of Analytical Chemistry, Pearson Education , 2017

Reference Books
1. Wilson K., Walker J. Principle and Techniques of Biochemistry and Molecular Biology. Cambridge University Press (2006) 6th edition
2. Pingoud A., Urbanke C., et la. Biochemical Methods – A concise guide for Students and researchers. Wiley (2002)
3. Stryer, A.L., Berg J.A. and Tymoczko, J.L., Biochemistry, W.H.Freeman & Co Ltd (2002).

BM 23.416 **Transport Phenomena in Biological Systems** **Total Lectures: 40**

Prerequisite: Basic Mathematics **Credit: 3-0-0-3**

Objective: This course provides the fundamental knowledge of process principles related to the transport process in biological system.

1. **Momentum transport:** Physical properties of fluids, forces on fluids, buoyancy, hydrostatic equation for compressible fluids. Laws of viscosity. Types of fluid motion-flow. Bernoullis theorem. **[06]**

2. **Nature and intensity of turbulence**. Universal velocity distribution. Laminar and turbulent flows. Flow past immersed bodies. Application of dimensional analysis in fluid dynamics **[10]**

3. **Mass transfer in Gas-liquid mass transfer in microbial systems**. Oxygen transfer rates. Single and multiple bubble aeration. Design of spargers and aeration equipment. Mass transfer across free surface as well as freely rising or falling bodies. **[09]**

4. **Basic concept of oxygen transfer** coefficient (Kla) and its measurement; Correlation of Kla with other operating variables; Factors affecting the Kla. **[07]**

5. **Applications**: Hemodialysis & Heart Lung Machine **[06]**

Outcomes: The students will be able to explain the mass and movement transfer , transport techniques and oxygen transfer

Text Books:

1. Bird R B, Stewart W E and Light fort R N (2007), Transport Phenomena, 2nd Ed. Wiley India
2. Transfer Welty J R, Wilson R E and Wicks C E (2019).Fundamentals of Momentum, Heat and Mass , 7 th Ed. Wiley

Reference Books:

1. Harvey W. Blanch and Douglas S. Clark (2018), Biochemical Engineering, CRC Press
2. James E. Bailey and David F. Ollis (1986), Biochemical Engineering Fundamentals 2nd edition, McGraw Hill Education

BM 23.418 **Medical Radiation Safety** **Total Lectures: 40**

Prerequisite: Basic Physics **Credit: 3-0-0-3**

Objective: Student Should be able to understand basic guidelines of radiation protection and radiation detectors, safety measures related to UV, laser and nuclear medicine.

6. **Introduction to RF and Microwave Radiation:** Sources of radio frequency radiation, Effects of radio frequency radiation, Development of standards for human safety, Calculation of RF field quantities, RF radiation measuring instruments and methods. **[07]**
7. **Radiation Detection and Measurement:** Fundamentals of radiation detection, Conducting radiation measurements and surveys, Gas detectors, Designing to reduce radiation hazards, Radio frequency radiation safety management and training, Scintillation detectors, Statistics of counting, minimum detectable activity, Quality assurance of radiation counters. **[09]**
8. **Radiation Safety in Nuclear Medicine and Radiotherapy:** Design and description of NM department, Radiation protection in nuclear industry, Guidelines for radiation protection, Molecular medicine and radiation safety program procedures for safe operation of Radiation equipment, Radiation protection in external beam radiotherapy, Radiation protection in brachy therapy, Radioactive wastes. **[10]**
9. **Monitoring Dosimetry:** Monitoring methods, personal radiation monitoring, Records of personal dosimetry, ICRP method, MIRD method. **[07]**
10. **Internal Dosimetry:** Internal doses from radiopharmaceuticals, Bioassay of radioactivity, Hazard and risk in radiation protection, radiological incidents and emergencies, Regulation to radiation protection. **[07]**

Outcomes: At the end of the course, the student should be able to explain the different radio diagnostic and therapeutic techniques.

Text Books:

3. Jamie V Trapp, Thomas Kron, “An introduction to radiation protection in medicine”, CRC press Taylor & Francis group, 2008.
4. Alan Martin, Samuel Harbison, Karen Beach, Peter Cole, Hodder Arnold, “An introduction to radiation protection”, 6th edition, 2012.

Reference Books:

3. Max Hlombardi, “Radiation safety in nuclear medicine”, CRC Press Taylor & Francis group, 2nd edition, 2007.
4. Aruna Kaushik, Anupam mondal, B.S. Dwarakanath, R. P. Tripathi, “Radiation protection manual”, INMAS, DRDO, 2010.
5. Ronald kitchen, “RF and microwave radiation safety”, Newness publishers, 2nd edition, 2001.

BM 23.325 **Biomedical Signal Processing Laboratory** **Credit: 0-0-2-1**

Prerequisite:

Objective: To attain the practical knowledge about the various bio signals, their characteristics and analysis techniques.

1. Representation of time-series; computation of convolution
2. Response of a difference equation to initial conditions; stability
3. DFT computation
4. Computational experiments with digital filtering
5. Sampling and waveform generation
6. FIR and IIR filters implementation
7. Fast Fourier Transform
8. Acquisition of bio signals using BIOPAC Amplifier
9. Analysis of ECG signals
10. Analysis of EEG signals
11. Analysis of EMG signals

Outcomes: After completion of this lab course, students would be able to work with different digital signal processing techniques in biomedical signal domain. They would also able to analyze the various biomedical signals using computational techniques.

Reference Books: Lab manual

BM 23.419 **Rehabilitation Engineering** **Total Lectures: 40**

Prerequisite: None **Credit: 3-0-0-3**

Objective: This course aims to introduce students to the field of Rehabilitation Engineering, covering topics such as the definition and concept of disabilities, rehabilitation team, and socio-legal aspects. It also focuses on impairments, orthotics, prosthetics, assistive devices, and advanced applications in rehabilitation engineering.

1. **Introduction to Rehabilitation Engineering:** Definition, Concept of Rehabilitation, Concept of Disability, Socio Vocational Rehabilitation, Medical, Psychological and Social Issues Influencing the Rehabilitation, Rehabilitation Team, Socio Legal Aspect of Rehabilitation. **[06]**

2. **Impairments & Disabilities:** Spinal Cord Injury, Stroke, Cerebral Palsy, Traumatic Brain Injury, Hemiplegic, Spasticity, Myopathy, Cerebral Injury and Limb Amputation. Rehabilitation engineering for the restoration of variety of human activities for disabilities that include Sensory, Motor of Cognitive Losses, Burn Injury. **[10]**

3. **Orthotics & Prosthetics in Rehabilitation:** Concept of Orthotics and Prosthetics, Types of Orthotics and Prosthetics, Intelligent Prosthetic Knee, Prosthetic Hand, Advance and Automated Prosthetics and Orthosis, Externally Powered and Controlled Orthotics & Prosthetics, Restoration of Hand Function. **[10]**

4. **Assistive Devices:** Wheel Chairs, Type of Wheel Chairs, Design of Wheel Chair, Assistive Devices for the Visual Impaired, Hearing Aids, Cochlear Implantation. Tricycle, Walkers, Crutches. Rehabilitation Aids for Mentally Impaired: Walking Aids, Seating Aids and Postural Aids etc. **[09]**

5. **Advanced Applications:** Functional Electrical stimulation, Robots in rehabilitation, Rehabilitation in sports, Daily living aids, Assistive technology for dyslexia, Computer & internet access for challenged people, Neural engineering in rehabilitation engineering, Role of biomedical engineering in rehabilitation **[05]**

Outcomes: Students will gain knowledge and understanding of rehabilitation engineering, including the concept of rehabilitation, disabilities, orthotics, prosthetics, assistive devices, and advanced applications like functional electrical stimulation, robotics, and the role of biomedical engineering in rehabilitation.

Text Books:
1. Rory A. Cooper, "An Introduction to Rehabilitation Engineering" CRC Press, 2010.
2. Albert M. Cook, "Assistive Technology: Principles & Practice", Elsevier, 2014.

Reference Books:
1. Smith, Raymond V. & John H. Leslie, "Rehabilitation Engineering". CRC Press, 2009
2. D. P. Bryant, "Assistive Technology for People with Disabilities", Pearson, 2012.

BM 23. 421 **Artificial Organs and Implants** **Total Lectures: 40**
3-0-0-3

Objective: This course is intended for understanding the design, principles and applications of various types of artificial and tissue derived implants and use of 3 D printing technology in implantation

Pre-requisite: Biomaterials

1	**Implant materials and their characteristics:** Properties and biocompatibility of metallic, ceramic and polymeric biomaterials used in the fabrication of biodevices, Bio polymers: collagen and elastin, materials for ophthalmology: contact lens, Intraocular lens, Dental Implants.	8
2	**Artificial limb:** Hand function, musculoskeletal anatomy of the hand and arm, non-hand-like prehensors, myoelectricity, Transradial, transhumeral and shoulder disarticular prostheses, Lower limb anatomy.	8
3	**Artificial Organs:** Artificial blood, artificial skin, Artificial Heart, Prosthetic Cardiac Valves, Artificial lung (oxygenator), Artificial Kidney (Dialyzer membrane),	8
4	**Tissue Replacement Implants:** Small intestinal submucosa and other decellarized matrix, biomaterials for tissue repair; Soft tissue replacements, Sutures, Surgical tapes, Adhesive, Percutaneous and skin implants, Maxillofacial augmentation, Vascular grafts, Hard tissue replacement Implants, Joint replacements, Pancreas replacement.	8
5	**Fundamentals of 3 D printing and its applications in Biomedical**, Introduction, Process, Classification, Advantages, Additive V/s Conventional Manufacturing processes, CAD Data formats, Data translation, Data loss, STL format, Materials and various forms of raw material and their desired properties, Applications.-Biomedical applications of 3 D printing technology-maxillofacial surgery- upper limb prosthetics-3 D printed, natural and synthetic polymeric scaffolds for bone tissue engineering	8

Outcome: By the end of the course, students will be able to analyze the properties and biocompatibility of implant materials. They will comprehend the design and functionality of artificial limbs, artificial organs, and tissue replacement implants. Additionally, students will grasp the fundamentals and biomedical applications of 3D printing technology.

Textbooks

1. Pal S. Design of artificial human joints & organs. Boston, MA: Springer US; 2014.
2. Singh S, Prakash C, Singh R, editors. 3D Printing in Biomedical Engineering. Springer; 2020.
3. Fisher JP, Mikos AG, Bronzino JD, Peterson DR, editors. Tissue engineering: principles and practices. CRC Press; 2012 Dec 11.

Reference Books

1. Du Toit L, Kumar P, Choonara Y, Pillay V, editors. Advanced 3D-printed systems and nanosystems for drug delivery and tissue engineering. Elsevier; 2020
2. Bernhard Palsson, Jeffrey A. JosephD. Bronzino, Principles and Applications in Engineering Series :Tissue Engineering
3. 3.Larry L. Hench, Julian R. Jones Biomaterials, artificial organs and tissue engineering ,Woodhead Publishing Limited, 2005

BM 23.423 **Data Mining And Machine Learning for Biomedicine** **Total Lectures: 40**
3-0-0-3

Objectives:
1. To learn various data mining techniques used to analyses huge biological data to find the hidden patterns.
2. To familiarize students with a new rapidly evolving filed of machine learning and mining

Pre-requisite: None

1	**OVERVIEW OF MACHINE LEARNING TECHNIQUES:** Supervised and unsupervised techniques. Empirical Risk Minimization, Structural Risk Minimization; Measuring the accuracy of learned hypotheses. Comparing learning algorithms: cross-validation, learning curves, and statistical hypothesis	6
2	**MACHINE LEARNING TECHNIQUES: Classification**: Decision tree, Bayesian, Rule based classification, ANN, SVM, HMM; Case based reasoning and Applications in Bioinformatics. Clustering: Partition Methods, Hierarchical methods,/Density based methods, Grid based clustering, Model based clustering, clustering of high dimensional data, constraints based clustering, Analysis of MD trajectories, Protein Array data Analysis.	9
3	**INTRODUCTION TO DATA MINING:** Introduction to Data mining, Data mining Functionalities, Classification of Data mining Systems, Data Mining Task Primitives, Integration of Data mining systems, Major issues of Data mining.	9
4	**DATA PREPROCSSING AND VISUALIZATION**: Overview of data preprocessing, Data cleaning, Data integration, Data reduction, Data transformation and discretization, Visualization- Visualizing a single attributes, Visualizing pair of attributes, Visualizing several attributes, Visualizing results of machine learning.	9
5	**APPLICATIONS:** Medical Image Analysis, Application of Data Mining in Biomedical data analysis: DNA/protein sequence Analysis, Genome analysis, Protein Structure Analysis,	7

Outcome: Upon successful completion of this course, the students will be able to
1. Know the basic notions and terminology used in Machine learning and Data mining.
2. Understand fundamental principles of modern data analysis.
3. Understand the applications of Machine learning and Data mining in biological data processing and visualization.

Textbooks
1. Witten, H. I., Frank, E. and Hall, M. A., Data Mining: Practical Machine Learning Tools and Techniques, 2011.
2. Hastie, T., Tibshirani, R., Friedman, J. H. The Elements of Statistical Learning: Data Mining Interface and Prediction, 2009.

Reference Books
1. Data Mining Techniques, A. K. Pujari, UniversityPress, Hyderabad, 2006
2. Data mining in bioinformatics by Wang et al, Springer-Verlag, 2005.

BM 23.425 **BioMEMS** **Total Lectures: 40**

Prerequisite: BM 23.301 **Credit: 3-0-0-3**

Objective:
1. Learn various MEMS fabrication techniques, different types of sensors and actuators and their principles of operation at the micro scale level.
2. Know the application of MEMS in different field of medicine.

1. **Introduction to BioMEMS:** Introduction to MEMS technology, Materials used for MEMS- active substrate materials - Silicon, Silicon piezo resistors, Gallium Arsenide, quartz, polymers, Method for thin film deposition, Photolithography, itching, doping. **[07]**

2. **Sensor and Actuator:** MEMS design approach, Mechanical sensor, Thermo sensor, cantilever, strain, pressure and flow measurements, thermal couples, thermal resistor, Shape memory alloys- Inertia sensor, flow sensor. **[08]**

3. **Electrostatic and Piezoelectric Sensors:** 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. **[10]**

4. **Microfluidics Technology:** Fluid properties and different laws, fluid flow in microconduits, in submicrometer and nanoscale. Microscale fluid, expression for liquid flow in a channel, fluid actuation methods, dielectrophoresis, microfluid dispenser, microneedle, micropumps-continuous flow system. **[09]**

5. **BioMEMS Application:** MEMS for drug delivery, micro total analysis systems detection, microsystem approaches to polymerase chain reaction, DNA sensor. **[06]**

Outcomes: At the end of the course, the student should be able to apply MEMS in different field of medicine.

Text Books:
1. Tai Ran Hsu, "MEMS and Microsystems Design and Manufacture", Tata McGraw Hill Publishing Company, New Delhi, 2017.
2. Wanjun Wang, Stephen A. Soper, "BioMEMs: Technologies and Applications", CRC Press, New York, 2007.

Reference Books:
1. Shekhar Bhansali & Abhay Vasudev, "MEMS for Biomedical Applications", Woodhead Publishing, 2012.
2. Marc J. Madou, "Fundamentals of Microfabrication and Nanotechnology", Taylor & Francis, Third Edition, 2011.
3. Bruce Albert et al, "Molecular Biology of the Cell", Taylor & Francis, Sixth Edition, 2017.

BM 23.422 **Fiber Optics & Laser in Medicine** **Total Lectures: 40**

Prerequisite: Basics of Physics and Biology **Credit: 3-0-0-3**

Objective:
- To impart in students detailed knowledge about Principle and working of LASER fiber optics.
- To give brief knowledge about integration of LASER & fiber optic techniques for therapeutic, diagnosis and imaging modalities.

1. Introduction to Fiber Based Optical System: **[06]**
Introduction of light, EM spectrum, Internal & External Reflections, Snell's law, Optical Fiber Numerical Aperture, Fresnel Reflection, Fiber Optic Properties, Basic Fiber Optic Construction.

2. Sources and Detectors: **[06]**
Formation of Photons, LED, ILD, Photodetectors- Characteristics, Types of Photodiodes, Photodiode Parameters, Detector Noise, Speed of Response.

3. Splices, Couplers and Modulation Approach: **[08]**
Splices: mechanical, fusion, protection of splice, connectors: SMA, STC, bionic, coupling: passive, Stan, Digital Modulation and Analog Modulation Schemes, Multiplexing.

4. Laser Systems: **[10]**
Solid state lasers, Gas lasers, Dye lasers, Lasers used in medical practice- Principle, Instrumentation, Advantages, Limitations, Laser Safety Aspects, etc.

5. Applications of Lasers in Healthcare: **[10]**
Dermatology, ophthalmology, cardiovascular & chest surgery, dentistry, neuro surgery, otolaryngology & head and neck surgery, tumor surgery, gynecology, orthopedics, gastroenterology.

Outcomes: At the end of the course, the student should be able to:
- Apply lasers in different areas of medicine.
- Explain the special techniques of Lasers.
- Use the Photonics instrumentation.

Text Books:
1. Marfolf H Niemz, "Laser Tissue Interactions- Fundamentals and Applications", Springer, 2013.
2. Abraham ketzir, "Laser & optical Fiber in Medicine", Academic Press, 2012.

Reference Books:
1. David H Shiney, Stephen and L. Trokel, "Medical Lasers and Their Safe Use", Springer, 2012.
2. Russell K Hobbie and Bradley J Roth, "Intermediate Physics for Medicine and Biology", Springer, 2015.

BM 23. 424 **Design & Development of Medical Devices** **Total Lectures: 40**

Prerequisite: BM 23.301, BM 23.302 **Credit: 3-0-0-3**

Objective:
- To understand about basic design of medical device & data acquisition system used in medical device.
- To study the minimally invasive device and technique used in medical devices.
- To study in detail about system description of diagnostic equipment.

1. Fundamentals of Implant Design: **[07]**
Principles of Implant Design, Clinical Problems Requiring Implants for Solution, Principles of Implant Design / Design Parameters: Permanent versus Absorbable Devices, the Missing Organ and its Replacement, Criteria for Materials Selection.

2. Biocompatibility of Medical Devices: **[07]**
Scaffolds, Cells and Regulators, Case Study of Organ Regeneration, Design Parameters, Design Specifications: Biomaterials, Biocompatibility: Local and Systemic Effects, Design Specifications: Tissue Bonding and Modulus Matching.

3. Degradation of Medical Devices: Natural and Synthetic Polymers, Biocompatibility: Scar Formation and Contraction, Degradation of Devices: Corrosion and Wear, Regulation of Medical Devices, Scaffolds for Cartilage Repair, Implants for Bone, Implants for Plastic Surgery. **[08]**

4. Medical Prosthetics Devices: **[10]**
Cardiovascular Prostheses: Heart Valves and Blood Vessels, Devices for Nerve Regeneration, Musculoskeletal Soft Tissues: Meniscus, Intervertebral Disk, Dental and Ear Implants, Other Devices: Spinal Cord, Heart Lung. Design and Application of Electromechanical Biomedical Devices, Concept of prototype development and testing of medical instrument.

5. Electronics in Device Design: **[08]**
Techniques for designing electronic circuits as part of complete sensor systems, basic electronics circuits, principles of accuracy, Op amp circuits, analog signal conditioning, power supplies, microprocessors, wireless communications, sensors, and sensor interface circuits, practical printed circuit board (PCB) design including component selection, PCB layout, assembly.

Outcomes: At the end of the course, the student should be able to explain the principles of implant design, Degeneration of device & PCB design.

Text Books:
1. Paul H. Hing et al, "Design of Biomedical Devices & System", CRC Press, 2014.
2. Bikramjit Basu, "Biomaterials Science & Tissue Engineering: Principles & Methods" Cambridge-IISC Press, 2017.

Reference Books:
1. Yannas, I. V., "Tissue and Organ Regeneration in Adults", Springer-Verlag, 2015.
2. Webster JG, "Medical Instrumentation: Application and Design", John Wiley & Sons, 2009.
3. Tugrul ozel et al, "Biomedical Devices: Design, Prototyping & Manufacturing", Wiley, 2016.

BM 23. 426 **Bioethics, IPR and Regulatory affairs** **Total Lectures: 40**

Prerequisite: Nil **Credit: 3-0-0-3**

Objective: This course aims to provide students with a comprehensive understanding of biomedical ethics, bioethics, intellectual property rights (IPR), patents, and regulatory affairs in the context of biotechnology and biomedical devices. Students will learn about ethical principles, legal guidelines, IPR concepts, patenting issues, regulatory frameworks, and quality assurance in the field.

1. **Introduction to Biomedical Ethics:** Nature of medical ethics, Principles of medical ethics, Codes of medical ethics, Legal guidelines for Health Professionals, Regulations and Professional Liability for Health Professional, Consent, Death and Euthanasia. **[07]**
2. **Introduction To Bioethics**: Bioethics – need, applications. Impact of bioethics to the environment and society. Bioethical issues pertaining to various aspects of Biotechnology. Bioengineering ethics, responsible researchers, research ethics, ethical decision making. Biowarfare and biopiracy, Ethics in Animal and Human Research, Ethics stem cell research. **[10]**
3. **Intellectual Property Rights:** Introduction, Concept of Intellectual Property, Bio-diversity and IPR, Copyrights, Trademarks, Patents, Industrial & Software Designs, Leading International Instruments concerning Intellectual Property Rights. **[10]**
4. **Patents:** Concept of Patent, Patent Databases & Patent Information System, Patenting issues in biotechnology, Patenting issues in Biomedical and Medical Devices, Process for Examination of Patent Application, Patent Infringement. **[07]**
5. **Regulatory Affairs:** Regulatory frame work for genetically engineered plant, Regulatory approval for Biopharmaceuticals, Medical Device Regulations, Classification of Medical Devices. Harmonized standards, CE approval. Quality. Assurance and Quality Control, Principles of TQM. Standards for medical devices, **[06]**

Outcomes: Students will understand medical ethics, principles, codes, and legal guidelines. They will analyze bioethical issues in biotechnology, stem cell research, and human research. Comprehension of intellectual property rights (IPR) and its applications in biotechnology, including copyrights, and patents. Students will grasp patenting processes, databases, examination procedures, and infringement issues in biotechnology. They will gain knowledge of regulatory frameworks, approval processes, and quality assurance in genetically engineered plants, biopharmaceuticals, and medical devices.

Text Books:

1. Michael Boylan, “Medical ethics”, Second Edition, Wiley, 2013.
2. Padma Nambisan, “An Introduction to Ethical Safety & Intellectual Property Rights Issues in Biotechnology”, Academic Press, 2017.

Reference Books:

1. Val Theisz, “Medical Device Regulatory Practices: An International Perspective”, CRC Press, 2015.
2. Ronald Munson's, “Intervention and Reflection: Basic Issues in Medical Ethics”, Cengage Learning, 5th Ed, 2016.
3. Benedict M. Ashley et al, “Ethics of Health Care: An Introductory Textbook”, Georgetown University Press; Third Edition, 2002.
4. Prof. Niharika Sahoo Bhattacharya Legal and Regulatory Issues in Biotechnology, NPTEL Course.