RCOEM

Shri Ramdeobaba College of Engineering and Management, Nagpur

SHRI RAMDEOBABA COLLEGE OF ENGINEERING AND MANAGEMENT, NAGPUR – 440013

An Autonomous College affiliated to Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur, Maharashtra (INDIA)

PROGRAMME SCHEME

2022-2023

B. TECH. (BIOMEDICAL ENGINEERING)

About the Department

Biomedical Engineering is the blend of engineering principles and medical procedures in order to create solutions for the healthcare. The aim of Biomedical Engineering programme is to provide educate students so as to bridge engineering with life sciences and represent the biomedical profession with distinction tools that helps the doctors in diagnosis and treatment of different medical conditions. Being a transdisciplinary field, it is behind some of the most important medical breakthroughs today, and has significantly contributed to improvement in quality of life.

The nature of the programme goes beyond the subject barriers and instils the faculty to train the students from both Engineering as well as Science aspects application to Biomedical Engineering. Students will be given an opportunity to explore different dimensions of learning in the field of Biomedical engineering through the blended and experiential learning mode and elevate their education as part of our engineering Honors / Minor Programme with additional certification.

Program Educational Objectives

1. To inculcate the knowledge and skills in designing, manufacturing, testing and instrumentation in the field Biomedical Engineering.

2. Exercise the acquired knowledge to provide economically feasible and socially acceptable solutions for healthcare problems

Program Outcomes

Engineering Graduates will be able to:

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design /development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5. **Modern Tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

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

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

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

9. **Individual and Team Work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multi-disciplinary settings.

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

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

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

Program Specific Outcomes

PSO1: To apply concepts of Biomedical Engineering and Computing Technology to analyze Biomedical systems and signals.

PSO2: To design and develop indigenous medical solutions for healthcare and life sciences

Teaching Scheme for B.Tech. Biomedical Engineering

SEMESTER I

Sr. No.	Course code	Course Name	Hours/week			Credits	Maximum marks			ESE Duration (Hrs)
			L	T	P		Conti-nuous Evaluation	End Sem Exam	Total	
1.	MAT152	Differential Equations, Linear Algebra, Statistics & Probability	3	0	0	3	40	60	100	3Hrs
2.	MAP151	Computational Mathematics Lab	0	0	2	1	25	25	50	3Hrs
3.	PHT155	Physics of Materials	3	1	0	4	40	60	100	
4.	PHP155	Physics of Materials Lab	0	0	3	1.5	25	25	50	3Hrs
5.	BMT101	Fundamentals of Electrical & Electronics Engineering	3	0	0	3	40	60	100	
6.	BMP101	Fundamentals of Electrical & Electronics Engineering Lab	0	0	2	1	25	25	50	3Hrs
7.	MET151	Engineering Graphics and Design	1	0	0	1	40	60	100	
8.	MEP151	Engineering Graphics and Design Lab	0	0	4	2	50	50	100	
9.	HUT152	Constitution of India	2	0	0	0				
10.	PEP151	Yoga /sports	0	0	2	0				
		TOTAL	**12**	**1**	**13**	**16.5**				

SEMESTER II										
Sr. No.	Course code	Course Name	Hours/week			Credits	Maximum marks			ESE Duration (Hrs)
			L	T	P		Conti-nuous Evaluation	End Sem Exam	Total	
1.	MAT151	Calculus	3	1	0	4	40	60	100	3Hrs
2.	CST151	Programming for Problem solving	4	0	0	4	40	60	100	3Hrs
3.	CSP151	Programming for Problem solving Lab	0	0	2	1	25	25	50	
4.	CHT153	Biochemistry	3	1	0	4	40	60	100	3Hrs
5.	CHP153	Biochemistry Lab	0	0	3	1.5	25	25	50	
6.	BMT102	Human Anatomy and Physiology for Engineers-I	3	0	0	3	40	60	100	3Hrs
7.	IDT151	Creativity, Innovation and Design thinking	1	0	0	1	20	30	50	1.5 Hrs.
8.	HUT151	English	2	0	0	2	40	60	100	3Hrs
9.	HUP151	English lab	0	0	2	1	25	25	50	
		TOTAL	**16**	**2**	**7**	**21.5**				

SEMESTER III										
Sr. No.	Coursecode	Course Name	Hours/week			Credits	Maximum marks			ESE Duration (Hrs)
			L	T	P		Conti-nuous Evaluation	End Sem Exam	Total	
1.	BMT201	Human Anatomy and Physiology for Engineers-II	3	0	0	3	40	60	100	3 Hrs
2.	BMT202	Digital Circuit Design	3	0	0	3	40	60	100	3 Hrs.
3.	BMP202	Digital Circuit Design Lab	0	0	2	1	25	25	50	
4.	MAT274	Applied Mathematics and Descriptive Statistics	2	1	0	3	40	60	100	3 Hrs
5.	BMT203	Signals and Systems	3	1	0	4	40	60	100	
6.	BMT204	Data Structures and Algorithm	2	0	0	2	40	60	100	3 Hrs
7.	BMP204	Data Structures and Algorithm Lab	0	0	2	1	25	25	50	
8.	BMT205	Electronics Devices and Circuits	3	0	0	3	40	60	100	3 Hrs
9.	BMP205	Electronics Devices and Circuits lab	0	0	2	1	25	25	50	
		TOTAL	**16**	**2**	**6**	**21**				

SEMESTER IV										
Sr. No.	Course code	Course Name	Hours/week			Credits	Maximum marks			ESE Duration (Hrs)
			L	T	P		Conti-nuous Evaluation	End Sem Exam	Total	
1.	BMT206	Network analysis and Synthesis	3	0	0	3	40	60	100	3Hrs
2.	BMT207	Digital Signal Processing	3	0	0	3	40	60	100	3Hrs.
3.	BMP207	Digital Signal Processing Lab	0	0	2	1	25	25	50	
4.	BMT208	Microprocessor and Microcontroller	3	0	0	3	40	60	100	3Hrs
5.	BMP208	Microprocessor and Microcontroller Lab	0	0	2	1	25	25	50	
6.	BMT209	Analog Circuits	3	1	0	4	40	60	100	3Hrs
7.	BMP209	Analog Circuits Lab	0	0	2	1	25	25	50	
8.	BMP210	Project-I	0	0	2	1	25	25	50	
9.	BMT299	Open Elective - 1 / MOOC's	3	0	0	3	40	60	100	3 Hrs.
10.	CHT252	Environmental Sciences	2	0	0	0				
	TOTAL		17	1	8	20				

Open Elective – 1	
Course Code	**Course Title**
BMT299-1	Healthcare Instrumentation

SEMESTER V										
Sr. No.	Course code	Course Name	Hours/week			Credits	Maximum marks			ESE Duration (Hrs)
			L	T	P		Conti-nuousEvaluation	End Sem Exam	Total	
1.	BMT301	Program Elective -1	3	0	0	3	40	60	100	3 Hrs
2.	BMP301	Program Elective - 1Lab	0	0	2	1	25	25	50	
3.	BMT302	Biomaterials	3	0	0	3	40	60	100	3 Hrs
4.	BMT303	Healthcare application design using FPGA	3	1	0	4	40	60	100	3 Hrs
5.	BMP303	Healthcare application design using FPGA lab	0	0	2	1	25	25	50	
6.	BMT304	Biomedical Sensors and Measurement Devices	3	0	0	3	40	60	100	3 Hrs
7.	BMP304	Biomedical Sensors and Measurement Devices Lab	0	0	2	1	25	25	50	
8.	BMT398	Open Elective - 2/ MOOC's	3	0	0	3	40	60	100	3 Hrs
9.	MBT391-1	Business Management and Entrepreneurship	3	0	0	3	40	60	100	3 Hrs
10.	HUT351	Professional Skill Development	2	0	0	0				
		TOTAL	**20**	**1**	**6**	**22**				

Sr. No.	Course Code	Program Elective –1
1	BMT301-1	Bioinformatics
2	BMT301-2	Medical Robotics & Automation
3	BMT301-3	Biostatistics

Open Elective – 2	
Course Code	**Course Title**
BMT398-1	Bioinformatics

SEMESTER VI										
Sr. No.	Course code	Course Name	Hours/week			Credits	Maximum marks			ESE Duration (Hrs)
			L	T	P		Conti-nuousEvaluation	End Sem Exam	Total	
1.	BMT306	Program Elective -2	3	0	0	3	40	60	100	3Hrs
2.	BMP306	Program Elective - 2 Lab	0	0	2	1	25	25	50	
3.	BMT307	Medical Imaging	3	0	0	3	40	60	100	3Hrs
4.	BMT308	Machine Learning	3	0	0	3	40	60	100	3Hrs
5.	BMP308	Machine Learning Lab	0	0	2	1	25	25	50	
6.	BMT309	Control Systems	3	0	0	3	40	60	100	3Hrs
7.	BMT310	Biomechanics	3	0	0	3	40	60	100	3Hrs
8.	BMP311	Project –II	0	0	2	1	25	25	50	
9.	BMT399	Open Elective - 3 / MOOC's	3	0	0	3	40	60	100	3Hrs
10.	BMP313	Comprehensive Viva	0	0	2	1	50		50	
		TOTAL	**18**	**0**	**8**	**22**				

Sr. No.	Course Code	Program Elective –2
1	BMT306-1	Biomedical Microsystems
2	BMT306-2	Biomedical Image Processing
3	BMT306-3	Biomaterial Applications.

Open Elective – 3	
Course Code	**Course Title**
BMT399	Ergonomics of Product Design

SEMESTER VII										
Sr. No.	Course code	Course Name	Hours/week			Credits	Maximum marks			ESE Duration (Hrs)
			L	T	P		Conti-nuous Evaluation	End Sem Exam	Total	
1.	BMT401	Program Elective -3	3	0	0	3	40	60	100	3Hrs
2.	BMT402	Program Elective -4	3	0	0	3	40	60	100	3Hrs
3.	BMT403	Analytical & Diagnostic Equipments	3	0	0	3	40	60	100	3Hrs
4.	BMP404	Medical Equipments Lab	0	0	2	1	25	25	50	
5.	BMT405	Design and Manufacturing of Implants and Prostheses	3	0	0	3	40	60	100	3Hrs
6.	BMP405	Design and Manufacturing of Implants and Prostheses lab	0	0	2	1	25	25	50	
7.	BMT406	Open Elective-4 (Industry Module) / MOOC's	3	0	0	3	40	60	100	3Hrs
8.	BMP407	Industry Internship Evaluation (6-8 weeks)	0	0	2	0	50		50	
9.	BMT408	Biomedical Engineering: Legal & Ethical Perspective	2	0	0	0				
10.	BMP409	Project - III	0	0	10	5	50	50	100	
TOTAL			**17**	**0**	**16**	**22**				

***6-8 weeks Internship must be completed before reaching VII Semester**

Sr. No.	Course Code	Program Elective –3	Sr. No.	Course Code	Program Elective –4
1	BMT401-1	Molecular Biology and Genetics	1	BMT402-1	Tissue engineering
2	BMT401-2	Reliability of Healthcare Equipments	2	BMT402-2	Hospital Engineering and Management
3	BMT401-3	Advanced Biomechanics	3	BMT402-3	Bionanotechnology

Open Elective-4	
BMT498	Biological Databases and Software

VIII Semester										
Sr. No.	Course code	Course Name	Hours/week			Credits	Maximum marks			ESE Duration(Hrs)
			L	T	P		Continuous Evaluation	End Sem Exam	Total	
1.	BMT410	Program Elective -5	3	0	0	3	40	60	100	3 Hrs.
2.	BMT411	Program Elective -6	3	0	0	3	40	60	100	3 Hrs
3.	BMP412	Project –IV	0	0	18	9	50	50	100	
		OR								
4.	BMP413	Internship / Incubation (six months)				15	100	100	200	
		TOTAL	**6**	**0**	**18**	**15**				

Sr. No.	Course Code	Program Elective – 5
1	BMT410-1	Diagnostic Medical Biotechnology
2	BMT410-2	Therapeutic Medical Biotechnology
3	BMT410-3	Hospital Management and Entrepreneurship

Sr. No.	Course Code	Program Elective – 6
1	BMT411-1	Pathology and Medical Microbiology
2	BMT411-2	Bioinstrumentation
3	BMT411-3	Biomedical Product Design

Syllabus for B. Tech. I Semester
Department of Biomedical Engineering

Course Code	MAT152				
Category	Basic Science Course				
Course Title	Differential Equations, Linear algebra, Statistics & Probability				
Scheme& Credits	L	T	P	Credits	Semester I
	3	0	0	3	

Course Outcomes
After successful completion of the course, the students will learn,

1. The effective mathematical tools for the solutions of ordinary differential equations that modelphysical processes.
2. The essential tool of matrices in a comprehensive manner.
3. The ideas of probability and various discrete and continuous probability distributions and thebasic ideas of statistics including measures of central tendency, correlation and regression.

Syllabus

Module 1:First order ordinary differential equations(7 hours)

Exact, linear and Bernoulli's equations, Euler's equations, Equations not of first degree: equations solvable for p, equations solvable for y, equations solvable for x and Clairaut's type.

Module 2:Ordinary differential equations of higher orders (8 hours)

Second order linear differential equations with constant and variable coefficients, method of variationof parameters, Cauchy-Euler equation.

Module 3:Basic Statistics: (7 hours)

Curve fitting by the method of least squares- fitting of straight lines, second degree parabolas and moregeneral curves, correlation and regression – Rank correlation, Multiple regression and correlation.

Module 4: Basic Probability: (8 hours)

Probability spaces, conditional probability, independence; Discrete random variables, Binomial distribution, Poisson distribution, Normal distribution. Relation Between binomial, Poisson and Normal distributions.

Module 5: Matrices (10 hours)

Algebra of matrices, Inverse and rank of a matrix, rank-nullity theorem; System of linear equations;Symmetric, skew-symmetric and orthogonal matrices; Eigen values and eigenvectors; Diagonalization of matrices; Cayley-Hamilton Theorem, Orthogonal transformation and quadratic tocanonical forms.

Topics for Self Learning

Application of Differential Equations.Textbooks/References:

1. Erwin Kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.
2. W. E. Boyce and R. C. DiPrima, Elementary Differential Equations and Boundary ValueProblems, 9th Edition, Wiley India, 2009.
3. S. L. Ross, Differential Equations, 3rd Ed., Wiley India, 1984.
4. E. A. Coddington, An Introduction to Ordinary Differential Equations, Prentice Hall India, 1995.
5. E. L. Ince, Ordinary Differential Equations, Dover Publications, 1958.
6. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 35th Edition, 2000. 7.Theoryand Problems of probability and statistics : 2nded :J. R. Spiegal ,Schaum series
8. A text book of Applied Mathematics Volume I & II, by P. N. Wartikar and J. N. Wartikar, PuneVidhyarthi Griha Prakashan, Pune - 411030 (India).
9. S. Ross, A First Course in Probability, 6th Ed., Pearson Education India, 2002.

Syllabus for B. Tech. I Semester
Department of Biomedical Engineering

Course Code	MAP151				
Course Title	Computational Mathematics Lab				
Scheme& Credits	L	T	P	Credits	Semester I
	0	0	2	1	

Course Outcomes:

The Computational Mathematics Lab course will consist of experiments demonstrating the principles of mathematics relevant to the study of science and engineering. Students will show that they havelearnt laboratory skills that will enable them to properly acquire and analyze the data in the lab and draw valid conclusions. At the end of the Course the students will learn to:

1. Develop skills to impart practical knowledge in real time.
2. Understand principle, concept, working and application of areas in mathematics and compare the results obtained with theoretical calculations.
3. Understand basics of mathematics, and report the results obtained through proper programming.The Lab turns will be utilized for performing the experiments based on the following list:
    1. Calculus.
    2. Ordinary Differential Equations.
    3. Statistics.
    4. Linear Algebra

Reference Books

1. Computational Mathematics Lab Manual written by the Teaching Faculty of MathematicsDepartment, RCOEM.

Syllabus for B. Tech. I Semester
Department of Biomedical Engineering

Course Code	PHT155				
Course Title	Physics of Materials				
Scheme& Credits	L	T	P	Credits	Semester I
	3	1	0	4	

Course Objectives

1. To provide basic knowledge of materials in sensors, electronic and electrical systems
2. To understand the governing mechanisms in engineering materials

Course Outcomes

The students will understand and work with,

1. Modern theory of solids
2. Quantum mechanical descriptions of the electronic conduction processes
3. Semiconducting and Dielectric materials
4. Magnetic materials and superconductivity

Module 1:Electrical and thermal conduction in Solids

Classical Theory of electrical conduction in Metals, Resistivity of Materials, Thermal conduction, Electrical conductivity in non-metals

Module 2: Quantum Physics

Electron in Quantum Mechanics, Confinement, Tunneling, Hydrogen Atom, Periodic Table, Light- matter interaction, Applications of lasers in biomedical instrumentation

Module 3:Modern Theory of Solids

Molecular Orbital Theory of Bonding, Band theory of solids, Energy band formation, Concepts in Statistical Mechanics, Quantum Theory of metals, Metal-Metal contacts, Thermionic Emission, Phonons, Thermal and Electrical conductivity

Module 4: Semiconductors

Intrinsic and Extrinsic Semiconductors, Carrier concentrations, Drift mobility, Recombination, Diffusion and conduction equations, Continuity Equation, Optical Absorption, Piezoresistivity, Junction physics, Applications in bioelectric sensors

Module 5: Dielectric Materials and Insulation

Polarization and relative permittivity, Type of polarization, Frequency dependence, Dielectric loss,Dielectric strength and Insulation breakdown, Capacitor dielectric materials, Piezo-ferro and Pyroelectricity, Applications in Transducers.

Module 6: Magnetic Materials and Superconductivity

Magnetization vector, Permeability and Susceptibility, Magnetic materials, Ferromagnetism, Soft and hard magnetic materials, Ferro fluids for drug delivery, Superconductivity, Phenomenological theoryof superconductivity, Josephson Effect, Flux quantization, Superconducting magnets in Biomedicalimaging.

Text Book

1. Principles of Electronic Materials and Devices, S. O. Kasap,3rd Edition McGraw Hill.

Reference Books

1. Electrical Engineering Materials, A. J. Dekker, Prentice Hall
2. Introduction to Solid State Physics, Charles Kittle, John Wiley & Sons,Inc.
3. Semiconductor Nanocrystals and Metal Nanocrystals, Physical Properties and DeviceApplications, Eds. Tupei Chen, Yang Liu, CRC Press2017
4. Clinical Applications of Magnetic Nanoparticles, Eds. Nguyên T. K. Thanh, CRC Press 2018
5. How Does MRI work, Eds. D. Weishaupt, V. D. Kochli, B. Marincek, 2nd Edition, Springer2006

Syllabus for B. Tech. I Semester
Department of Biomedical Engineering

Course Code	PHP155				
Course Title	Physics of Materials Lab				
Scheme& Credits	L	T	P	Credits	Semester I
	0	0	3	1.5	

Course Outcomes

The physics laboratory will consist of general physics experiments and study of materials properties illustrating the principles of physics relevant to the study of biomedical engineering. During the training in the Physics Lab, the students will be able,

1. To develop skills for experimental verification of physics laws
2. To analyze the results using the mathematical techniques
3. To learn the measurement of materials properties
4. To synthesize the nanoparticles and write the project reports

The laboratory will consist of the following general physics experiments, the measurement of materialsproperties and the synthesis of the nanoparticles

General Physics

1. Measuring scales and error estimation
2. Verification of Ohm's law and linear least square fitting method
3. Verification of Newton's law of cooling
4. Simple harmonic motion
5. Magnetic flux measurement using the graphical method of integration
6. Dispersive power of prism
7. Compound Microscopes Materials Lab:
8. Determination of energy gap of semiconducting materials
9. Seeback effect
10. Thermal Conductivity of Metals
11. Dielectric constant measurement
12. Magnetic materials and characterization
13. Hall effect

Synthesis of Nanoparticles for Biomedical Applications

1. Preparation of Magnetic oxide, Fe2O3,nanoparticles
2. Ferro fluid preparation methods
3. Preparation of Semiconducting nanoparticles (ZnO,Ti2O)
4. Preparation of Metallic (Au, Ag)nanoparticles

Reference Books

1. Lab manual prepared by Physics Department, RCOEM, Nagpur
2. Semiconductor Nanocrystals and Metal Nanocrystals, Physical Properties and Device Applications, Eds.Tupei Chen, Yang Liu, CRC Press2017
3. Clinical Applications of Magnetic Nanoparticles, Eds. Nguyên T. K. Thanh, CRC Press 2018

Syllabus for B. Tech. I Semester
Department of Biomedical Engineering

Course Code	BMT101				
Course Title	Fundamentals of Electrical and Electronic Engineering				
Scheme& Credits	L	T	P	Credits	Semester I
	3	0	0	3	

Course Outcomes

Upon the completion of this course, students will demonstrate the ability to:

1. Understand DC and AC operations.
2. Design different Electric and Magnetic circuits.
3. Develop applications employing appropriate electrical machines.
4. Apply knowledge of two terminal semiconductor devices like diodes to develop applications.

Syllabus

Unit –I : Introduction to DC and AC circuits, Active and passive two terminal elements, Ohms law, Voltage-Current relations for resistor, inductor, capacitor , Kirchhoff's laws, Mesh analysis, Nodal analysis, Voltage and current sources, equivalent resistor, current division, voltage division, Superposition theorem, Thevenin's and Norton's theorems, Star- delta and Delta- star conversions, Maximum Power Transfer Theorem.

Unit –II : Sinusoids, Generation of AC, Average and RMS values, Form and peak factors, concept of phasorrepresentation, J operator, Analysis of R-L, R-C, R-L-C circuits, Introduction to three phase systems - types of connections, relationship between line and phase values.

Unit –III : Single Phase Transformer: Analogy Between electrical and magnetic circuits, solutions of magnetic circuits, Constructional details and Principle of transformer, EMF equation, Phasor diagram on no load and full load, Equivalent circuits, Open circuit and short circuit tests, regulation and efficiency, Hysteresis and eddycurrent losses.

Unit –IV : DC and AC Rotating Machines: Types, Construction, Principle, EMF and torque equation, Application Speed Control, Basics of Stepper Motor, Brushless DC motors, Servo Motors, Solenoid pump.

UNIT - V : PN diode operation- forward bias and reverse bias , Volt-Ampere characteristics of p-n diode, Temperature dependence of VI characteristics, Current components in p-n diode, Diode equation, Transition and Diffusion capacitances, Breakdown Mechanisms in Semi Conductor diodes,Rectifiers: half wave and fullwave, Wave shaping circuits

UNIT - VI : Zener diode characteristics and application, Tunnel Diode, LED, LDR, Varactor, Photo diode, PINdiode, Schottky diode, LASER, Applications.

Text books

1. Basic Electrical and Electronics Engineering by S.K.Bhattacharya, Pearson Publications
2. Basic Electrical and Electronics Engineering by D.P. Kothari and I J Nagrath, TMH.

Reference Book

1. Basic Electrical Engineering by Fitzerald and Higginbotham, TMH.
2. Basic Electrical Engineering by I.J Nagrath, TMH.
3. Millman's Integrated Electronics: Jacob Millman, Christos Halkias, Chetan Parikh, McGraw Hill

Syllabus for B. Tech. I Semester
Department of Biomedical Engineering

Course Code	BMP101				
Course Title	Fundamentals of Electrical and Electronics Engineering Lab				
Scheme& Credits	L	T	P	Credits	Semester I
	0	0	2	1	

Course Outcomes

Upon the completion of this course, students will demonstrate the ability to :

1. Understand DC and AC operations.
2. Design different Electric and Magnetic circuits.
3. Develop applications employing appropriate electrical machines.
4. Apply knowledge of two terminal semiconductor devices like diodes to develop applications.

List of Experiments

Practical are based on BMT101 Syllabus

Syllabus for B.Tech. I Semester
Department of Biomedical Engineering

Course Code	MET151				
Course Title	Engineering Graphics and Design				
Scheme& Credits	L	T	P	Credits	Semester I
	1	0	0	1	

Course outcomes

The expected learning outcome is that, the students shall be able to

1. Draw and interpret technical drawing
2. Convert 2 - D to 3 - D drawing and viceversa.
3. Represent the various positions of planes and solids in different orientations.
4 Develop the solid surface for sheet metal working.

UNIT 1: Introduction to Engineering Drawing

Principles of Engineering Graphics and their significance, usage of drawing instruments, Lettering anddimensioning.

UNIT 2: Orthographic Projections

Principles of Orthographic Projections-Conventions: Projections of Points and lines (line inclined to both planes) Projections of planes (inclined to both the planes), Introduction to Auxiliary Planes;

UNIT 3: Projections of Solids

Inclined to both the Planes-Auxiliary Views; Draw simple annotation, dimensioning and scale. Floorplans that include: windows, doors, and fixtures such as WC, bath, sink, shower, etc.

UNIT 4: Sections and Sectional Views of Right Angular Solids

Prism, Cylinder, Pyramid Cone-Auxiliary Views; Development of surface of Right Regular solids- Prism, Pyramid, Cylinder and Cone; Draw the sectional orthographic views of geometrical solids, objects from industry and dwellings(foundation to slab only)

UNIT 5: Isometric Projections

Principles of Isometric projection-Isometric Scale, Isometric Views, Conventions; Isometric Views ofSimple Solids; Conversion of Orthographic views to Isometric Views/Projection.

Text / Reference Books

i) Bhatt N. D. Panchal V. M. & Ingle P.R., (2014) Engineering Drawing, Charotar Publishing House.

ii) Jolhe D. A. (2016) Engineering Drawing with an Introduction to Auto CAD", Tata McGraw- HillPublishing Co.Ltd.,New Delhi.

iii) Narayan K.L. & P. Kannaiah (2008),Text book on Engineering Drawing, Scitech Publishers.
iv) Shah, M.B. & Rana B.C. (2008), Engineering Drawingand Computer Graphics, PearsonEducation.
v) Agrawal B & Agrawal C.M.(2012),Engineering Graphic, TMH Publication.
vi) Corresponding set of CAD Software Theory and User Manuals.

Syllabus for B.Tech. I Semester
Department of Biomedical Engineering

Course Code	MEP151				
Course Title	Engineering graphics and design Lab				
Scheme& Credits	L	T	P	Credits	Semester I
	0	0	4	2	

Minimum 10 Practical's based on the course

Course Outcomes

Students are prepared for actual work situations through practical training in a new state of the artcomputer designed CAD laboratory using engineering software. The student will learn to:

1. Draw and interpret technical drawing
2. Plan the sheet layout for the given drawing
3. Convert 2-D to 3-D drawing and vice versa
4. Represent the various positions of planes and solids in different orientations.
5. Develop the solid surface for sheet metal working
6. Use & demonstrate drafting package.

UNIT 1 : Introduction to Engineering Drawing

Conic sections including the Rectangular Hyperbola (General method only); Cycloid, Epicycloids,Hypocycloid and involutes; Introduction to Scales.

UNIT 2 : Orthographic Projections

Principles of Orthographic Projections-Conventions-Projections of Points and lines inclined to bothplanes; Projections of planes-Auxiliary Planes.

UNIT 3 : Projections of Solids

Inclined to both the Planes Auxiliary Views; Draw simple annotation, dimensioning and scale, Floorplans that include: windows, doors, and fixtures such as WC, bath, sink, shower, etc.

UNIT 4 : Sections and Sectional Views of Right Angular Solids

Prism, Cylinder, Pyramid, Cone- Auxilary Views; Development of surfaces of Right Regular Solids Prism, Pyramid, Cylinder and Cone; Draw the sectional orthographic views of geometrical solids, objects from industry and dwellings (foundation to slab only)

UNIT 5 : Isometric Projections

Principles of Isometric projection-Isometric Scale, Isometric Views, Conventions; Isometric Views ofSimple Solids; conversion of Orthographic views to Isometric views / Projection.

UNIT 6 : Overview of Computer Graphics

Demonstrating knowledge of the theory of CAD software such as(the Menu System Toolbars Standard, Object

Properties, Draw, Modify and Dimension), Drawing Area (Background, crosshairs, Coordinate Systems), Dialog boxes and windows, Shortcut menus (Button Bars), The command Line

(wherever applicable), The Status Bar, Different methods of zoom as used in CAD, select and eraseobjects; Isometric Views of lines, Planes, Simple and compound solids).

UNIT7:Customization & CAD Drawing

Setting up drawing page and the printer, including scale settings, Setting up of units and Drawing limits; ISO and ANSI standards for coordinate dimensioning ;Orthographic constraints, map to objects, manually and automatically, Producing drawings by using various coordinate input entry methods to draw straight lines, Applying various ways of drawing circles.

UNIT 8 : Annotations Layering & Other Functions

Applying dimensions to objects, applying annotations to drawings; Changing line lengths through modifying existing lines (extend/lengthen); Printing documents to paper using the print command;orthographic projection techniques.

UNIT 9 : Demonstration of a simple team design project that illustrates

Geometry And Topology Of Engineered Components Creation Of Engineering models and theirpresentation in standard 2D blueprint form and as 3D wire-frame and shaded solids; Meshed topologies for engineering , Introduction to Building Information Modeling(BIM), Drafting and designpackage, 3D Printing.

List of sheets

1. Curves(ellipse, Parabola, hyperbola, Cycloid, involute)
2. Line, Planes, Solids
3. Application of Section and development of solids
4. Orthgraphic Projection
5. Isometric
6. Auto CAD practice sheet 1
7. Auto CAD practice sheet
8. Blueprint sheet

Text/ Reference Books

i) Bhatt N.D. Panchal V.M.& Ingle P.R.,(2014),Engineering drawing, Charotar Publiishing house.

ii) Jolhe D.A.,(2016) Engineering drawing with an Introduction to AutoCAD",Tata McGraw-HillPublishing Co. Ltd., New Delhi.

iii) Shah M.B.& Rana B.C.(2008),Engineering drawing and Computer Graphic, Pearson Education.

iv) Agarwal B & Agarwal C.M.(2012),Engineering Graphics, TMH PUBLICATION

v) Narayana, K.L & P.Kannaiah (2008), Text Book on Engineering Drawing, Scitech Publishers.

vi) (Concesponding set of) CAD Software Theory and USER Manuals.

Syllabus for B. Tech. I Semester
Department of Biomedical Engineering

Course Code	HUT152				
Category	Mandatory Course				
Course Title	Constitution of India				
Scheme& Credits	L	T	P	Credits	Semester I
	2	0	0	0	

Course outcome

1. Students will understand the role of constitution in democratic India
2. Students will be responsible students by knowing their fundamental rights and duties
3. Students will develop better understanding of democratic functions of the government of India
4. Students will form better understanding of system of governance for effective participation

Course content

1. Meaning of the constitution law and constitutionalism
2. Historical perspective of the Constitution of India
3. Salient features and characteristics of the Constitution of India
4. Scheme of the Fundamental Rights
5. The scheme of the Fundamental Duties and its legal status
6. The Directive Principles of State Policy– Its importance and implementation
7. Federal structure and distribution of legislative and financial powers between the Union and the States.
8. Parliamentary Form of Government in India – The constitution powers and status of the President of India.
9. Union Executive: structure, functions
10. Judiciary: Structure, role with special reference to PIL, writ petitions, strengthening of democracy & socialjustice
11. Amendment of the Constitutional Powers and Procedure
12. Emergency Provisions: National Emergency, President Rule, Financial Emergency
13. Local Self Government – Constitutional Scheme in India
14. Provisions of civil services: Characteristics, functions, merits and demerits
15. Democratic principles in industry

Book

Durga Das Basu "An Introduction to Constitution of India" 22nd Edition, Lexis Nexis

Syllabus for B.Tech. I Semester
Department of Biomedical Engineering

Course Code	PEP151				
Category	Mandatory Course				
Course Title	Yoga / Sports				
Scheme& Credits	L	T	P	Credits	Semester I
	0	0	2	0	

Course outcome

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

1. Understand fundamental skills and basic rules of games offered by the Physical Education Department of RCOEM.
2. Obtained health-related physical fitness.
3. Develop body-mind coordination through games and yoga.
4. Changed sedentary life styles towards active living.

Brief Objectives of Sports/Yoga Practical Classes

It has long been proven that a healthy body leads to a healthy mind. With a strong belief in this, PhysicalEducation Department at RCOEM will conduct Sports/Yoga Classes with the objective of maintaining health, fitness and wellness of students as well as create awareness about need for good health and physical fitness. Theobjective would also be to make the all-round development with team spirit, social values as well as to identifyand develop leadership qualities in students through various sports activities. Sports activities would also be conducted with the objective to provide better interaction and recreation to the students which is an importantneutralizer for stress. Additionally, the objective would be to evaluate the health-related fitness of students so asto recommend and conduct specific Yoga and Sports activities. The emphasis is on participation, with healthy competition.

Program Outline

Sports:

1. Introduction to sports, offered by the department.
2. Health and safety issues related to sports; knowledge, recognition and ability to deal with injuries andillness associated with sports.
3. Practicing the fundamental skills and bringing awareness of basic rules and regulations.
4. Conduction of small recreational games and activities.

Yoga: Includes various sitting, standing and lying Asanas, Surya namaskars and Pranayamas.

Physical Efficiency Tests: This includes 6 health related physical fitness tests.

Components	**Name of Tests**
Speed	50 mts Dash
Agility	Shuttle run
Cardiovascular Endurance	8 mins Run/Walk
Test Flexibility	Sit and Reach Test
Abdominal Strength (M)/Shoulder strength (F)	Bent Knee Sit-ups (M)/Modified Pull-ups (F)
Yogic exercises	Surya namesakes

Syllabus for B.Tech. II Semester
Department of Biomedical Engineering

Course Code	MAT151				
Course Title	Calculus				
Scheme& Credits	L	T	P	Credits	Semester II
	3	1	0	4	

Course outcomes

On successful completion of the course, the students will learn:

1. The fallouts of Mean Valve Theorems that is fundamental to application of analysis to Engineering problems, to deal with functions of several variables that are essential in most branches of engineering.
2. Basics of improper integrals, beta and Gamma functions, Curve tracing tool of power series and Fourierseries for learning advanced Engineering Mathematics.
3. Multivariable Integral Calculus and Vector Calculus and their applications to Engineering problems.

Syllabus

Module 1: Differential Calculus: (12hours)

Taylor's and Maclaurin series expansions ,Radius of Curvature(Cartesian form) , evolutes and involutes, Limit and countinuity of Functions of several Variable and their partial derivatives,Eulers theorem,Chain rule,Total derivative,Jacobian,Maxima , Minima and Saddle points; Method of Lagrange multipliers.

Module 2:Integral Calculus (6 hours)

Evaluation of definite and improper integrals; Beta and Gamma functions and their properties; Tracingof curves(Cartesian form)

Module 3:Sequences and series: (7 hours)

Convergence of sequence and series, tests for convergence, power series, Fourier series: Half rangesine and cosine series, Parseval's theorem.

Module 4 Multiple Integrals (10 hours)

Multiple Integration: double and triple integrals (Cartesian and polar), change of order of integrationin double integrals, Change of variables (Cartesian to polar), Applications: areas and volumes by (double integration) Center of mass and Gravity (Basic Concepts).

Module 5 : Vector Calculus(7 hours)

Vector Differentiation, Directional derivatives, total derivative , Gradient, curl and divergence. Vector integration , Theorems of Green, Gauss and Stokes and their application.

Topics for self learning

Rolls theorem, Mean value theorem ,Indeterminate form, Maxima and minima for function of one variable, Geometrical interpretation of Partial Differentiation (Tangent plane and Normal line) , Applications of definite integrals to evaluate perimeter, area, surface areas and volumes of revolutions.

Textbooks/References:

1. Erwin Kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.
2. Veerarajan T., Engineering Mathematics for first year, Tata McGraw-Hill, New Delhi, 2008.
3. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 35th Edition, 2000.
4. Ramana B.V., Higher Engineering Mathematics, Tata McGraw Hill New Delhi, 11th Reprint,2010.
5. A text book of Applied Mathematics Volume I & II, by P. N. Wartikar and J. N. Wartikar, PuneVidhyarthi Griha Prakashan, Pune-411030 (India).

Syllabus for B.Tech. II Semester
Department of Biomedical Engineering

Course Code	CST151				
Course Title	Programming for problem solving				
Scheme& Credits	L	T	P	Credits	Semester II
	4	0	0	4	

Course Outcomes

On successful completion of course student will learn:

1. To formulate simple algorithms for arithmetic and logical problems, translate the algorithms toprograms (in C language), test and execute the programs and correct syntax and logical errors.
2. To implement conditional branching, iteration and recursion, to decompose a problem intofunctions and synthesize a complete program using divide and conquer approach.
3. To use arrays, pointers, structures and I/O operations for the formulation of algorithms andprograms.
4. To apply programming to solve matrix addition, multiplication problems and searching & sortingproblems.

UNIT-I: Introduction to Programming

Introduction to components of a computer system (disks, memory, processor, where a program is stored and executed, operating system, compilers etc.) Idea of Algorithm : Steps to solve logical and numerical problems. Representation of Algorithm: Flowchart / Pseudocode with examples. Arithmetic expressions and precedence

UNIT-II: C Programming Language

Introduction to C language: Keywords, Constant, Variable, Data types, Operators, Types of Statements, Preprocessor Directives, Decision Control Statement-if, if-else, Nested if-else statement, Switch case, Loops and Writing and evaluation of conditionals and consequent branching.

UNIT-III: Arrays and Basic Algorithms

Arrays: 1-D, 2-D, Character arrays and Strings. Searching, Basic Sorting Algorithms (Bubble, Insertionand Selection), Finding roots of equations, notion of order of complexity through example programs(no formal definition required)

UNIT-IV: Functions and Recursion

User defined and Library Functions, Parameter passing in functions, call by value, Passing arrays tofunctions: idea of call by reference. Recursion: As a different way of solving problems. Example programs, such as Finding Factorial, Fibonacci series, Ackerman function etc. Quick sort or Merge sort.

UNIT-V: Pointers and Structures

Structures, Defining structures, Array of Structures, Introduction to pointers, Defining pointers, Pointer arithmetic, pointer operators, Use of Pointers in self-referential structures, notion of linked list(no implementation)

UNIT-VI: File handling

Streams in C, Types of Files, File Input/ Output Operations: Modes of file opening, Reading andwriting the file,

Closing the files, using fflush().

Text Books

1. Programming in ANSI C : E. Balguruswami McGraw Hill
2. Mastering C: K. R. Venugopal and S. R. Prasad, Tata McGraw Hill

Reference Books

1. Programming with C: Byron Gottfried, Schaums Outline Series.
2. Let Us C: Yashwant Kanetkar, BPB Publication

Syllabus for B.Tech. II Semester
Department of Biomedical Engineering

Course Code	CSP151				
Course Title	Programming for problem solving lab				
Scheme& Credits	L	T	P	Credits	Semester II
	0	0	2	1	

Course Outcomes

On successful completion of course student will be able to:

1. Apply fundamentals of C programming and choose the loops and decision makingstatements to solve and execute the given problem.
2. Implement different Operations on arrays also design functions to solve the given problem usingC programming.
3. Develop program using pointers, structures, and unions to solve specific problems.
4. Implement file Operations in C programming for a given application.

Syllabus

Practicals based on CST151 Syllabus.

Syllabus for B.Tech. II Semester
Department of Biomedical Engineering

Course Code	CHT153				
Course Title	Biochemistry				
Scheme& Credits	L	T	P	Credits	Semester II
	3	1	0	4	

Course outcomes

After the successful completion of the course, students will be able;

1. To understand the basic concepts of the quantitative analysis.
2. To apply the knowledge to understand the structure and function of biological molecules.
3. To understand the role of bio-molecules in biological system.
4. Demonstrate an understanding of the principles of a wide range of biophysical and biochemicaltechniques.
5. To understand spectroscopic methods used for qualitative and quantitative analyses.
6. To gain the information about role of water in biological system.

Syllabus

Module 1: Introduction to Biochemistry [6 Hours]

Introduction to Biochemistry, weak acid and bases, pH, buffers, Handerson - Hasselbalch equation,physiological buffers in living systems, Energy in living organism, Kinetics of biological systems; Michaelis-Menten equation.

Module 2: Introduction to Biomolecules [8 Hours]

Carbohydrates: Chemistry of few carbohydrates , Glycolysis and glycogenolysis, glycogensis,Amino Acid:

Chemistry properties and metabolism.

Proteins: primary, Secondary, tertiary and quaternary structure, Isoenzymes.

Lipids: Chemistry, Metabolism of fatty acids, Phospholipids, Cholesterol regulation of metabolism.

Nucleic Acid: Chemistry of DNA and RNA, Enzymes: Classification and role in biological systemVitamins: Structure and functions of some vitamins

Module 3: Fundamental Biochemical Concepts [7 Hours]

Basic concept in Techniques – Different methods of concentration calculations, Purification techniques, Centrifugation, Filtration, Dialysis, Homogenization, Adsorption, Absorption, Partition, Centrifuge- types & application, Density Gradient centrifugation, Sedimentation, Sedimentation coefficient.

Module 4: Biophysical and Biochemical Techniques [7Hours]

General principles and application of Paper chromatography, Thin layer chromatography, Gaschromatography, High performance liquid chromatography.

Module 5: Material Characterization using different Spectroscopic Techniques [7 Hours]

Fundamentals of spectroscopy, concept of photochemical reaction, absorption, beers Lamberts law, Infrared Spectroscopy, Electronic Spectroscopy, Nuclear Magnetic Resonance Spectroscopy, MRI.

Fundamentals of X-Ray Diffractions (XRD), X-Ray Fluorescence (XRF) spectroscopy.

Module 6: Role of water in biological systems[7 Hours]

Impurities in natural water, hardness and alkalinity, Desalination of water using Reverse Osmosis. Properties of water and their applications in biological systems, Weak Interactions in Aqueous Systems, Hydrogen Bonding, Hydrophilic and Hydrophobic Interactions, van der Waals Interactions,Colligative Properties of Aqueous Solutions, Osmosis, Water as a reactant.

Suggested Books

1. J. Michael Hollas, Modern Spectroscopy, Fourth Edition, John Wiley and Sons,2004.
2. William Kemp, Organic Spectroscopy, Third Edition, Palgrave Publication,1991.
3. S. S. Dara, A Textbook of Engineering Chemistry, S. ChandPublications.
4. P. C. Jain and Monica Jain, Engineering Chemistry, Dhanpat RaiPublication.
5. Y. Keith Wilson and J. Walkar, Principles and Techniques of Biochemistry and MolecularBiology, Seventh edition, Cambrige University Press,2007.
6. Satyajit D. Sarker and Lutfun Nahar, Chemistry for Pharmacy Students General, Organic andNatural Product Chemistry, Wiley-Interscience and Sons Limited,2007.
7. Thomas M. Devlin, Textbook of Biochemistry with Clinical Correlations, Fourth Edition, Wiley-LISS,1977.
8. A. Upadhayay, K. Upadhayay, N. Nath, Biophysical Chemistry (Principles and Techniques),Himalaya Publishing House,2009.
9. David L. Nelson and Michael M. Cox, Lehninger Principles of Biochemistry, Fifth Edition, W. H.Freeman and Company, New York, 2008.
10. Elsa Lundanes, Léon Reubsaet and Tyge Greibrokk, Chromatography Basic Principles, SamplePreparations and Related Methods, Wiley-VCH.
11. O. P. Agrawal.

Syllabus for B.Tech. II Semester
Department of Biomedical Engineering

Course Code	CHP153				
Course Title	Biochemistry Lab				
Scheme& Credits	L	T	P	Credits	Semester II
	0	0	3	1.5	

Course Outcomes

The chemistry laboratory course will consist of experiments illustrating the principles of chemistryrelevant to the study of science and engineering.

The students will learn to:

1. Estimate the amount of different impurities in water/waste water/food samples.
2. Measure molecular/system properties such as surface tension, viscosity of aqueous or otherindustrially important liquids/mixtures etc.
3. Synthesize a polymer or drug molecule or nano-material.
4. Use principle of spectroscopic and chromatographic techniques.

List of Experiments: [Any Eight from the List]

1. Preparation of different Solutions: Molar solution, Normal solution and percent solution andDetermination ofconcentration.
2. To find out types of alkalinity and estimation of their extent in the water sample.
3. Estimation of hardness present in the water sample by complexometric titration method usingEDTA.
4. Determination of COD in waste water sample.
5. Determination of BOD in waste water sample.
6. To study effect of bondings of water molecules with electrolyte (NaCl/KCl) and non- electrolytesolute (Soap) in the solution through Surface Tension Determination.
7. Synthesis of Drug/Polymer and itsstudy.
8. Separation of different organic compounds by paper chromatography.
9. Estimation of urea inblood.
10. Estimation of carbohydrate in blood.
11. Determination of Fe content in food sample.
12. Demonstrations of laminar flow equipment
13. Spectroscopic/Colorimetric determine of wavelength of maximum absorption of chemical/biological compound in solution and determination of concentration using Lamberts-beer's Law.
14. Demonstration of chromatographic techniques: Gas chromatography, HPLC

15. Demonstrations of organic spectral techniques: IR,NMR.

Suggested Books/Reference Books

1. S. S. Dara, A Textbook on Experiments and Calculations in Engineering Chemistry,S.Chand Publications.
2. J. B. Yadav, Advanced Practical Physical Chemistry, Krishna's Prakashan Media (P) Limited.
3. A. J. Elias, Collection of Interesting General Chemistry Experiments, Universities PressPublications.
4. V. K. Ahluwalia, S. Dhingra and A. Gulati, College Practical Chemistry, Universities PressPublications.
5. Ashutosh Kar, Advanced Practical Medicinal Chemistry, New Age International Publisher.
6. D. M. Vasudevan and Subir Kumar Das, Practical Textbook of Biochemistry for MedicalStudents, Jaypee Brothers Medical Publishers (P) Ltd., 2013.
7. Geetha Damodaran K, Practical Biochemistry, Jaypee Brothers Medical Publishers (P) Ltd., 2011

Syllabus for B.Tech. II Semester
Department of Biomedical Engineering

Course Code	BMT102				
Course Title	Human Anatomy and Physiology for Engineering				
Scheme& Credits	L	T	P	Credits	Semester II
	3	0	0	3	

Course Outcomes:

After completion of the course student will be able to:

1. Understand human physiology at a cellular, tissue, and organ systems level.
2. Recognize the integration and control of the different physiological systems and their roles inmaintaining homeostasis.
3. Appreciate the structural and functional aspects of Human Anatomy
4. Understand the process of development and aging of organ systems

Syllabus

Module – 1 Fundamentals of Anatomy, Cells and Tissues

Introduction to Human Body; Cell Level Organization; Types of cell and their function; Tissue LevelOrganization; Types of Tissue and there function

Module – 2 Integumentary System and Special senses

Structure and Function of Skin; Accessory structures of skin; Skin Wound Healing; Development andAging of Integumentary System; Anatomy and Physiology of Olfaction, Gustation, Vison, Hearing andEquilibrium senses; Aging of senses

Module – 3 Skeletal System

Structure and Function of Bone and the Skeletal System; Bone formation; Fracture and Repair; Typesof Bones; Structure and Function of Axial and Appendicular Skeleton; Joint and its classification; Types of Movements at Synovial Joints and Types of Synovial Joints; Aging of Joints

Module – 4 Muscular System

Overview of Muscular Tissue; Skeletal Muscle Tissue; Working of Muscle Fibers; Metabolism; Control of Muscle Tension; Types of Muscle Fiber and Tissue; Regeneration; Development and Agingof Muscle.

Module – 5 Digestive System

Overview of the Digestive System; Layers of the GI Tract; Neural Innervation of the GI Tract; Structureand Function of Organs of Digestive system; Phases of Digestion; Development and Aging

Module – 6 Excretory system

Overview of Renal Physiology; Anatomy and Physiology of the Kidney; Glomerular Filtration;Reabsorption and Secretion; Waste Management of in other body system; Aging of Urinary System

Text Book

1. Principles of Anatomy & Physiology, 13th Edition, Gerard J. Tortora and Bryan Derrickson, JohnWiley & Sons, Inc
2. Human Anatomy & Physiology Standalone Book, Marieb, Human Anatomy & Physiology, 11thEdition, Pearson.

Reference Books

1. Atlas of Human Anatomy Professional Edition, 7th Edition, Frank H. Netter
2. Ross & Wilson Anatomy and Physiology in Health and Illness, 13th Edition.
3. Clinical Anatomy: Applied Anatomy for Students and Junior Doctors, 14th Edition.
4. Gray's Anatomy for Students, 4th Edition.

Syllabus for B.Tech. II Semester
Department of Biomedical Engineering

Course Code	IDT151				
Course Title	Creativity Innovation and Design thinking				
Scheme& Credits	L	T	P	Credits	Semester II
	1	0	0	1	

Course Outcomes:

1. Be familiar with processes and methods of creative problem solving
2. Enhance their creative and innovative thinking skills
3. Practice thinking creatively and innovative design and development

Syllabus

UNIT I. Introduction:

Making a case for creativity, Creative thinking as a skill, Valuing diversity in thinking: Thinkingpreferences, Creativity styles, Creativity in problem solving

UNIT 2. Pattern Breaking

Thinking differently, Lateral thinking, Mind stimulation: games, brain-twisters and puzzles, Idea- collection processes, Brainstorming/Brainwriting, The SCAMPER methods, Metaphoric thinking, Outrageous thinking , Mapping thoughts, Other (new approaches)

UNIT 3.

Using Math and Science, Systematic logical thinking, Using math concepts, Eight-Dimensional (8D)Approach to Ideation: Uniqueness, Dimensionality, Directionality, Consolidation, Segmentation, Modification, Similarity, Experimentation

UNIT4. Systematic Inventive Thinking

Systematic inventive thinking: The TRIZ methodology, Decision and Evaluation: Focused thinking framework, Six thinking hats , Ethical considerations

UNIT 5. Design for Innovation

Introduction to design for interaction, nine lessons for innovation, difference in creativity and innovation, Building blocks for innovation.

UNIT 6.Intellectual Property

Introduction to intellectual property: Patents, Copyrights©, Trademarks ®, Trade Secret, Unfair Competition.

Reference Books and Text Book

1. Creative Problem Solving for Managers - Tony Proctor - Routledge Taylor & Francis Group
2. 101 Activities for Teaching creativity and Problem Solving - By Arthur B Vangundy - Pfeiffer
3. H. S. Fogler and S.E. LeBlanc, Strategies for Creative Problem Solving, Prentice Hall
4. E. Lumsdaine and M. Lumsdaine, Creative Problem Solving, McGraw Hill,
5. J. Goldenberg and D. Mazursky, Creativity in product innovation. Cambridge University Press,2002.

Course Assignments for internal continuous assessment of 20 Marks (NO T1 and T2)

- Brain teasers (aka Puzzle Busters, to be solved individually)• Cartoon captions (small teams)
- TRIZ, a systematic ideation method, reading (individual)
- Book readings and discussions (small teams)
- Small teams presentations on innovation: (1) innovative individual, (2) innovative company, (3) innovative movie / game, (4) sustainable innovation, (5) innovation in business, (6) innovation in art, (7) innovation in architecture, (8) innovative nation, (9) innovation in science, and (10) innovation in engineering.
- Large groups hands-on projects
- Eight-dimensional (8D) ideation method examples
- Large teams videos

Syllabus for B.Tech. II Semester
Department of Biomedical Engineering

Course Code	HUT151				
Course Title	English				
Scheme& Credits	L	T	P	Credits	Semester II
	2	0	0	2	

Course Objective

The main objective of the subject is to enhance the employability skills of engineering students as wellas communication skills at work place. The sub-objectives are:

1. To develop vocabulary of students.
2. To orient students in basic writing skills.
3. To orient students in functional grammar.
4. To orient students in the process of effective writing.

To provide practice and improve students' oral communication skills. Course Outcomes

1. Students will have good word power.
2. Students will acquire basic writing skills.
3. Students will understand functional grammar and its usage.
4. Students will organize and express their thoughts effectively through written communication.
5. Students will learn oral communication skills in order to handle themselves effectively in aninterview and group discussion

Syllabus

Module -1: Vocabulary Building

1.1. The concept of Word Formation

1.2. Root words from foreign languages and their use in English

1.3. Acquaintance with prefixes and suffixes from foreign languages in English to form derivatives

1.4. Synonyms, Antonyms and standard abbreviations

Module -2: Basic Writing Skills

2.1. Sentence Structures

2.2. Use of phrases and clauses in sentences

2.3. Importance of proper punctuation

2.4. Creating coherence

2.5. Organizing principles of paragraphs in documents

2.6. Techniques for writing precisely

Module -3: Identifying Common Errors in Writing

3.1. Subject-verb agreement

3.2. Noun-pronoun agreement

3.3. Misplaced modifiers

3.4. Articles

3.5. Redundancies

3.6. Clichés

Module -4: Nature and Style of sensible Writing

4.1. Describing

4.2. Defining

4.3. Classifying

4.4. Providing examples or evidence

Module -5: Writing Practices

5.1. Comprehension

5.2. Précis Writing

5.3. Essay Writing

5.4. Letter Writing

5.5. Email Writing

Module -6: Oral Communication

6.1. Listening Comprehension.

6.2. Pronunciation, Intonation, Stress and Rhythm

6.3. Common Everyday Situations: Conversations and Dialogues

6.4. Communication at Workplace

6.5. Interviews

6.6. Formal Presentations

Books

1. Communication Skills. Sanjay Kumar and Pushp Lata. Oxford University Press.2011.
2. Practical English Usage. Michael Swan. OUP.1995.
3. Remedial English Grammar. F.T. Wood.Macmillan.2007
4. On Writing Well. William Zinsser. Harper Resource Book.2001
5. Study Writing. Liz Hamp-Lyons and ben Heasly. Cambridge University Press.2006.
6. Exercises in Spoken English. Parts. I-III. CIEFL, Hyderabad. Oxford University Press

Syllabus for B. Tech. II Semester
Department of Biomedical Engineering

Course Code	HUP151				
Category	Humanities Social Science and Management				
Course Title	English Lab				
Scheme& Credits	L	T	P	Credits	Semester II
	0	0	2	1	

Course objective

1. To enhance competency of communication in English among learners.

Course outcomes

1. Students learn presentation and public speaking skills
2. Students learn to practice effective strategies for Personal Interview and Group Discussions
3. Students learn and effectively apply language skills– listening, speaking, reading and writing

List of Practical (2 hours each for each batch) based on unit 6 (oral communication).

1. Common Everyday Situations: Conversations and Dialogues
2. Pronunciation, Intonation, Stress, and Rhythm
3. Formal Presentations: Orientation
4. Formal Presentations: Practice Session
5. Interviews: Orientation
6. Interviews: Practice Session
7. Communication at Workplace: Group Discussion- Orientation
8. Communication at Workplace: Practice Session

Syllabus for B. Tech. III Semester
Department of Biomedical Engineering

Course Code	BMT201				
Course Title	Human Anatomy and Physiology for Engineers-II				
Scheme& Credits	L	T	P	Credits	Semester II
	3	0	0	3	

Course Outcomes

After completion of the course student will be able to:

1. Understand the concepts and knowledge of the cardiovascular, Respiratory, immune,Gastrointestinal
2. Recognize the integration and control of the different physiological systems and their roles inmaintaining homeostasis.
3. Understand the process of development and aging of organ systems
4. Communicate information related to these systems through written, verbal, or multimediaformats in order to assess current knowledge, answer investigative questions.

Syllabus

Module – 1 Respiratory System

Respiratory system Anatomy; Exchange and Transport of Oxygen and Carbon dioxide; Control of respiration; Development and Aging of Respiration System

Module – 2 Cardiovascular System

Blood and its Property and Function; Anatomy of Heart; Cardiac Muscle tissue and conductionsystem; the cardiac cycle and output; structure and function of blood vessels; Capillary exchange;Hemodynamics; Circulatory route; Aging and development of cardiovascular system

Module – 3 Nervous System

Overview of nervous system; Generation and transmission of electrical signals in neurons; Anatomyand Physiology of Spinal Cord; Brain; Somatic and Autonomic nervous systems

Module – 4 Fluid, Electrolyte & Acid Base Homeostasis

Fluid compartment and Balance; Electrolyte in Body Fluids; Acid Base balance; Aging.

Module – 5 The Lymphatic and Immune system

Structure and Function of Lymphatic system; Innate and Adaptive Immunity; Ceel and AntibodyMediated Immunity; Self recognition and Self Tolerance; Aging and stress on Immunity

Module – 6 Reproductive system

Male and Female Reproductive system; The Female reproduction cycle; Development and Aging ofreproductive systems

Text Book

1. Principles of Anatomy& Physiology, 13th Edition, Gerard J. Tortora andBryan Derrickson, JohnWiley & Sons, Inc
2. Human Anatomy & Physiology Standalone Book, Marieb, Human Anatomy & Physiology, 11thEdition, Pearson.

Reference Books

1. Atlas of Human Anatomy Professional Edition, 7th Edition, Frank H. Netter
2. Ross & Wilson Anatomy and Physiology in Health and Illness, 13th Edition.
3. Clinical Anatomy: Applied Anatomy for Students and Junior Doctors, 14th Edition.
4. Gray's Anatomy for Students, 4th Edition.

Syllabus for B. Tech. III Semester
Department of Biomedical Engineering

Course Code	BMT202				
Course Title	Digital Circuit Design				
Scheme& Credits	L	T	P	Credits	Semester II
	3	0	0	3	

Course Outcomes

1. Understand number systems conversions and apply the principles of Boolean algebra tomanipulate, \minimize and design logic circuits using logic gates.
2. Design and analysis of complex hierarchical combinational blocks like multipliers, fast addersetc.
3. Design and analysis of sequential blocks like flip flops, counters, registers, simple finite statemachines and similar circuits.
4. Understand and describe the architecture of logic families, memory elements and combinationaldigital circuits implementation with programmable logic devices.
5. Design, debug and verify simple digital circuits and systems with the aid of HDL (Verilog) andappropriate EDA tools.

Syllabus

Module – 1 Logic Simplification

Binary Arithmetic, Boolean Algebra and De Morgan's Theorem, SOP & POS forms, Logic Gates,combinational Logic Optimization Techniques.

Module – 2 Combinational logic Design

Comparators, Multiplexers, Demultiplexer, Encoder, Decoder, Arithmetic Circuit Design, BarrelShifter, ALU.

Module – 3 Sequential Logic Design

Latches, Flip flop – S-R,JK, D, T and Master-Slave JK FF, counters, Shift registers, Finite state machines & their implementation with respect to biomedical application.

Module – 4 Logic Families and Programmable Devices

Introduction to logic families, comparison and interfacing, Concept of PLDs like ROM, PAL, PLA, CPLDs, FPGA etc. Logic implementation using Programmable devices, Memories & their architecture.

Module – 5 Overview of Digital Design with HDL

Different methodologies and its implementation process. Introduction to Verilog HDL for Digital Circuit implementation, language constructs

Module – 6 Modeling Styles

Structural, sequential behavioral constructs, test bench, synthesis of HDL.

Text Book

1. Fundamentals of Digital Logic with Verilog: Stephen Brown and Zvonko Vranesic, Mc Graw Hill,2nd Edition.

Reference Books

1. Fundamentals of digital circuits: A. Anand Kumar, Prentice-Hall of India, 4th Edition.
2. Modern digital Electronics: R.P. Jain, Tata McGraw Hill, 4 th Edition
3. Digital Electronic Principles: Malvino, PHI, 3rd Edition.
4. Verilog HDL: A Guide to Digital Design and Synthesis: Samir Palnitkar, Prentice Hall PTR, 2ndEdition.

Practical are based on BMT202 Syllabus

Syllabus for B. Tech. III Semester
Department of Biomedical Engineering

Course Code	MAT274				
Course Title	Applied Mathematics and Descriptive statistics				
Scheme& Credits	L	T	P	Credits	Semester III
	2	1	0	3	

Course Objectives

1. Technique of separation of variables to solve Partial differential equations and analyze the behavior of solutions.
2. Techniques of complex analysis that make practical problems easy.
3. Basics of Probability and Descriptive Statistics mostly used in varied applications inEngineering.

Course Outcomes

On successful completion of the course, students shall be able to

1. Make use of partial differential equation to solve problems in engineering.
2. Make use of complex variable to evaluate contour integration.
3. To understand probability theory and use it for analysis of data.
4. Analyze and compare different sets of data and classify the data by means of diagrams and graph.

SYLLABUS

Unit - I: Partial Differential equations (9 - Lectures) : Partial differential equation of first order first degree i.e. Lagrange's form. Linear homogeneous PDE of nth order with constant coefficient, methodof separation of variables, Applications of partial differential equations.

Unit - II: Functions of a Complex Variable (9 - Lectures) : Function of a complex variable, Analytic functions, Cauchy - Riemann conditions, Conjugate functions, singularities Cauchy's integral theorem and integral formula, Taylor's and Laurent's theorem, Residue theorem, contour integration.

Unit - III: Random variables (9 - Lectures) : Random variables, Discrete and continuous distributions, Mathematical expectations, variance and standard deviation, moment generating function.

UNIT - IV: Descriptive Statistics (9 - Lectures) : Types of statistical data: categorical, ranked, discrete, and continuous. Distinction between univariate, bi-variate, and multivariate statistics, Visualization techniques such as joint contingency tables, scatter plots, 2D histograms and line graphs , Measures of central tendency and Dispersion .

Text Books

1. Higher Engineering Mathematics :B. S. Grewal., 43rd ed: Khanna Publishers, Delhi (India).
2. Biomedical Statistics -Shantikumar Yadav , Sompal Singh, Ruchika Gupta
3. Theory and Problems of Probability and Statistics - M.R. Spiegal (Mc Graw Hill) Schaum Series

Reference Books

1) Statistics (Theory and Practice) by R. S. N. Pillai and Bagavathi, S. Chand Publications.
2) Advance Engineering Mathematics by H. K. Dass

Syllabus for B. Tech. III Semester
Department of Biomedical Engineering

Course Code	BMT203				
Course Title	Signals and Systems				
Scheme& Credits	L	T	P	Credits	Semester III
	3	1	0	4	

Course Outcomes

Upon the completion of this course, students will demonstrate the ability to:

1. Skillfully use the concepts of mathematics for the analysis of bio physical signals and systems intime and frequency domain.
2. Appreciate the importance of Fourier series and Fourier transform techniques
3. Analyze the Continuous Time signals and systems through Laplace Transform
4. Recognize the need for of discretizing a signal and importance of Nyquist Criterion
5. Build necessary foundation for Digital Signal Processing

Syllabus

Module – 1 Introduction to Signals and Systems

Elementary continuous & discrete time signals, introduction to biomedical signals like electroencephalogram (EEG), electrocardiogram (ECG),electro-oculography (EOG), surface electromyogram (EMG), galvanic skin response(GSR), basic operations on signals, classification of signals, introduction to system and system classification.

Module – 2 Time domain analysis of Continuous Time(CT) system

Classical method, convolution integral and their properties, causality, correlation, stability, step response, impulse response of interconnected systems.

Module – 3 Fourier series analysis of CT Periodic signals

Representation, properties, Fourier spectrum, Gibb's phenomenon, introduction to Discrete Time Fourier Series (DTFS).

Module – 4 Continuous Time Fourier transform (CTFT) Properties, FT of periodic signals, modulation,system analysis with FT.

Module – 5 Overview of Laplace Transform

Need of Laplace Transform, Unilateral and bilateral Laplace Transform, properties criterion, concept of Region of Convergence (ROC), inverse of Laplace Transform, the S-plane and BIBO stabilitycriterion and Causality, Transfer function, Solution of differential equations, Analysis of LTI System Using L.T. and Applications, relation

between Fourier Transform and Laplace Transform.

Module – 6 Sampling

Nyquist Criteria of sampling, sampling theorem, aliasing, signal reconstruction, analog to digital conversion, signal transmission through linear system, distortion less transmission through a system, linear phase system, ideal filter, signal and system bandwidth, relationship between bandwidth andrise time.

Text Book

1. Signals and Systems: A.V. Oppenhemn, A.S. Willsky and Hamid Nawab; Pearson publication,2nd edition 2015.

Reference Books

1. Principles of Linear Systems & Signals: B.P. Lathi, Oxford Press, Second Edition, 2009
2. Signals and Systems; Simon Haykin, Barryvan Veen; John Wiley and Sons, 2nd edition, 2003.
3. Signals and Systems; A. NagoorKani, McGrawHill Education, 2015
4. Signals and Systems in Biomedical Engineering: Physiological Systems Modeling and SignalProcessing: Devasahayam, Suresh R., Springer Publication, 2019.

Syllabus for B. Tech. III Semester
Department of Biomedical Engineering

Course Code	BMT204				
Course Title	Data Structure and algorithm				
Scheme& Credits	L	T	P	Credits	Semester III
	2	0	0	2	

Course Outcomes

1. Understand the fundamentals of basic data structures.
2. Design and analyze simple algorithms.
3. Understand the basics of Python language.
4. Write programs using python.

Syllabus

Module – 1

Introduction to programming, algorithms and data structures, Introduction to Python variables, operators, control flow statements, loops statements.

Module – 2

Python strings, lists, tuples, array, dictionary. Python functions: optional arguments, default values, passing functions as arguments, Nested functions, higher order functions on lists: map, list comprehension.

Module – 3

Exception handling, Basic input/output, Handling files, String processing.

Module – 4

Introduction to Python object oriented Programming, Abstract data-types, Classes and objects in Python.

Module – 5

Introduction to Data structures and algorithm: stack, queue, Heaps. Sorting, Hashing & Searching, Linked lists, Trees and tree algorithm, graphs and graph algorithm.

Module – 6

Introduction to Open CV python, reading, writing and storing images. Various operations on images with Open CV python.

Text Book

1. Michael T. Goodrich, Roberto Tamassia, Michael H. Goldwasser, "Data Structures and Algorithms in Python", Wiley, 2013.

2. Kenneth A. Lambert, “Fundamentals of Python:Data Structures” Cengage Learning PTR, 2014.

Reference Books

1. Gowrishankar S, Veena A, “Introduction to Python Programming”, 1st Edition, CRC Press/Taylor& Francis, 2019. ISBN-13: 978-0-8153-9437-2.
2. 2. Benjamin Baka, “Python Data Structures and Algorithms” Published by Packt Publishing Ltd.,2017.
3. Gary Bradski, Adrian Kaehler, “Learning OpenCV Computer Vision with the Open CV Library”,O'Reilly Media, 2008.

Practical are based on BMT 204 Syllabus

Syllabus for B. Tech. III Semester
Department of Biomedical Engineering

Course Code	BMT205				
Course Title	Electronic Devices and Circuits				
Scheme& Credits	L	T	P	Credits	Semester III
	3	0	0	3	

Course Outcomes

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

1. Describe the characteristics and working principle of MOSFET, BJT.
2. Employ suitable biasing technique for the MOSFET/BJT based design of amplifier circuits.
3. Analyze amplifier circuits at low, mid and high frequencies using low frequency and highfrequency models of MOSFET/BJT.
4. Examine the effect of negative feedback on gain, bandwidth, i/p and o/p impedance, and thestability of the amplifier.
5. Contrast various types of power amplifiers and differential amplifiers, and evaluate theirperformance parameters.
6. Design small signal amplifiers comprising of MOSFET & BJT using the concepts of biasing,incremental analysis, and negative feedback.

Syllabus

Module – 1 Bipolar Junction Transistors

Device structure and Physical Operation, Current Components in BJT, Input- Output and Transfer characteristics in CB,CC and CE configuration, Load line concept, Biasing techniques, Bias Stability,The Ebers-Moll Model and small signal model of BJT, Applications of BJT.

Module – 2 Field-effect Transistors

FET, MOSFET – Classification, Construction, Physical Operation, Volt-Ampere Characteristics, DC operating point, biasing the MOSFET; small signal model of the MOSFET, small signal analysis,Applications of MOSFET: Switch, Amplifier, Digital Logic Inverter.

Module – 3 Basic BJT & MOSFET Amplifiers

Classification of amplifiers, distortions in amplifiers, basic configurations of MOSFET amplifier, lowfrequency and high frequency response, effect of emitter (or source) bypass capacitor on the frequency response of amplifier, High frequency model of the MOSFET, Miller's theorem.

Module – 4 Feedback amplifier & Stability

General Feedback amplifier Structure, Properties of Negative Feedback, Basic Feedback Topologies,The Stability of

Amplifier.

Module – 5 Power Amplifiers

Class-A/class-B/class-C; push-pull amplifier, class-AB power amplifier.

Module – 6 Differential Amplifier

Basic differential amplifier and its operation using MOS transistor, dc characteristics, operation with common mode and differential mode input voltage, common mode gain, differential mode gain andCMRR, Constant current source and current mirror circuits.

Text Book

1. Microelectronics Circuits: Theory and Applications: Adel S. Sedra, Kenneth C. Smith, Arun N.Chandorkar, Seventh Edition, Oxford University Press, 2017.

Reference Books

1. Electronic Circuits: Analysis and Design: Donald Neamen, Third Edition, McGraw-HillPublication, 2006.
2. Solid State Electronic Devices: G. Streetman, and S. K. Banerjee, Seventh edition, Pearson, 2014.
3. Semiconductor Physics and Devices: Basic Principles: Donald Neamen, Fourth edition,McGraw-Hill, 2011.
4. Millman's Integrated Electronics: Jacob Millman, Christos Halkias, Chetan Parikh, Second edition, McGraw Hill Education, 2017.
5. Microelectronics: behzad Razavi, Second edition, Wiley India Pvt. Ltd., 2018.
6. Electronic Devices and Circuits: David A. bell, Fifth Edition, Oxford 2008.
7. Microelectronic Circuits Analysis and Design: Muhammad H. Rashid, Second edition, CengageLearning India, 2012.

Practical are based on BMT205 Syllabus

Syllabus for B. Tech. IV Semester
Department of Biomedical Engineering

Course Code	BMT206				
Course Title	Network Analysis and Synthesis				
Scheme& Credits	L	T	P	Credits	Semester IV
	3	0	0	3	

Course Outcome

Upon Completion of this course student will demonstrate the ability to:

1. Understand basics electrical circuits with nodal and mesh analysis.
2. Apply network theorems for the analysis of electrical circuits.
3. Apply Laplace Transform for steady state and transient analysis.
4. Analyze different network function.
5. Analyze two port network circuit with different interconnections.

Syllabus

Module – 1 Node and Mesh Analysis

Node and mesh analysis, matrix approach of network containing voltage, current sources andreactances, source transformation and duality. Mutual coupled circuits, Dot Convention in coupledcircuits.

Module – 2 Network theorems

Superposition, reciprocity, Thevenin's, Norton's, Maximum power Transfer, compensation and Tallegen's theorem as applied to AC. circuits.

Module – 3 behaviors of AC circuit and Introduction to Filters

Ac circuit analysis with dependent current and voltage sources. Series and parallel resonant circuits.Introduction to band pass, low pass, high pass and band reject filters.

Module – 4 Electrical Circuit Analysis Using Laplace Transforms

Review of Laplace Transform, Partial fractions, singularity functions, Analysis of electrical circuitsusing Laplace Transform for standard inputs, convolution integral, inverse Laplace transform, evaluation of initial conditions. Transformed network with initial conditions, waveform synthesis, and analysis of RC, RL, and RLC networks with and without initial conditions with Laplace transforms.

Module – 5 Transient behavior of Network and Network Functions

Driving points and transfer functions poles and zeros of immittance function, their properties,sinusoidal response from pole-zero locations, convolution theorem.

Module – 6 Two port network

Two Port Networks, terminal pairs, relationship of two port variables, impedance parameters, admittance parameters, transmission parameters and hybrid parameters, interconnections of two port networks.

Text Book

1. M. E. Van Valkenburg, "Network Analysis", Prentice Hall, 2006.
2. D. Roy Choudhury, "Networks and Systems", New Age International Publications, 1998.
3. W. H. Hayt and J. E. Kemmerly, "Engineering Circuit Analysis", McGraw Hill Education, 2013.

Reference Books

1. Sudhakar, A., Shyammohan, S. P.; "Circuits and Network"; Tata McGraw-Hill New Delhi, 1994
2. C. K. Alexander and M. N. O. Sadiku, "Electric Circuits", McGraw Hill Education, 2004.
3. K. V. V. Murthy and M. S. Kamath, "Basic Circuit Analysis", Jaico Publishers, 1999.

Syllabus for B. Tech. IV Semester
Department of Biomedical Engineering

Course Code	BMT207				
Course Title	Digital Signal Processing				
Scheme& Credits	L	T	P	Credits	Semester IV
	3	0	0	3	

Course Outcomes

Upon Completion of this course student will demonstrate the ability to:

1. Describe discrete time signals in different forms and analyze the LTI system in frequency domain.
2. Process the signal in Z domain for various discrete time systems
3. Design Finite Impulse Response (FIR)filters , and evaluate the performance to meet expectedsystem specifications
4. Design Infinite Impulse Response (IIR) filters, and evaluate the performance to meet expectedsystem specifications
5. Analyze the various finite world length effects while rounding and truncating the signal, multiratesignal processing, Applications of DSP in Bio medical Engineering.

Syllabus

Module – 1 Discrete Time Fourier Transform (DTFT)

Analysis of LTI system using DTFT, block diagram and signal flow graph representation of linearconstant coefficient difference equations.

Module – 2 Z-transform

Z-transform and its properties, analysis of LTI discrete time system using Z transform, Relationbetween Laplace and Z transform, Inverse Z-transform, Unilateral Z- transform.

Module – 3 Discrete Fourier Transform (DFT)

Frequency Domain sampling, DFT and its properties, filtering of long data sequences using overlap-save method and overlap-add method, Radix-2 Fast Fourier Transform (FFT) algorithms.

Module – 4 Design of FIR filter

Digital filter concepts, FIR filters Design techniques: Fourier series, Windows (Rectangular, Bartlett,Hanning, Hamming, Blackman, Kaiser) and Optimal frequency sampling, structures for FIR systems.

Module – 5 Design of IIR filter

Impulse invariance transformation, Bilinear Transformation, Design of Butterworth and Chebyshevfilters, structures for IIR systems.

Module – 6 DSP hardware and Finite word length effects

Quantization by truncation and Rounding, Quantization of Input data and filter coefficients,Applications of DSP in Bio medical Engineering.

Text Book

1. Digital Signal Processing: Principles, Algorithms & Applications, John G. Proakis & Dimitris G. thManolakis, PHI, 4 Edition
2. Bio-medical signal processing principles and Techniques by D.C. Reddy. Mc-Graw Hill.

Reference Books

1. Digital Signal Processing: A Computer based Approach, Sanjit K. Mitra, 4 Edition Mc-Graw Hill.
2. Discrete Time Signal Processing, Alan V. Oppenheim & Ronald W. Schafer, 3 Edition, Pearson.
3. Digital Signal Processing, A NagoorKani, 2 Edition Mc-Graw Hill.

*BMP207 (Credit 1) Practical will be based on theory syllabus.

Syllabus for B. Tech. IV Semester
Department of Biomedical Engineering

Course Code	BMT208				
Course Title	Microprocessor and Microcontroller				
Scheme& Credits	L	T	P	Credits	Semester IV
	3	0	0	3	

Course Outcomes

Upon Completion of this course student will demonstrate the ability to:

1. Understand the basic concepts of microprocessor & microcontroller and its application in biomedical field.
2. Develop, understand and analyze the programs for microprocessor and microcontroller.
3. Understand the interfacing of external peripheral devices with microprocessor or microcontroller.
4. Understand the basic concepts related to Embedded OS, Interrupt, Task, Resources and programming.

Syllabus

Module – 1 8085 architecture and Instructions

Introduction to RISC and CISC processors, Harvard and Von Neumann architecture, Introduction toIntel's 8085, architecture, pin diagram, bus concepts, addressing modes. Instruction set, stack andsubroutines- simple & nested, stack manipulation, simple programs.

Module – 2 8085 Timing diagram and Interrupts

Timing diagrams, Memory mapping, interrupts-concept and structure, interrupt service routines. Introduction to X86.

Module – 3 The Cortex - M processor

Simplified view – block diagram, programming model –Registers, Operation modes, Exceptions andInterrupts, Reset Sequence, Instruction Set.

Module – 4 Interfacing with Cortex M0

Interfacing of Switches & Relays, Stepper motor, LED, SSD, LCD, Analog-to-Digital Converter (ADC),DC motor. Power management: Sleep mode, idle mode, Run Mode. Commutation Protocols: I/O PortExpansion using RS232, RS422, RS485, Serial Peripheral Interface (SPI), I2C Communication.

Module – 5 Introduction to EmBedded OS, Interrupt, Task, Resources

Semaphore, Events, Message Queue, Mailbox, Mutex Linux as an emBedded OS, Tools anddevelopment, Building Linux Kernel.

Module – 6 EmBedded systems medical and biomedical applications

MRI and CT Scanner, Sonography, Digital Flow Sensors, Blood Pressure and Glucose Test Device,Wearable Device.

Text Book

1. Microprocessor: Architecture, Programming & applications with 8085; Ramesh S. Gaonkar;Penramth International, 5 Edition.
2. The Definitive Guide to the ARM Cortex-M0: Joseph Yiu, Elsevier, (1/E) 2011.
3. An emBedded software primer: David E Simon, Pearson education Asia, 2001.

Reference Books

1. 8085 Microprocessor: Programming and Interfacing; N. K. Srinath; PHI, 1 Edition.
2. Free scale ARM Cortex-M EmBedded Programming, Mazidi and Naimi ARM
3. Micro C/OS II The Real Time Kernel: Jean J. Labrosse, CMP Books,(2/E) 2002
4. EmBedded Linux Primer: christopher Hallinan, Pearson (1/E) 2007l.

*BMP208 (Credit 1) Practical will be based on theory syllabus.

Syllabus for B. Tech. IV Semester
Department of Biomedical Engineering

Course Code	BMT209				
Course Title	Analog Circuits				
Scheme& Credits	L	T	P	Credits	Semester IV
	3	1	0	4	

Course Outcomes

At the end of this course, students will demonstrate the ability to:
1. Understand characteristics of operational amplifiers and its inverting and non-inverting configuration.
2. Elucidate and design the linear and non-linear applications of an opamp.
3. Explain and compare the working of multivibrators using special application IC 555 and general purpose op-amp.
4. Classify and comprehend the working principle of data converters ADC/DAC.and Illustrate PLL IC and its application.
5. Design and test electronic circuits using appropriate tool.

Syllabus

Module – 1 Op-amp fundamentals

Block schematic, Ideal and practical operational amplifier characteristics, open loop Op-amp circuits,concept of virtual ground and negative feedback in Op_amp circuits.

Module – 2 Op_amp basic circuits

Inverting and Non inverting Op-amp circuits with negative feedback, Voltage gain, input resistance,output resistance, Bandwidth of op_amp with negative feedback, Op-amp parameters: Offset voltage, bias and offset current, CMRR, Slew rate.

Module – 3 Op-amp linear applications

Voltage follower, summing amplifiers, signal conditioning circuits integrators and differentiators, difference amplifiers, instrumentation amplifiers, Current to voltage and voltage to current converters,logarithmic amplifiers.

Module – 4 Oscillators and Active filters design

Precision rectifiers, Op-amp based sinusoidal oscillators, design of Active filters: Low pass, High pass,Band pass and Band stop first order and higher order Butter worth filters.

Module – 5 Op-amp Non-linear applications

Clipper, Clamper, Comparators, Schmitt trigger circuits, Comparator IC 339, Triangular wave generator, multivibrator circuits using op-amps, Sample/Hold circuits, Digital to analog converters (DAC), Analog to digital converters (ADC).

Module – 6 Timer IC and PLL IC

Timer IC 555: Internal block schematic and operating principle, multivibrator configurations. Operating principle of Phase lock loop (PLL) IC 565 and its applications, Basic concept and configurations of Switched capacitor

circuits.

Text Book

1. Linear Integrated Circuits: D. Roy Choudhary, Shail Jain, 4th Edition, New Age International
2. Microelectronic Circuits: Theory and Applications :Adel S. Sedra, Kenneth C. Smith, Arun N.Chandorkar, Seventh Edition, Oxford University Press, 2017.

Reference Books

5. Operational Amplifiers: Ramakant Gaikwad, Second edition, Prentice Hall.
6. Design with Operational Amplifiers and Analog Integrated Circuits, 3rd Edition: Sergio Franco,TMH.
7. Operational Amplifiers and Linear Integrated Circuits, 4th Edition: Coughlin Driscoll, PHI
8. Introduction to Operational Amplifier theory and applications: J. V. Wait, L. P. Huelsman and GA Korn, McGraw Hill,1992
9. Electronic Circuits: Analysis and design: Donald Neaman, Third Edition, McGraw Hill, 2006.

*BMP209 (Credit 1) Practical will be based on theory syllabus.

Syllabus for B. Tech. IV Semester

Department of Biomedical Engineering

Course Code	CHT252				
Course Title	Environmental Sciences				
Scheme& Credits	L	T	P	Credits	Semester IV
	2	0	0	0	

Course Outcomes

Upon Completion of this course student will demonstrate the ability to:

1. Will get sufficient knowledge regarding different types of environmental pollutions, their causes, detrimental effects on environment and effective control measures.
2. Will realize the need to change an individual's outlook, so as to perceive our environmental issues correctly, using practical approach based on observations and sel f learning.
3. Will become conversant with recent waste management techniques such as E-wastes, its recycling and management.
4. Will gain knowledge about the modes for sustainable development, importance of green energyand processes.
5. Will be able to identify and analyze environmental problems as well as risks associated with these problems and greener efforts to Be adopted, to protect the environment from getting polluted.

Syllabus

Principle of contaminant Behaviour and recent trends in environmental pollution control

Module – 1 Air pollution and its control techniques: (4 lectures)

Contaminant Behaviour in the environment, Air pollution due to SOx, NOx, photochemical smog,Indoor air pollution

Natural pathways for degradation: Carbon cycle, Sulphur cycle, Nitrogen cycle, Oxygen cycle.

Factors responsible for altering the composition of atmosphere (deforestation, burning of fossil fuels,industrial and vehicular emissions, CFCs).

Techniques to control Air pollution, ambient air quality and continuous air quality monitoring,Control measures at source, Kyoto Protocol, Carbon Credits.

Module – 2 Noise pollution and its control techniques: (2 lectures)

Introduction to noise pollution and its causes

Noise pollution control: Recent advances in noise pollution control and Benefits.**Module – 3**

Soil pollution and its control techniques: (5 lectures) Soil pollution: Soil around us, Soil water characteristics, soil pollution.

Solid waste management: Composting, vermiculture, landfills, hazardous waste treatment, bioremediation technologies, conventional techniques (land farming, constructed wetlands), andphytoremediation.

Degradation of xenobiotics in environment: Petroleum hydrocarbons, pesticides, heavy metals.

Module – 4 Water pollution and its control techniques: (8 lectures)

Major sources of water pollution: Eutrophication, acid mine drains, pesticides and fertilizers, dyeingand tanning, marine pollution, microplastics

Techniques to control water pollution: Conventional waste water treatment-types of sewage, sewerage system, alternative systems, primary, secondary and tertiary processes including aerobic and anaerobic techniques, safe disposal.

Case studies: Treatment schemes for waste water from dairy, textile, power plants, pharmaceutical industries, and agro based industries such as rice mills.

Module – 5 E-wastes (2 lectures)

Introduction, types of e-wastes, environmental impact, e-waste recycling, e-waste management rules.

Module – 6 Environmental Sustainability: Role of Green technology (5 lectures) Concept of green technologies, categories, goals and significance, sustainability

Green energy, green chemistry, challenges to green technology, advantage and disadvantages ofgreen processes, Eco mark certification- its importance and implementation.

Module – 7 Different government initiatives (2 lectures)

National ambient air quality standard 2009, Swacch bharat abhiyan, National afforestation programand Act- 2016, National river conservation plan, Formation of National Green Tribunal.

Books

1. Benny Joseph, Environmental Studies, Mc Graw Hill Education (India) Private Limited
2. B. K. Sharma, Environmental Chemistry, Goel Publishing House, Meerut
3. P Aarne Vesilind, J. Jeffrey Peirce and Ruth F. Weiner, Environmental Pollution and Control,Butter worth-Heinemann
4. D. D. Mishra, S. S. Dara, A Textbook of Environmental Chemistry and Pollution Control, S.Chand & Company Ltd. Sultan Chand & Company
5. Shree Nath Singh, Microbial Degradation of Xenobiotics, Springer-Verlag Berlin HeidelBerg
6. P.T. Anastas & J.C. Warner, Green Chemistry: Theory & practice, Oxford University Press

Syllabus for B. Tech. V Semester
Department of Biomedical Engineering

Course Code	BMT301-1				
Course Title	Bioinformatics				
Scheme& Credits	L	T	P	Credits	Semester V
	3	0	0	3	

Course Outcomes

1. Understand the basic principles and concepts of Genetics, and basic computer science
2. Know the basic concepts of sequence alignment and analysis.
3. Understand the principles of protein primary, secondary, tertiary structure and DNA mapping and sequencing
4. Develop the analytical and experimental skills necessary to understand how bioinformatics data is stored and databases are organized.

Syllabus

Module I (7 Hours)
Concepts and importance of Bioinformatics, Concept of gene, Coding and non-coding regions, Promoter, Sequence analysis: protein and nucleic acids

Module II (9 Hours)
Biological Databases: Types, Nucleotide sequence database (Primary database), EMBL, DDBJ, GenBank, protein sequence database and their classification, motif sequence databases, structural databases. Sequence Alignment: Pair wise and multiple sequence alignment, Global and local alignment, Tools used for sequence alignment BLAST, CLUSTAL. Tools used for sequence analysis.

Module III (8 Hours)
Protein Primary, secondary and tertiary structures Ramachandran plot, secondary structure prediction, Protein Data Bank, visualization tools, structural classification of protein databases.

Module IV (6 Hours)
Protein stability, energetic contributions, database, stabilizing residues, stability upon mutations, Protein folding rates, proteins interactions, binding site residues. Computer aided drug design, docking.

Module V (6 Hours)
DNA Mapping and sequencing: Map alignment, Large scale sequencing and alignment, Shotgun-DNA sequencing, Sequence assembly, Gene predictions, Molecular predictions with DNA strings. Introduction to next generation sequencing techniques and its application.

Text Books:

1. D.E. Krane and M.L. Raymer, “Fundamental Concepts of Bioinformatics”, Pearson Education Inc. 2006.

2. Supratim Choudhuri, Bioinformatics for Beginners: Genes, Genomes, Molecular Evolution, Databases and Analytical Tools 1st Edition

Reference Books:

1. M. Michael Gromiha, "Protein Bioinformatics: From Sequence to Function", 1st edition, Academic Press, 2010
2. D.E. Krane and M.L. Raymer, "Fundamental Concepts of Bioinformatics", Pearson Education Inc. 2006.
3. Keith, J. Humana , "Bioinformatics. Keith" , J. Humana Press, 2008.
4. R.F. Doolittle "Computer methods for macromolecular sequence analysis.", Academic Press, 1996.
5. Bioinformatics: A practical guide to the Analysis of Genes and Proteins, A.D, Francis Ouellette Baxevanis, Wiley Interscience, New York

*BMP301-1 (Credit 1) Practical will be based on theory syllabus.

Syllabus for B. Tech. V Semester
Department of Biomedical Engineering

Course Code	BMT301-2				
Course Title	Medical Robotics & Automation				
Scheme& Credits	L	T	P	Credits	Semester V
	3	0	0	3	

Course Outcomes

1. Apply Asimov's laws of robotics to real world problems
2. Solve robot kinematics
3. DescriBe medical and military robotics applications
4. Design robotic assistance for minimally invasive surgery and image guided interventions

Syllabus

Module I (7 Hours)
Basic Concepts: Definition and origin of robotics, Different types of robotics, various generations of robots, Asimov's law s of robotics, Degrees of freedom – dynamic stabilization of robots

Module II (7 Hours)
Review of Mathematical Preliminaries, Robot Forward Kinematics - Position, velocity, and acceleration analysis, Robot Inverse Kinematics, Manipulator Jacobian

Module III (7 Hours)
Introduction to medical robotics applications and paradigms, robotics exoskeleton military applications, Robotic control and sensing systems, human-robot interaction, Basic control concepts -impedance, admittance

Module IV (7 Hours)
Minimally Invasive Surgery (MIS), Human-machine interfaces, Robot design concepts, Video images in MIS, Augmented reality, Image-Guided Interventions, Robot compatibility with medical imagers(e.g., MRI, US, X-ray, CT), Image segmentation and modeling, Tracking devices, Surgical navigation, Calibration

Module V (7 Hours)
Case Studies: Cardiac, abdominal, and urologic procedures with tele-operated robots, Robotic catheters for heart electrophysiology, Orthopedic surgery with cooperative robots, Prostate interventions with manual robots, Rehabilitation robotics

Text Book:

I. Achim Schweikard, Medical Robotics, 2015 Springer

Reference Books:

1. John J. Craig, Introduction to Robotics: Mechanics and Control, Third Edition, Prentice-Hall (Pearson), 2005, ISBN: 0-13-123629-6.
2. P. Mikell, G. M. Weiss, R. N. Nagel, and N. G. Odraj, Industrial Robotics, McGrawHill

*BMP301-2 (Credit 1) Practical will be based on theory syllabus.

Syllabus for B. Tech. V Semester
Department of Biomedical Engineering

Course Code	BMT301-3				
Course Title	Biostatistics				
Scheme& Credits	L	T	P	Credits	Semester V
	3	0	0	3	

Course Outcomes

1. Analyze and interpret the data by means of various graphs.
2. Understand the concepts of hypothesis testing as well as the procedures of the various tests of significance applied in Biomedical Sciences.
3. Understand fundamental concepts in multivariate regression analyses
4. Identify and propose suitable designs to test given hypotheses within biological sciences or related fields.

Syllabus

Module I (8 Hours)

Introduction to Descriptive Statistics and Sampling Methods: Sources and presentation of data, methods of presentation, Sampling distribution and sampling methods, Simple random sampling, Systematic Sampling, Stratified Sampling, Cluster Sampling, Multistage Sampling.

Module II (8 Hours)

Test of Significance: Standard error of the mean and confidence intervals of the mean, Hypothesis Testing, Type I error, Type II error, Power of test, Z-Statistics, Student t Statistics for one sample, for two samples as well as for paired data, Chi squared test of independence, ANOVA method.

Module III (8 Hours)

Correlation and Regression Analysis: Analysis of Bivariate data, Scatter diagram, correlation Analysis, Types of correlation, Correlation coefficient, Determination coefficient, Linear Regression, multivariate regression analyses

Module IV (8 Hours)

Study of Designs: Descriptive studies, Analytical Studies, Observational studies, Cross-sectional study, Cohort study, Case- Control Study, Experimental Studies with examples

Text Books :

1. Biomedical Statistics -Shantikumaryadav ,SompalSingh,RuchikaGupta
2. Theory and Problems of Probability and Statistics - M.R. Spiegal (Mc Graw Hill) SchaumSeries

Reference Books :

1. Introduction to Statistics for Biomedical Engineers -KristinaM.Ropella
2. Probability and Statistics for Engineers -Miller & Freund's, sixth edition

*BMP301-3 (Credit 1) Practical will be based on theory syllabus.

Syllabus for B. Tech. V Semester
Department of Biomedical Engineering

Course Code	BMT302				
Course Title	Biomaterials				
Scheme& Credits	L	T	P	Credits	Semester V
	3	0	0	3	

Course Outcomes

1. Apply the learn concepts to test different biomaterial (In-Vivo, In-Vitro) for targeted biomedical applications.
2. Analyze and identifythe components of biocompatibility and learn how to apply for different biomaterials.
3. Analyze and select the specific biomaterial such as Metals, Ceramics, Polymers and Blends/composites - for different targeted biomedical applications.
4. Learn and applybiomaterial relevant international standards: ISO, FDA and ASTM.

Syllabus

Module I (7 Hours)
Introduction to Biomaterials: Introduction to Biomaterials, Historical background of biomaterials, Introduction to processing of biomaterials, Different types of Biomaterials (three classes: metals, ceramics, and polymers).

Module II (7 Hours)
Biomaterials Biocompatibility: Definition of biocompatibility, Introduction to Biomaterials Biocompatibility, Components of biocompatibility (cytotoxicity, genotoxicity, mutagenicity, carcinogenicity and immunogenicity etc.), Biocompatibility Test Methods (In-Vivo, In-Vitro)

Module III (6 Hours)
Metal-Biomaterials: Metals-biomaterial types, classifications, essential properties and applications related medical application.

Module IV (6 Hours)
Ceramic-Biomaterials: Ceramics-biomaterial type, classifications, essential properties and applications related medical application.

Module V (6 Hours)
Polymers-Biomaterial: Polymers-biomaterial type, classifications, essential properties and applications related medical application.

Module VI (8 Hours.)

Blends/composites-Biomaterial: Blends/composites-Biomaterial, Biopolymers, Hydrogels, Sterilization of implants, implants failures, implant retrieval and evaluation, Relevant

international standards: ISO, FDA and ASTM.

Text Books:

1. Biomaterials by Bhat Sujata V., Kluwer Academic Publishers and Narosa Publishing House (New Delhi, India), (1st edition 2002, 2nd edition 2004)

Reference Books:

1. J. B. Park and R. S. Lakes, An Introduction to Biomaterials, Springer
2. J.B Park, and J.D. Boonzino, Biomaterials: Principles and Application, CRC Press
3. Biomaterial Science and Engineering", Park J.B., Plenum Press, 1984
4. Biomaterial: an interfacial approach", Hench L.L. & E. C. Ethridge, Academic Press
5. B. D. Ratner, F. J. Schoen, A. S. Hoffman, and J. E. Lemons, Biomaterials Science: An introduction to Materials in medicine, Academic Press
6. Biomaterials by Temenoff Johnna S., Dorling Kindersley India Pvt Ltd
7. Wong, J.Y., &Bronzino, J.D. (Eds.). (2007). Biomaterials (1st ed.). CRC Press.

Syllabus for B. Tech. V Semester

Department of Biomedical Engineering

Course Code	BMT303				
Course Title	Healthcare application design using FPGA				
Scheme& Credits	L	T	P	Credits	Semester V
	3	0	0	3	

Course Outcomes

1. Design and analyze combinational, sequential and arithmetic circuits on FPGAs
2. Understand digital system design flow, timing, synthesis and testability on FPGA
3. Understand the need of FPGA in healthcare application design
4. Understand the basic concepts of softcore based system design applied to healthcare applications

Syllabus

Module I (10hrs)
Verilog HDL Language Fundamentals and FPGA design flow: Overview of Verilog HDL, FPGA architecture and resources, FPGA Design flow, Design methodologies. Case studies: Case studies on Modelling, Simulation and Synthesis of Combinational and Sequential circuits, Building blocks in FPGA

Module II (08hrs)
Overview of Back end Processes: Logic partitioning, floor planning, and placement, routing, high level synthesis. Role of FPGAs in Healthcare applications. Diagnostic techniques using FPGA, Real time data analysis using FPGAs

Module III (12hrs)
Introduction to soft-core processor and its implementation on FPGA. Introduction to IP Cores and its implementation in FPGA. Introduction to SOC design. Introduction to soft core based SOC design with FPGA. Need for accelerators, Hardware acceleration techniques, Hardware software co-design techniques.

Module IV (10Hrs)
Introduction to Healthcare Solutions from Diagnostics to Clinical in following healthcare application areas with FPGA: Medical Imaging with Ultrasound, Medical Imaging with CT Scanners and MRI Machines, Multi-parameter Patient Monitors & ECGs, Robot-assisted surgery, and Other Medical Equipment. Introduction to build healthcare systems with the highest level of safety, security and reliability with FPGA.

Text Books:

1. Verilog HDL: A Guide to Digital Design and Synthesis, Samir Palnitkar; Pearson Education; 2nd edition
2. Rapid System Prototyping with FPGAs: Accelerating the design process: RC Cofer, Benjamin F. Harding. 2005

Reference Books:

Designing with Xilinx® FPGAs: Using Vivado: Springer International Publishing, 2017

1. Digital System Design with FPGA Implementation Using Verilog and VHDL;CemUnsalan, Yeditepe University, Istanbul, Turkey Bora Tar ; McGraw Hill India.
2. EmBedded Microprocessor System Design using FPGAs: Uwe Meyer-Baese, Springer, Year: 2021

Reference Links:

1. https://www.intel.in/content/www/in/en/healthcare-it/products/programmable/overview.html
2. Smart Solutions for Healthcare: Imaging, Diagnostics, and Clinical Equipment https://www.xilinx.com/applications/medical.html

Research Journals:

IEEE, ACM, Elsevier, Springer

*BMP303 (Credit 1) Practical will be based on theory syllabus.

Syllabus for B. Tech. V Semester

Department of Biomedical Engineering

Course Code	BMT304				
Course Title	Biomedical Sensors and Measurement Devices				
Scheme& Credits	L	T	P	Credits	Semester V
	3	0	0	3	

Course Outcomes

1. Understand basic fundamentals principles involved in transducers and sensors.
2. Comprehend physical, chemical and biological sensors with construction details
3. Identify data acquisition system, measurement and display devices

Syllabus

Module I (6 Hours)

Basics of Sensors and Measurement: General Structure of the measurement system, Classification of transducer, Performance characteristics of transducer, Static - dynamic Characteristics, Basic transduction techniques, Bridge based Measurement: DC bridges, AC bridges.

Module II (7 Hours)

Temperature and Displacement Measurement: Resistance Temperature Detectors, Thermistors, Radiant Temperature Sensors, ICs based Temperature Sensors, FiBer-optic Temperature Sensor, Strain gauges, Load cell, Biomedical Application of Strain gauges, Displacement Sensors, Motion Transducer.

Module III (7 Hours)

Pressure and Flow Measurement: Types of flows in physiological System, Differential pressure flow transducers, Ultrasound flow transducers, Electromagnetic flow transducers, Pressure Transducer, Physiological Pressure Measurement, Absolute Pressure Sensors for Implantable Devices, Differential Pressure Measurements, Indirect Measurement of Systolic, Diastolic, and Mean Blood Pressure

Module IV (6 Hours)

Electrochemical Sensors: Electrode Potential and Reference Electrode, Potentiometric Sensors, Amperometric Sensors, Impedimetric Sensors, Electroanalytical methods.

Module V (7 Hours)

Optical Transducer: Principle of the functioning of pulse oximetry, Transmission configuration of pulse oximetry, IR light sources and detectors, Transmittance and reflectance pulse oximetry, Beer-LamBert law. Capnography: Electromechanics and solid-state transducers, Case study: Advancing Sensors in Biomedical and Biotechnology.

Module VI (7 Hours)

Data Acquisition System: Interfacing transducers to Electronics Control and Measuring System. Instrumentation Amplifier, Isolation Amplifier. An Introduction to Computer-Controlled Test

Systems, Measurement and display system: Electronic multi-meter, True-RMS meter, Digital storage

oscilloscope, Digital meter, Frequency, Time interval and pulse width measurement basics, Portable display units.

Text Book:

1. Khandpur, R. S, Handbook of Biomedical Instrumentation", 3rdedition, McGraw Hill Education (India) Private Limited, 2017

Reference Books:

1. John G Webster, Medical Instrumentation - Application and Design. 4th edition, John Wiley& Sons, NY
2. Tatsuo Togawa, ToshiyoTamura , Biomedical Transducers & Instruments , P. Ake OBerg. CRC
3. Vera Lucia Da Silveira Nantes Button, Principles of Measurement & Transduction of Biomedical Variables, Elsevier
4. D. Patranabis , Sensors & Transducers , Phi Learning Pvt. Ltd

*BMP304 (Credit 1) Practical will be based on theory syllabus.

Syllabus for B. Tech. V Semester

Department of Biomedical Engineering

Course Code	MBT391-1				
Course Title	Business Management and Entrepreneurship				
Scheme& Credits	L	T	P	Credits	Semester V
	3	0	0	3	

Course Outcomes

At the end of this course students will demonstrate the ability to

1. Understanding of the evolution of management, its history and the development of importantconcepts.
2. Exposure to the practice of management in contemporary organization
3. Ability to analyze and understand management as well as exploring and developing their ownpersonal philosophy of management.
4. To provide an introduction to entrepreneurship and its development process.
5. To provide understanding about various sources of finances and business expansion.
6. To provide conceptual clarification of networking, e-business and growth strategies.

Syllabus

Module I: (5 Hours)

Introduction to Business Management: Nature – Function – Definition – Importance of Management – Scope of Management – Is management a science or art? – Management Functions and skills –Development of Management Thought (Contribution of Taylor, Fayol, Hawthorne experiments).

Module II: (5 Hours)

Planning: Concept – Nature – Importance – Types of Planning – Strategic and Operational Plans(Policy, Procedures, Methods, Rules, Budget, Mission, Objectives), Planning Premises.

Module III: (6 Hours)

Organizing: Concept – Principles involved – Types of organization structure - Combining Jobs: Departmentation, Span of Control, Delegation of Authority.

Decision Making: Concept – Types - Steps involved– methods of decision making – CommitteeDecision Making.

Module IV: (7 Hours)

Entrepreneurship – Meaning, Types, Qualities of an Entrepreneur, Classification of Entrepreneurs, Factors influencing Entrepreneurship, Entrepreneurship Development Programmes (EDP), Business Idea: Sources & Evaluation .

Module V: (6 Hours)

Entrepreneurial Finance: Debt, Venture Capital, Buying a Business: challenges, The Search, Process,Scrutiny,

Valuation, Negotiation, Franchising, Commercial Banks.

Module VI: (6 Hours)

Entrepreneurship E-Business, Networking: Starting & Managing a Network, Infrastructure, Best Practices, Growth Strategies: Stages of Growth, Global Expansion, Relocation, Financing Growth, Business Cases

Text Books

1. Principles and Practice of Management: L M Prasad, Sultan Chand & Sons educational.
2. Entrepreneurship: Rajeev Roy, Oxford Publication.

Reference Books

1. Management Theory and Practice: P SubbaRao, Himalaya Publishing House
2. Principles of Management: Dr. NeeruVasishth, Taxmann's Publication
3. Management Principles, Processes and Practices: Anil Bhat&Arya Kumar, Oxford Publications
4. Vasanta Desai: Dynamics of entrepreneurial development and management, HimalayaPublishing House
5. Innovation and development: Peter F. Drucker.

Syllabus for B. Tech. V Semester

Department of Biomedical Engineering

Course Code	HUT351				
Course Title	Professional skill development				
Scheme& Credits	L	T	P	Credits	Semester V
	2	0	0	0	

Course Outcomes

At the end of this course students will develop the ability to

CO 1 : Students will learn the importance and skills of verbal and non-verbal communication in aprofessional setting

CO 2 : Students will learn and apply the skill to write effective professional / workplace documents.CO 3 : Students will learn the generic skills required to work in a team.

Syllabus

Unit 1 : Verbal and non-verbal skills

Verbal : Presentation and public speaking skills, Skills to conduct a meeting, PAC concept incommunication.

Non-verbal : Body Language, Kinesics, Proxemics, Haptic, Paralinguistic, Chromatic, Chronomatic,Dress sense.

Unit 2 : Writing Skills

Grammar for effective writing : Tighten word sentences, repair sentence fragments, subject-verbagreement, Pronoun and antecedent agreement, tense and voice.

Email and letter Writing : Basic format, types.

Report writing : Basic format, Progress, project report, business proposal. **Organizational communication :**

Notices, circulars, minutes of the meeting.

Technology enabled communication : Text messaging, Podcast, Videoconferencing, and Socialmedia in professional settings.

Unit 3 : Generic Skills

Leadership Skills, Innovation and creativity, Problem-solving skills, Decision-making, Time-management.

Text/Reference books

1. Shalini Varma (2015), Business Communication : Essential Strategies for 21st Century Managers, Vikas Publishing House.
2. P. D. Chaturvedi and Mukesh Chaturvedi (2018) The Art and Science of Business Communication: Skills, concepts, cases, and Applications, Pearson India Education Services Pvt.Ltd.
3. E. H. MacGrath, S. J. (2016) Basic Managerial Skills for All, PHI Learning Pvt. Ltd.
4. Diana Hacker (2019) Rules for Writers, Bedford Books, St. Martin's Press, 9th Edition.

Syllabus for B. Tech. VI Semester

Department of Biomedical Engineering

Course Code	BMT306-1				
Course Title	Biomedical Microsystems				
Scheme& Credits	L	T	P	Credits	Semester VI
	3	0	0	3	

Course Objectives:

Upon the completion of this course, students will demonstrate the ability to:

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

Course Outcome:

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

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

Syllabus

Module I: (6 Hrs)

Introduction to MEMS & BioMEMS: Benefits of Miniaturization, Types of MEMS: Optical MEMS, Bio- MEMS, RF- MEMS, Microfludics, Success Stories, Pressure sensor, Accelerometer, BioMEMS in healthcare

Module II: (6 Hrs)

Microfabrication and Micromachining: Integrated Circuit Processes, Bulk Micromachining, Isotropic Etching and Anisotropic Etching, Wafer Bonding, High Aspect-Ratio Processes (LIGA), MEMS Device fabrication using Bulk Micromachining and surface Micromachaning.

Module III: (6 Hrs)

Physical Micro sensors and actuators: Classification of physical sensors, Integrated, Intelligent, or Smart sensors, Sensor Principles and Examples: Thermal sensors, Electrical Sensors, Mechanical Sensors

Microactuators : Classification of microactuators, Electrostatic, Electromagnetic and Thermal microactuation

Module IV: (6 Hrs)

MEMS BIOSENSORS : Bio Sensing Principles and Sensing Methods, Biosensors Arrays and Implantable devices.

Module V: (6 Hrs)

Microfluidics: Introduction to microfluidics Microscale Behavior of Fluids, Microfluidic Components – Microvalves, Micropumps, Micromixer, and Logic Droplet Microfluidics, Lab on chip, Soft Lithography for microfluidics device fabrication

Module VI: (6 Hrs)

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

Text Books:

1. Micro and Smart Systems: Ananthasuresh, G. K., Vinoy, K. J., Gopalakrishnan, S., Bhat, K. N., and Aatre, V. K., Wiley-India, New Delhi, (1/E) (2010).
2. BioMEMS: Technologies and Applications, Wanjun Wang, Stephen A.Soper, CRC Press, New York, 2007.
3. MEMS and Microsystems Design and Manufacture, Tai Ran Hsu, Tata McGraw Hill Publishing Company, New Delhi, 2002.

Reference Books:

1. Microsensors, MEMS and Smart Devices , Julian W. Gardner , Vijay K. Varadan, Osama O. Awadelkarim, Wiley, (1/E) (2001).
2. VLSI Technology, Sze S.M., Mc Graw Hill, (2/E).

*BMP306-1 (Credit 1) Practical will be based on theory syllabus.

Syllabus for B. Tech. VI Semester

Department of Biomedical Engineering

Course Code	BMT306-2				
Course Title	Biomedical Image Processing				
Scheme& Credits	L	T	P	Credits	Semester VI
	3	0	0	3	

Course Outcomes

Upon the completion of this course, students will demonstrate the ability to:

1. Apply mathematical tools to obtain basic features from a medical image in time and frequency domain
2. Implement basic image processing algorithms for image enhancement and image restoration of medical images
3. Formulate image restoration model and design filters for noise reduction
4. Examine segmentation methods on medical image into its constituent regions and objects to extract the features from the biomedical images.
5. Extract and analyze color and texture features of medical images.

Syllabus

Module I (6 hrs)

Digital Image Fundamentals:

Elements of digital image processing systems; Elements of visual perception, image formation models, sampling and quantization, basic relationships Between pixels, digital image representation, bio medical imaging modalities, mathematical tools used in Digital Image Processing.

Module II (6 hrs)

Biomedical Image Enhancement:

Image Enhancement in spatial domain: Basic gray level transformations, Histogram Processing, Fundamentals of spatial filtering, Smoothing Spatial Filters, Order Statistic Filters, Sharpening Spatial Filters.

Image Enhancement in Frequency domain: Basics of filtering in the frequency domain, Image smoothing, sharpening using frequency domain filters.

Module III (6 hrs)

Image Transforms for Biomedical Images:

Two dimensional Orthogonal and Unitary Transforms, Properties of Unitary Transform; 2D Discrete Fourier Transform, Discrete Cosine Transform, Walsh Transform, Hadamard Transform, Haar Transform, KL Transform, Wavelet Transform: CWT, DWT.

Module IV (5 hrs)

Medical Image Restoration:

Basic model of image degradation/restoration processes; Types of image blur, linear position-invariant degradation, estimating degradation function, linear and nonlinear image restoration techniques, Inverse filtering, Wiener filtering and restoration in the presence of noise.

Module V (6 hrs)

Biomedical Image Segmentation and Feature Extraction:
Detection of discontinuities, edge and boundary detection, Localized feature extraction, Hough transform.
Image segmentation: Segmentation using thresholding, Region based segmentation: region growing split and merge techniques. Graph cut algorithm.

Module VI (6 hrs)

Color & Texture Based Image Analysis:
Color image processing: Color spaces; Color image demosaicing: problem definition, concept of Color Filter Array (CFA)-Bayer pattern, white balancing
Texture features: structural and statistical, Applications of image processing in medical industries.

Text Books :

I. Digital Image Processing by R. C. Gonzalez & R. E. Woods, Pearson education, 4th Edition, 2018.
II. Medical Image Processing Concepts and Applications by G R Sinha & Bhagwati Charan Patel, PHI learning, 2014

Reference Books :

1. Digital Image Processing using MATLAB by R. C. Gonzalez, R. E. Woods & Steven Eddins, Pearson education, 2nd Edition, 2017.
2. Feature Extraction and Image Processing for Computer Vision by AlBerto S. Aguado and Mark S. Nixon,AcademicPress, 3rd Edition, 2012.
3. Image Processing, Analysis and Machine vision by Milan Sonka, Roger Boyle, and Vaclav Hlavac, Cengage IndiaPrivate Limited, 4th Edition, 2017.
4. Digital Image processing by S. Jayaraman, S. Esakkirajan, T. Veerakumar, Tata McGraw- Hill Education, 15th reprint 2015.
5. Digital Image Processing for Medical Applications by Geoff Dougherty, Cambridge University Press, 1st edition 2009

*BMP306-2 (Credit 1) Practical will be based on theory syllabus.

Syllabus for B. Tech. VI Semester

Department of Biomedical Engineering

Course Code	BMT306-3				
Course Title	Biomaterial Applications				
Scheme& Credits	L	T	P	Credits	Semester VI
	3	0	0	3	

Course Outcomes

1. Perceive and identify the range of various biomaterial for different biomedical Applications.
2. Learn and demonstrate the Behavior of various biomaterial in terms of Toxicology for different targeted biomedical Applications.
3. Explore and select: Dental materials; Polymers in drug delivery applications.
4. Explore and select the Smart biomaterials fordifferent biomedical applications.
5. Explore and Identify advanced applications related to Nanobiomaterials.

Syllabus

Module I (6 Hrs)

Biomaterials: Introduction to classes of materials used in medical applications: Metals, polymers, ceramics, bioresorbable and biodegradable materials, coatings, medical fiBers, non-fouling surfaces.

Module II (8 Hrs)

Toxicology: cytotoxicity, systemic effects, genotoxicity, carcinogenicity, reproductive toxicity, sensitization & irritation, tissue compatibility and inflammatory response, evaluation of host response.

ModuleIII (8Hrs)

Dental materials: Introduction to dental materials polymers, ceramics and metals, applications of dental materials, physico-chemical, mechanical, toxicological and in vitro clinical performance of dental materials and implants.

Module IV(6 Hrs)

Polymers in drug delivery:Introduction to polymeric drug delivery systems, Targeted drug delivery. Passive or active targeting, targeting tumor cells.

Module V (6 Hrs)

Smart biomaterials: Stimuli responsive polymers (pH, temperature, light, magnetic and biomolecules) and their applications as biomaterials. Stimuli responsive hydrogels.

Module VI (6 Hrs)

Nanobiomaterials: Interaction of bio-molecules and nano particle surfaces. Biocompatible nanomaterials, Nanogels and microgels: preparation methods, characterization and applications.

Text Books:

1. Biomaterials by Bhat Sujata V., Kluwer Academic Publishers and Narosa Publishing House (New Delhi, India), (1st edition 2002 , 2nd edition 2004)

Reference Books:

1. J. B. Park and R. S. Lakes, An Introduction to Biomaterials, Springer
2. J.B Park, and J.D. Boonzino, Biomaterials: Principles and Application, CRC Press
3. B. Ratner, A. Hoffman, F. Schoen, J Lemons, Biomaterials Science: An introduction to materials in Medicine. 2nd edition, Academic Press, 2004.
4. S. Dumitriu, 2nd edition, Polymeric Biomaterials. Marcel Dekker, 2002
5. C. T. Laurencin, L. S. Nair, Nanotechnology and Tissue Engineering, The Scaffol, CRC Press, 2008
6. S. Ramakrishna, T. S. Sampath Kumar, Biomaterials: A nanoapproach.CRC press, 2010
   I. Galaev, Bo Mattiasson, Smart Polymers: Applications in Biotechnology and Biomedicine, 2ndEdition, CRC Press,2007
7. M. De Villiers, P Aramwit and G S. Kwon, Nanotechnology in drug delivery. Springer, 2009.
   B. Kirkland and J. Hutchison, Nano characterization, RSC publishers, 2007.
8. S. Li, A. Tiwari, M. Prabaharan and S. Aryal, Smart Polymer Materials for Biomedical Applications (Materials Science and Technologies), Nova Science Publishers Inc, 2010

*BMP306-3 (Credit 1) Practical will be based on theory syllabus.

Syllabus for B. Tech. VI Semester

Department of Biomedical Engineering

Course Code	BMT307				
Course Title	Medical Imaging				
Scheme& Credits	L	T	P	Credits	Semester VI
	3	0	0	3	

Course Outcomes

1. Understand basic principles of X-ray imaging systems
2. Categorize knowledge of improving image quality in Computed Tomography images and PET scan images
3. Scan various Magnetic Resonance Imaging protocols for Better representation of images.
4. Define physics of Ultrasound Imaging and recognizing the artifacts associated with Ultrasound Imaging
5. Discuss the specificity of Optical Coherence Tomography and Photoacoustic Imaging techniques
6. Evaluate the performances of the different modalities together with the quality of the images (resolution, noise, contrast etc).

Syllabus

Module1 (6 Hrs)
X-Rays: Properties, types, generation, medical use, physical parameters of X-Ray imaging: spatial resolution, contrast, noise, modulation transfer function (MTF) etc.

Module II (6 Hrs)
Computed Tomography (CT)/Positron Emission Tomography (PET): CT scan: Image formation, Radon Transform & Fourier Slice Theorem, CT instrumentation, Image reconstruction
PET scan: definition, purpose, procedure and results

Module III (6 Hrs)
Magnetic Resonance Imaging (MRI): Basic principle, imaging methods, slice section- plain & contrast studies, image contrast, factors affecting image quality

Module IV (6 Hrs)
Ultrasound Imaging: Basic acoustics, ultrasound terminologies, interaction of ultrasound with matter, ultrasound display modes etc

Module V (5 Hrs)
Optical Coherence Tomography: Principles, instrumental designs and biomedical applications

Module VI (6 Hrs)
Photoacoustic Imaging: Fundamentals, photoacoustic image contrast, penetration depth and spatial resolution, photoacoustic imaging configurations (Photoacoustic Tomography,

Photoacoustic Microscopy etc.) photoacoustic sensing techniques (Photoacoustic spectroscopy ,

Photoacoustic Doppler flowmetry, Photoacoustic thermometry), applications

Text Books:

1. Medical Image Processing Trends and techniques by Ushus S. Kumar and S. P. Manikandan, Notion Press
2. Fundamentals of Photonics B. E A. Saleh and M. C. Teich John Wiley 2009.

Reference Books:

1. R. C. Gonzalez, Digital Image Processing, Pearson Education India , 3rd Edition, 2013
2. Medical Instrumentation Application and Design, John Webster Ed. John Wiley & Sons 2009.
3. Medical Imaging Technology, Victor Mikla, 1st Edition - July 30, 2013, Elsevier

Syllabus for B. Tech. VI Semester

Department of Biomedical Engineering

Course Code	BMT308				
Course Title	Machine Learning				
Scheme& Credits	L	T	P	Credits	Semester VI
	3	0	0	3	

Course Outcomes

1. Understand fundamental concepts of machine learning algorithm.
2. Apply machine learning algorithms for solving Real-world problems.
3. Understand basic of Artificial Neural Network and apply ANN for solving Real-world problems in various domains.

Syllabus

Module I (5 Hrs)
Introduction to machine learning, the concept learning task, Inductive Learning Bias, FIND-S and Candidate-Elimination algorithm, Decision Trees, Basic decision trees learning algorithm, inductive bias in decision tree learning, overfitting.

Module II (6 Hrs)
Supervised learning algorithms: Linear and Logistic Regression – Bias/Variance Trade-off, Regularization, Variants of Gradient Descent, Support Vector Machines, Kernel functions in SVM, K-Nearest Neighbors, and Applications.

Module III (7 Hrs)
Artificial Neural Networks, Perceptron, Multilayer networks and Backpropagation algorithm, Introduction to Deep Neural networks, Recurrent Neural Networks (RNNs) and Convolutional Neural Networks (CNNs).

Module IV (6 Hrs)
Probabilistic Machine Learning- Bayesian learning and Bayesian networks, Gibbs algorithm, Naive Bayes classifier. Bayes optimal classifiers, Maximum Likelihood Estimation, MAP; Gaussian Discriminant Analysis.

Module V (6 Hrs)
Unsupervised learning algorithms: Instance based learning, K-Means clustering, Expectation Maximization, and Gaussian Mixture Models. Dimensionality Reduction-PCA, LDA, and Feature Selection, PAC Learnability , Multi-class Classification

.

Module VI (5 Hrs)
Reinforcement Learning: Introduction to RL terminology, Markov property, Markov chains, Markov reward process (MRP). Overview of Monte Carlo methods for model free RL. Overview of dynamic programming for Markov Decision Process (MDP). Overview TD(0), TD(1) and TD(λ), k-step estimators, unified view of DP, MC and TD evaluation methods.

Text Book:

1. Machine Learning: A Probabilistic Perspective by Kevin P. Murphy, Francis Bach, MIT Press,2012.

Reference Books:

1. The Elements of Statistical Learning Data Mining, Inference, and Prediction by Trevor Hastie, RoBert Tibshirani, Jerome Friedman, 2nd Edition, Springer, 2009.
2. Machine Learning by Mitchell Tom 1st Edition, McGraw Hill, 1997.
3. Deep Learning by Ian Good fellow, YoshuaBengio, Aaron Courville & Francis Bach, MIT Press, 2017.
4. Introduction to Machine Learning by EthemAlpaydin, 3rd Edition, PHI Learning, 2015.
5. Machine Learning: An Algorithmic Perspective by Stephen Marsland, Second Edition, Chapman And Hall/CRC, 2014.
6. Understanding Machine Learning: From Theory to Algorithms by Shalev-Shwartz, Shai Ben-David, 3rd Edition, Cambridge University Press, 2015.
7. Pattern classification by Richard O. Duda, Peter E. Hart, David G. Stork. Wiley, New York, 2001.

*BMP308 (Credit 1) Practical will be based on theory syllabus.

Syllabus for B. Tech. VI Semester

Department of Biomedical Engineering

Course Code	BMT309				
Course Title	Control Systems				
Scheme& Credits	L	T	P	Credits	Semester VI
	3	0	0	3	

Course Outcomes

1. Understand the need for mathematical modeling of various systems, representation of systems in block diagrams and signal flow graphs and are introduced to biological control systems
2. Analyze the Time and frequency response characteristics of various systems using differentcharts
3. Create state models and apply optimum control to a system.
4. Comprehend the application aspects of time and frequency response analysis in physiological controlsystems.

Syllabus

Module I (8 hrs)

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

Module II (9 hrs)

TimeResponse:Analysis Step and impulse responses of first order and second order systems, time domain specifications of first and second order systems, steady state error constants, Definition of stability, Routh-Hurwitz criteria of stability, root locus technique, construction of root locus and study of stability.Analytical design for PD, PI,PID control systems.

Module III (7 hrs)

Frequency ResponseAnalysis: Frequency domain specifications - Polar plots, Bode plots, Nyquist plot, Nyquist stability criterion, closed loop stability, Constant M and N circles, Nichol‘s chart.

Module IV (7 hrs)

State variable Analysis- Concepts of state, state variable, state model, state models for linear continuous time functions, diagonalization of transfer function, solution of state equations, concept of controllability & observability, Introduction to Optimal control system.

Module V (9 hrs)

Biological System Models**:** Distributed parameter versus lumped parameter models, Model development of Cardiovascular system- Heart model-circulatory model, Pulmonary mechanics- Lung tissue visco-elastance-chest wall- airways, Interaction of Pulmonary and Cardiovascular models, Simple models of muscle stretch reflex action, Study of steady state analysis of muscle stretch reflex action, Study of transient response analysis

of neuromuscular reflex model action, Study of frequency response of circulatory control model

Text Books:

1. I.J. Nagarath and M. Gopal-Control Systems Engineering", Fifth Edition, AnshanPublishers, 2008.
2. Michael CK Khoo, -Physiological Control Systems‖, IEEE Press, Prentice Hall of India, 2005

Reference Books:

1. John Enderle Susan Blanchard, Joseph Bronzino-Introduction to Biomedical Engineering‖, second edition, Academic Press, 2005.
2. Richard C.Dorf,RoBertH.Bishop,-Moderncontrolsystems‖, Pearson,2004.
3. Modern Control Engineering; Katsuhiko Ogata; Prentice Hall. , 2010 - Technology & Engineering.
4. M. Gopal, “Control Systems- Principle of Design”, Fourth Edition, 2012, McGrawHill.

Syllabus for B. Tech. VI Semester

Department of Biomedical Engineering

Course Code	BMT310				
Course Title	Biomechanics				
Scheme& Credits	L	T	P	Credits	Semester VI
	3	0	0	3	

Course outcomes:

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

1. Understand the Biomechanical Aspects of Human Body
2. Determine the response behavior of bone subjected to external forces
3. Correlate the causes (loading) and effects (deformation) of soft tissue based on viscoelasticity
4. Analyze the fluid flow parameters with elastic vessels.
5. Create a mathematical model for Tissue-implant pair

Syllabus

Module I:

Introduction to Biomechanics: Introduction, Newton's law- mechanical behaviour of bodies; Stress, Strain, Elasticity; Hooke's Law; Introduction to biomechanics, work, power and energy relationship – Angular kinematics of human movement-measuring angles, resistance to angular acceleration, angular momentum, center of gravity, stability and balance.

Module II:

Biosolid Mechanics: Bone structure & composition, mechanical and viscoelastic properties of bone– Bone growth and development – Bone response to stress – Osteoporosis – causes, diagnosis, treatment – Elasticity and strength of bone.Mechanical Properties of Bones and Implants; Design Consideration of Stress Shielding, Kinetics and Kinematics of Joints; Lubrication of Joints.

Module III:

Soft Tissue Mechanics: Non-Linear Stress-Strain Relationship; viscoelastic properties of cartilage – Anisotropy and composite models Structure Function and Mechanical Properties of cartilage, Ligaments and Tendons, muscles and skin. Factors affecting muscular force generation – Muscular strength, power and endurance – Muscle injuries.

Module IV:

Biofluid Mechanics: Nature of fluids, Newtonian Fluid; Non- Newtonian Fluid; Viscoelastic Fluids; non-viscous fluid, Rheological properties of blood, Velocity and Pressure of Blood Flow; Propulsion in fluid medium, Resistance Against Flow. Fundamental properties of arterioles, capillary vessels and veins.

Module V:

Cardiovascular Mechanics: Mechanical Properties of Blood Vessels: Arteries, Arterioles, Capillaries and Veins; Function of Cardiac Chambers & Valves; Mechanics of Angiography and Angioplasty; Stent Deployment & Prosthetic Replacement of Cardiac Valves.

Module VI:

Case Studies in Biomechanics: Computational Biomechanics, Tissue material models, Case studies in Biomechanical clinical research, Some Applications of Biomechanics in Qualitative Analysis

Text Books:

1. Fung, Y.C., 2013. Biomechanics: Mechanical properties of living tissues. Springer Science & Business Media.
2. Hall, S.J. and Lysell, D., 1995. Basic Biomechanics (Vol. 2). St. Louis: Mosby.
3. Knudson, D., 2007. Fundamentals of Biomechanics. Springer Science & Business Media.

Reference Books:

1. Peterson, D.R. and Bronzino, J.D. eds., 2014. Biomechanics: principles and practices. CRC Press.
2. Zamir, M., 2006. The physics of coronary blood flow. Springer Science & Business Media.
3. J. G Webster, "Medical instrumentation –Application & design", John Wiley and Sons Inc., 3 rd edition, 2003.
4. D. J. Schneck and J. D. Bronzino, "Biomechanics- Principles and Applications", CRC Press, 2 nd Edition, 2000.

Syllabus for B.Tech VII Semester
Department of Biomedical Engineering

Course Code	BMT401-1				
Course Title	Molecular Biology and Genetics				
Scheme and Credits	L	T	P	Credits	Semester
	3	0	0	3	VII

Course Objectives

Upon the completion of this course the students will demonstrate the ability to:

1. Understand fundamentals of Molecular Biology
2. Acquire knowledge on clinical applications of Molecular Biology and Genetic engineering

Course Outcomes

1. Understand the Concept of Genome Structure and organization
2. Familiar to concept of gene, gene families, Genomics and Proteomics
3. Obtain knowledge of Amplification of DNA and Protein Synthesis
4. Familiarize with basics of cloning strategies
5. Obtain knowledge of Detection techniques used for validating cloning strategies in Molecular Biology
6. Understand Different types of vectors and plasmids used in Genetic Engineering

Syllabus

Unit I (6 Hours)

General introduction and concept of Biosafety guidelines and containment strategies DNA modifying enzymes and restriction enzymes, satellite DNA, DNA melting and buoyant density

Unit II (5 Hours)

Gene families, clusters, packaging of chromatins and evolutionary advantage, Organelle genomes, Rearrangement and amplification of DNA in the genome, Genomics and proteomics.

Unit III (8 Hours)

DNA Replication, Transcription and Protein Synthesis, Genetic Code, Regulation of Protein Synthesis, Post translational Modification

Unit IV (6 Hours)

Cloning strategies: Genomic libraries, cDNA libraries, single gene cloning. Vectors in gene cloning: Types of vectors and choice of vectors- Plasmids, cosmids, lamda phage vectors, shuttle vectors, BACs and YACs Choice of hosts, Methods for transferring recombinant DNA to host cells (Transformation and Transfection)

Unit V (8 Hours)

Detection and Characterization of Transformants Screening and selection for transformants: Hybridizations-colony, Southern, Northern, Western, Detection (radioactive and non-radioactive procedures). DNA sequencing techniques including automated DNA sequencing. Site-directed mutagenesis.

Unit VI (7 Hours)

Various expression vectors in bacteria and eukaryotes. Choice of appropriate hosts, Induced expression. Chimeric constructs, Expression of industrially important products.

Text Book

Watson et al. (2014). Molecular Biology of the Gene. 7th Edition

Reference Books

1. Krebs JE, Goldstein ES and Kilpatrick ST. Lewin's Gene XII, Jones and Bartlett
2. Weaver RF Molecular Biology (2012), 5th Edition, McGraw Hill Higher Education
3. Trun&Trempy (2004). Fundamentals of Bacterial Genetics. Blackwell. 3rd Edition
4. Alberts et al (2007). Molecular Biology of The Cell. Garland

Syllabus for B.Tech VII Semester
Department of Biomedical Engineering

Course Code	BMT401-2				
Course Title	Reliability of Healthcare Equipments				
Scheme and Credits	L	T	P	Credits	Semester
	3	0	0	3	VII

Course Objective:
Upon completion of this course the students will able to:
1. Understand the basic concept of Reliability related to healthcare equipment.
2. Calculate the failure rate and other reliability parameters related to design of healthcare equipment

Course outcomes:
After completion of this course, students will be able to:
1. Understand basic concept of reliability and its estimation with respect to healthcare equipment.
2. Apply the various methods for calculation of system reliability.
3. Identify the ways for design and improvement of system reliability.
4. Identify the need of EMI/EMC and its impact on reliable design of healthcare instruments.

Syllabus

Module I (10 Hrs.)
Introduction to the concept of reliability related to biomedical devices. Reliability and Regulation, Elements of Probability theory, Bays Theorem. Causes of failures, Failure data analysis technique, Mean failure rate, MTTF (Mean Time To Failure), MTBF (Mean Time Between Failure), MTTF in terms of failure density, Reliability in terms of hazard rate and failure density.

Module II: (10 Hrs)
Reliability modeling, Hazard Models. System Reliability, Mixed configuration, r-out-of-n structure, system not reducible to mix configuration, Logic diagrams. Fault tree analysis, Tie-set and Cut-Set method, Availability and maintainability, reparable system, Instantaneous repair rate, MTTR (Mean Time To Repair)

Module III: (10 Hrs)
Designing for Reliability, Reliability allocation for a series system, Worst case design consideration. Reliability improvement techniques, Optimization, Reliability-Cost-trade-off, Failure mode and effects analysis (FMEA). Safety and Risk Management in biomedical instruments, facilities.

Module IV: (10 Hrs)
Electromagnetic Compatibility for healthcare equipment, facilities, designing for Electromagnetic Compatibility. Sources of Electromagnetic Interface, Noise and Methods of Noise Coupling. Electrostatic Discharge, EMC regulations for healthcare equipment. Specific criteria for biological testing, Medical Device Standards.

Text Books:
1. Richard C. Fries, “Reliable Design of medical devices”, CRC Press, 2013
2. B. S. Dhillon, “Medical Device Reliability and Associated areas”, CRC Press, 2000
3. Srinath L.S., “Concept in Reliability”, East West Press, 2006.
4. Ott W.H., “Noise reduction techniques in electronic systems”, John Wiley & Sons, 1988

Reference Books:

1. Fuqua, Marcel Dekker, “Reliability Engineering for Electronic Design”, 1988.
2. Patrick DT O'Connot, “Practical Reliability Engineering” - John Wiley and Sons, 1985.
3. Dr. Gupta A.K.,“Reliability, Maintenance and Safety Engineering”, Laxmi Publications, 2009

Syllabus for B.Tech VII Semester
Department of Biomedical Engineering

Course Code	BMT401-2				
Course Title	Advanced Biomechanics				
Scheme and Credits	L	T	P	Credits	Semester
	3	0	0	3	VII

Course Objective

Upon the completion of this course the students will demonstrate the ability to:

3. Understand the physics relevant to human locomotion and other bodily functions
4. Determine the forces coming on the musculoskeletal system

Course Outcomes

After completing this course, students will be able to:

1. Determine the internal heat generation in human body arising out of metabolism and body temperature regulation
2. Understand the physics of Alveoli during inspiration and expiration cycle of pulmonary system
3. Understand the mechanism of sound produced in vocal chords and auditory sensitivity of human ears
4. Acquire knowledge about the physics of human vision and image formation on retina
5. Understand the physics behind signal transmission in central nervous system as well the magnetic properties of nervous system

Syllabus

Module I (7 Hrs)

Metabolism, Heat and Power

Energy conservation in Human Body, Energy Storage mechanisms, Metabolic Rates, Introduction to Heat Transfer, Modes of Heat Transfer, Heat balance Sheet, Concept of heat Generation in Human Body, Body Temperature Regulation Mechanism

Module II (7 Hrs)

Physics of Lungs and Breathing

Physics of breathing, Construction of Alveoli, Air Flow during breathing, Mechanical model of human respiratory system, Inspiration and Expiration cycle, Higher Elevation breathing cycle, Work Required to Breathe

Module III (7 hrs)

Mechanics of Sound Speech and Hearing

Physics of Sound, Sound Generation by Vocal Chords, Intensity of sound waves, Resonant Cavities in Human Body, Energetics of Speaking, Auditory Sensitivity, Connections to hearing perception, Energy Transfer in sound production

Module IV (7 Hours)

Mechanics of Light Optics and Vision

Mechanics of vision, focussing and imaging with lenses, Combination of lenses for refractive surfaces, Transmission of light within the eye Field of view and stereoscopic vision, Types of vision impairment,

Module V (7 hours)

Electrical and Magnetic Properties

Review of electrical properties of body tissues, Nerve Conduction, Ion Channels, physics of senses, Electrical properties of heart, Signal transmission though brain, Magnetic properites of anxiom, Magnetic sense of nervous system

Textbook

1. Physics of Human Body- Irving P. Herman. – Springer Books- 2007 ISBN No /978-3-540-29603-4

Course Code	BMT402-1				
Course Title	Tissue Engineering				
Scheme and Credits	L	T	P	Credits	Semester
	3	0	0	3	VII

Course Objective

Upon the completion of this course the students will demonstrate the ability to:

1. Understand fundamentals of tissue engineering and tissue repair
2. Acquire knowledge on clinical applications of tissue engineering
3. Understand the basic concept behind tissue engineering focusing on the stem cells, biomaterials and its applications

Course Outcomes

After completing this course, students will be able to:

1. Understand the components of the tissue architecture.
2. Understand the stem cell characteristics and their relevance in medicine
3. Become awareness about the properties and broad applications of biomaterials
4. Obtain exposure to the role of tissue engineering and stem cell therapy in Organogenesis

Syllabus

Module I (10 Hours)

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

Module II (10 Hours)

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

Module III (10 Hours)

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

Module IV (10 Hours)

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

Textbooks

1. Bernhard O.Palsson, Sangeeta N.Bhatia, "Tissue Engineering" Pearson Publishers 2009.
2. Meyer, U.; Meyer, Th.; Handschel, J.; Wiesmann, H.P. .Fundamentals of Tissue Engineering and Regenerative Medicine.2009.

Reference Books

1. Bernard N. Kennedy (editor). Stem cell transplantation, tissue engineering, and cancer applications, Nova Science Publishers, 2008.
2. Raphael Gorodetsky, Richard Schäfer..Stem cell-based tissue repair. RSC Publishing, 2011.
3. R. Lanza, I. Weissman, J. Thomson, and R. Pedersen, Handbook of Stem Cells, Two- Volume, Volume 1-2: Volume 1-Embryonic Stem Cells; Volume 2-Adult &Fetal Stem Cells, Academic Press, 2004.
4. R. Lanza, J. Gearhart etal (Eds), Essential of Stem Cell Biology, Elsevier Academic press,2006.
5. J. J. Mao, G. Vunjak-Novakovic et al (Eds), Translational Approaches In Tissue Engineering &Regenrative Medicine" Artech House, INC Publications, 2008.
6. Naggy N. Habib, M.Y. Levicar, , L. G. Jiao,.and N. Fisk, Stem Cell Repair and Regeneration, volume-2, Imperial College Press,2007.

Course Code	BMT402-3				
Course Title	Bionanotechnology				
Scheme and Credits	L	T	P	Credits	Semester
	3	0	0	3	VII

Course Objective

Upon the completion of this course the students will demonstrate the ability to:

1. Understand fundamentals of Bio Nanotechnology
2. Acquire knowledge on clinical applications of Nanomaterials and Nanodevices

Course Outcomes

1. Understand the basic principles Nano Science
2. Know the basic concepts of Nanomaterial
3. Identify the properties and Characterization of Nanomaterials
4. To understand the application of Nanomaterial in Biological system
5. Application of Nano Biotechnology in Diagnostics
6. Toxicity evaluation of Bio Nanomaterials

Syllabus

Unit I (8 Hours)

Fundamental of Nanoscience: The nanoscale dimension and paradigm, Definitions and historical evolution (colloids etc.) and current practices, Types of nanomaterials and their classifications (1D, 2D and 3D etc. Nanocrystal, Nanoparticle, Quantum dot, Quantum Wire and Quantum Well etc),

Unit II (10 Hours)

Fundamental of Nanomaterial: Polymer, Carbon, Inorganic, Organic and Biomaterials –Structures and characteristics, Physical and Chemical Fundamentals of Nanomaterials Overview of synthetic methods, Surfactants, polymers, emulsions. Micelles/reverse micelles and colloids Top-down and bottom up approaches, Biological Methods, Growth and stabilization, Self-assembly.

Unit III (8 Hours)

Properties and characterization: Optical (UV-Vis/Fluorescence) –X-ray diffraction – Imaging and size (Electron microscopy, light scattering, Zetapotential)- Surface and composition (ECSA, EDAX, AFM/STM etc) – Vibrational (FT-IR and RAMAN), SERS - Magnetic, Electrical and Electrochemical.

Unit IV (6 Hours)

Applications of Nano-Materials in Biosystems: Proteins - Lipids - RNA and DNA Protein Targeting - Small Molecule/Nanomaterial - Protein Interaction

Unit V (8 Hours)

Nanomaterials and Diagnostics/Drug Delivery and Therapeutics MRI, Imaging Surface Modified Nanoparticles, MEMS/NEMS based on Nanomaterials, Nanomaterials and Toxicity Evaluation: Peptide/DNA Coupled Nanoparticles Lipid Nanoparticles For Drug Delivery Inorganic Nanoparticles For Drug Delivery, Cyto-toxicity, Geno-toxicity In vivo tests/assays etc

Unit VI (8 Hours)

Introduction to nano material synthesis methods.

Text Book

1. Bionanotechnology, Principles and Applications- Anil Kumar Anal CRC Press, Taylor & Francis Group, 2018 - Nanobiotechnology - 189 pages 1st Edition

Reference Books

1. BioNanotechnology Concepts and Applications by Ljiljana Fruk, Antonina Kerbs, Cambridge University Press, 2021
2. Introduction to Bionenotechnology, Lee Young-Chul by Springer Verlag, Singapore
3. Bionanotechnology: Engineering Concepts and Applications, by Chen Jie, McGraw-Hill Education

Syllabus for B.Tech VII Semester
Department of Biomedical Engineering

Course Code	**BMT402**

Course Title	Hospital Engineering and Management				
Scheme and Credits	**L**	**T**	**P**	**Credits**	**Semester**
	3	**0**	**0**	**3**	**VII**

Course objectives

1. Upon the completion of the course ,the student will demonstrate the ability to
2. Develop knowledge of hospital maintenance, equipment and systems for health care.
3. Understand about effective hospital management.

Course Outcomes

After successful completion of the course, the students will be able to

1. Understand about engineering services in hospital.
2. Understand about management of different healthcare services.
3. Understand about management of different Health Care Sector in India
4. To understand the concepts of Health Care Regulation & Hospital standards

Syllabus

Unit I (6 Hours)

Engineering services in a hospital -Civil assets, Electricity supply, water supply, steam supply, piped medical gases, air and clinical vacuum delivery system, air conditioning and refrigeration, lifts and dumb waiters, public health services, lightening protection, public address system, telephones, paging system , TV and piped music system, non-conventional energy devices, and workshop facilities for repairs and maintenance.

Unit II (8 Hours)

A Conceptual Approach to Understanding the Health Care Systems – Evolution , Institutional Setting - Out Patient services – Medical Services – Surgical Services – Operating department – Pediatric services – Dental services – Psychiatric services – Casualty & Emergency services – Hospital Laboratory services – Anesthesia services – Obstetrics and Gynecology services – Neuro – Surgery service – Neurology services.

Unit III (8 Hours)

Overview of Health Care Sector in India – Primary care – Secondary care – Tertiary care – Rural Medical care – urban medical care – curative care – Preventive care – General & special Hospitals- Understanding the Hospital Management – Role of Medical, Nursing Staff, Paramedical and Supporting Staff - Health Policy - Population Policy - Drug Policy – Medical Education Policy

Unit IV (6 Hours)

Health Care Regulation – WHO, International Health regulations, IMA, MCI, State Medical Council Bodies, Health universities and Teaching Hospitals and other Health care Delivery Systems.

Unit V (6 Hours)

Hospital standards and design: Building requirement – Entrance & Ambulatory Zone – Diagnostic Zone – Intermediate Zone – Critical zone – Service Zone – Administrative zone – List of Utilities – Communication facility – Biomedical equipment - Voluntary & Mandatory standards – General standards – Mechanical standards – Electrical standards – standard for centralized medical gas system – standards for biomedical waste

Unit VI (6 Hours)

Epidemiology – Aims – Principles – Descriptive, Analytical and Experimental Epidemiology - Methods - Uses

References

1)Gupta S.K, SunilKant Chandra Shekhar, R Satpathy, Modern Trends In Planning And Designing Of Hospitals
2)Syed Amin Tabish, Hospital And Nursing Homes Planning, Organisations & Management
3)G.D.Kunders, Hospitals, Facilities Planning And Management
4) Gilienfeld, " Foundation Of Epidemiology"
5) R.C. Goyal, Handbook of Hospital Personal Management, Prentice Hall of India, 1993

Syllabus for B. Tech VII Semester
Department of Biomedical Engineering

Course Code	**BMT403**

Course Title	**Analytical & Diagnostic Equipments**				
Scheme and Credits	**L**	**T**	**P**	**Credits**	**Semester**
	3	**0**	**0**	**3**	**VII**

Course Outcomes

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

1. Understand the operating principles of various analytical instruments used in hospital and laboratories.
2. Explain the basics of pulmonary function analyzer, ventilators, and demonstrate the use of ventilation therapy and anesthesia machine.
3. Explain the basic principle and working of hemodialysis machine
4. Demonstrate knowledge about various automated drug delivery systems.

Syllabus

Unit I (8 Hours)

Introduction of to Biomedical analytical instruments:

Colorimeter, Spectrophotometer, Biochemical Analyzer, Principles of Electrophoresis apparatus, Principles of Chromatography, Enzyme Linked Immuno Sorbant Assay (ELISA)

Unit II (6 Hours)

Pulmonary Function Analyzer, Respiration measurement technique: lung volume and capacities, spirometry, nitrogen washout, helium dilution

Unit III (7 Hours)

Ventilators: Artificial ventilation, ventilator terms and its types, modes of ventilators, classification of ventilators, pressure volume flow and time diagrams. Microprocessor controlled ventilator

Unit IV (7 Hours)

Anesthesia Machine: Need for anesthesia, anesthesia machine: gas supply, flow and delivery system vapor delivery and humidification and patient breathing capnography.

Unit-V (7 Hours)

Hemodialysis machine: Basic principle of dialysis, different types of dialyzer membranes, portable dialyzers and various monitoring circuits

Unit –VI (5 Hours)

Automated drug delivery systems: Infusion pumps, components of drug infusion systems, syringe and peristaltic pumps

Text Book

1. Handbook of Biomedical Instrumentation (Third edition): R S. Khandpur. (PH Pub)
2. Medical Instrumentation, Application and Design: J G. Webster. (John Wiley)
3. Biomedical Instrumentation and measurements: Leislie Cromwell, Fred J. Weibell, Enrich A. Pfeiffer. (PHI Pub)

Reference Books

1. Introduction to Biomedical Equipment Technology: Carr –Brown. (PH Pub)
2. Encyclopedia of Medical Devices and Instrumentation: J G. Webster. Vol I- IV (PH Pub)
Various Instruments Manuals.

Syllabus for B.Tech VII Semester
Department of Biomedical Engineering

Course Code	BMT405				
Course Title	Design and Manufacturing of Implants and Prostheses				
Scheme and Credits	L	T	P	Credits	Semester
	3	0	0	3	VII

Course Objective

Upon the completion of this course the students will demonstrate the ability to:

5. Understand different implantable devices used within human body
6. Design and develop biocompatible implantable medical devices.

Course Outcomes

After completing this course, students will be able to:

1. Select Materials for Implants for the given application area within the human body depending upon the operating condition, and environment.
2. Determine the stresses and strains on Biomedical Implants subjected to forces during routine operation
3. Identify the cause of failure predict the failure of implant subjected to different types of forces during routine operation
4. Identify the fracture modes in implant failure, fatigue of implants, wear associated with implant operation
5. Select and identify the different process associated with implant manufacturing, and understand the data export mechanism for obtaining a CAD model of implant for additive manufacture
6. Understand the different types of implants used in human body along with their manufacturing process and materials

Syllabus

Module I (6 Hrs)

Material Selection for Implant/Prosthesis Design:

Biocompatibility, Sterilization, Biomaterials, Classification, Regulatory Requirements for Medical Implants and Prosthesis, Attributes and Features of Bio Compatible Materials, Physical Properties, Metals for Implants, Crystal Structure, Physical Properties of Metals, Crystal Structures, Packing Efficiency Calculation, Corrosion Treatments, Introduction to Heat Treatment, Ceramics, Properties of Ceramics, Processing of Ceramics for Implants, Polymers, and their processing

Module II (6 Hrs)

Mechanical Behaviour of Structural Tissues:

Tissue Building Blocks, Mechanism of Pull in a muscle, Load Bearing Tissues, Enamel and Dentin, Mechanics of Human Bone, Elasticity, Stress Strain Curves in Natural Bone, Introduction to bending theory, Principal Stresses and Strain, Mohr's Circle, Composite Member Analysis, Modifying Material Cross section for improving bone absorption,

Module III (7 Hours)

Failure Theories and Viscoelasticity

Introduction to Viscoelasticity, Material properties, Tissues as Viscoelastic Solids, first order Viscoelastic models, Generalized linear viscoelasticity, Failure Theories, Maximum Principal Stress Theory, Tresca's theory, Von Misses Theory, Maximum Normal Stress Theory, Stress Concentration Factor, Notch Sensitivity, Stress Distribution in Total join replacement

Module IV (7 Hours)

Fracture Mechanics , Implant Wear and Fatigue

Introduction to Fracture Mechanics, Crack Propagation, Linear Elastic Fracture Mechanics, Elastoplastic Fracture Mechanics, Fracture mechanisms in structural materials, Fatigue terminology,

Fatigue Fracture of Trapezoidal Hip Stems, Wear mechanism, Lubrication, Surface Contact Mechanics, hertzian Stresses, Surface Contact in Biomaterials

Module V (7 Hours)

Implant Manufacturing Process

Introduction to Implant Manufacturing Process, Machining, Casting Forming, Plastic Working Process, Data Conversion from CT scan to STL and Additive Manufacturing of Implants,

Module VI (7 Hours)

Cardiovascular Devices, Maxillofacial Devices, Soft Tissue Implants

Historical Perspectives, Cardiovascular Anatomy, Load bearing devices, Oral and Maxillofacial Anatomy, Dental Implants, and Introduction to Soft Tissue Implants

Textbook

1) Mechanics of Biomaterials- Fundamental Principles of Implant Design- First Edition- L.A.Pruitt, A.M.Chakravartula- Cambridge University Press- ISBN 978-0-521-76221-2

Reference Book

1) Bio integration of Medical Implant Materials- Second Edition- Chandra .P Sharma- Woodhead- Elsevier Publication- ISBN: 978-0-08-102680-9

Syllabus for B.Tech VII Semester
Department of Biomedical Engineering

Course Code	**BMP405**				
Course Title	**Design and Manufacturing of Implants and Prostheses Lab**				
Scheme and Credits	**L**	**T**	**P**	**Credits**	**Semester**
	0	**0**	**2**	**1**	**VII**

Experiments would be based on following topics

1. Determination of Hardness and Toughness of Implant Materials using Hardness tester and Charpy Izod Impact Testing
2. CAD Modelling of Implants- Point Cloud Extraction using Reverse Engineering to CAD and STL file generation, converting CT scan file to STL using free tools available
3. Hands-on training on CAD modelling software adding features on CAD model of Implant
4. CAE Analysis of Implant using ANSYS /COMSOL or any Multiphysics software
5. Demonstration of Investment Implant Casting for Dental Implants

Skills Developed: - Point Cloud Extraction using Reverse Engineering, STL file creation from CT Scan File, Preliminary operation and Solid Modelling skills using CAD software, Investment Casting procedure for Dental Implants.

Syllabus for B.Tech VII Semester
Department of Biomedical Engineering

Course Code	BMT408				
Course Title	Biomedical Engineering: Legal & Ethical Perspective				
Scheme and Credits	L	T	P	Credits	Semester
	2	0	0	0	VII

Course Outcome:

After completion of the course the student will be able to:

1. Understand their role as the biomedical engineers while developing the device along with their rights over their intellectual properties.
2. Develop conscientiousness among them and will get aware about the laws enacted for any kind of Medical Negligence.
3. Understand the powers and functions of licensing authorities and National Accreditation bodies.
4. Acknowledge the procedure for application of Import License along with condition to be complied with as a license holder to avoid cancellation or suspension of the license.

Module 1:

Biomedical Engineers vis-à-vis Intellectual Property

1. Role of Biomedical Engineers as a device developer
2. Intellectual Property Rights And Their Significance in Biomedical Research
3. Types of Intellectual Property Rights

Module 2:

Medical Negligence – Laws in India

1. Criminal negligence
2. Civil negligence
3. Negligence under consumer protection Act

Module 3:

The Medical Devices Rules, 2017

1. Short title, Commencement and Application of the rules
2. Licensing authorities and their power of delegation
3. National Accreditation bodies and their functions

Module 4:

Import of Medical Devices

1. Application for grant of import licence
2. Grant of import licence
3. Conditions to be complied with by licence holder
4. Suspension and cancellation of licence

References:

1. Law Relating to Intellectual Property Rights by Dr. M. K. Bhandari (Central Law Publications)
2. Intellectual Property For The Medical Professional by Joseph S. Heino, Booklocker.Com Inc

3. Medical Negligence & Legal Remedies by Anoop K Kaushal, Universal Law Publishing an imprint of LexisNexis
4. Y.V. Rao's Law relating to Medical Negligence by Asia Law House.
5. The Medical Devices Rules, 2017.

Syllabus for B. Tech. VIII Semester
Department of Biomedical Engineering

Course Code	**BMT410-1**				
Course Title	**Diagnostic Medical Biotechnology**				
Scheme and Credits	*L*	*T*	*P*	*Credits*	*Semester*
	3	*0*	*0*	*3*	*VIII*

Course Outcomes

After successful completion of the course, the students will learn

1. Acquire knowledge of host-pathogen interactions, disease pathology, and clinical diagnosis, along with molecular techniques for disorder analysis.
2. Develop skills in genomic analysis, including human disease genes, DNA polymorphism, and high-throughput sequencing for genetic diagnosis.
3. Understand proteomic methods for disease biomarker identification, including protein isolation, 2D analysis, and mass spectrometry.
4. Apply nanomolecular diagnostics, including nanoarrays and biosensors, for disease detection, with an awareness of ethical considerations.

SYLLABUS-

Unit I

Host pathogen interactions in disease process (Bacterial: Tuberculosis and Staphylococcal Diseases & Viral: Influenza and HIV/AIDS); Clinical diagnosis of diseases; Molecular Genetics of the host and the pathogen. Molecular techniques for analysis of these disorders; Bioinformatics tools for molecular diagnosis.

Unit II

Concept of Genomics, Human disease genes; DNA polymorphism including those involved in disease (Ex: Hemoglobin and the anemias); Phenylketonuria (monogenic) and diabetes (multigenic) genetic disorders; 'disease' gene vs. 'susceptibility' gene; SNP detection: hybridization based assays (allele specific probes); Polymerization based assays (allele specific nucleotide incorporation, allele-specific PCR); Ligation based assays (allele specific oligonucleotide ligation); Polymorphism detection without sequence information: SSCP. Single nucleotide polymorphism and disease association; High throughput DNA sequencing and diagnosis; and Array based techniques in diagnosis.

Unit III

Outline of a typical proteomics experiment, clinical proteomics and disease biomarkers. Isolation of proteins and other molecules associated with disease; 2D analysis of such proteins by sequencing individual spots by Mass Spectrometry; Protein Microarray; Present methods for diagnosis of Specific diseases like Tuberculosis and AIDS; Ethics in Molecular Diagnosis

Unit IV

Nanomolecular diagnostics and Biosensor: Introduction to Nanodiagnostics, Nanoarrays for diagnostics, detection of single DNA, self-assembled protein nanoarrays, protein nanobiochip nanoparticles for molecular diagnostics, DNA nanomachines, Nanobiosensor, CNT biosensor, DNA nanosensor, Nanowire biosensor, application of nanodiagnostics.

Text Book

Challa S.S.R. Kumar, Nanomaterials for medical diagnosis and therapy, Viley-VCH, 2007.

Reference Book

1. George Patrinos and Wilhelm Ansorage, Molecular Diagnostics, 1st Edition, Academic Press, 2005.
2. Willey J. Prescott, Harley, and Klein's Microbiology-7th international ed./Joanne M. Willey, Linda M. Sherwood, Christopher J. Woolverton. New York: McGraw-Hill Higher Education; 2008.
3. Lela Buchingham and Maribeth L Flawsm, Molecular Diagnostics: Fundamentals, Methods and Clinical Applications, 1st Edition, F A Davis Company, Philadelphia, USA, 2007.
4. Campbell, M.A and Heyer L.J., Discovering Genomics, Proteomics and Bioinformatics, 2nd Edition, CSHL Press, Pearson/Benzamin Cummings San Francisco, USA, 2007.
5. Andrew Read and Dian Donnai, New Clinical Genetics, Scion Publishing Ltd, Oxfordshire, UK, 2007.
6. Dr.Parag Diwan and Ashish Bharadwaj (Eds), Nano Medicines, Pentagon Press, 2006.

Syllabus for B. Tech. VIII Semester
Department of Biomedical Engineering

Course Code	**BMT410-2**				
Course Title	**Therapeutic Medical Biotechnology**				
Scheme and Credits	*L*	*T*	*P*	*Credits*	*Semester*
	3	*0*	*0*	*3*	*VIII*

Course Objective:
Upon completion of this course the students will able to:
1. Understand the concept of Molecular Therapeutics and Drug Discovery
2. Gain insights in legal and ethical issues concerned with Medical therapeutics

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

1. Understand gene therapy principles, including viral and non-viral delivery methods, with a focus on treating influenza and HIV/AIDS. Address ethical concerns in genetic manipulation.
2. Acquire skills in high throughput screening, drug target identification, and the impact of pharmacogenomics on drug development. Explore toxicogenomics and metagenomics.
3. Learn nanobiotechnology applications in cancer and diabetes, emphasizing nanoparticle-based drug delivery, lipid nanoparticles, and ethical considerations in nanomedicine.
4. Gain insights into clinical research, drug development phases, trial design, ethical considerations, ICH-GCP guidelines, and roles in clinical trials.

SYLLABUS

Unit I
Gene therapy; Intracellular barriers to gene delivery; Overview of inherited and acquired diseases for gene therapy; Retro and adeno virus mediated gene transfer; Liposome and nanoparticles mediated gene delivery. Gene silencing technology; siRNA- Concept, delivery and therapeutic applications in treatment of influenza and HIV/AIDS; Tissue and organ transplantation; Transgenics and their uses; Cloning; Ethical issues

Unit II
Proteomics and drug discovery: High throughput screening for drug discovery; Identification of drug targets; Pharmacogenomics and pharamacogenetics and drug development; Toxicogenomics; Metagenomics.

Unit III
Nanobiotechnology for drug discovery, protein and peptide based compounds for cancer and diabetes, drug delivery - nanoparticle based drug delivery, lipid nanoparticles, vaccination, cell therapy, Gene therapy. Ethical, safety and regulatory issues of nanomedicine. Physicochemical characteristics of nanomaterials, Nanoparticle interaction with biological membrane, Neurotoxicology.

Unit IV
Introduction and importance of clinical research, Drug Development and phases of Clinical trials, Designing clinical Trials, Protocol designing, Ethical issues in clinical research, ICH-GCP Guidelines, Informed consent

process, Role of CRC and CRA in clinical trials, Pharmacovigilance.

Text Book

Kewal K. Jain, The Hand book of Nanomedicine, Humana Press, Springer 2008

References:

1. Bernhard Palsson and Sangeeta N Bhatia, Tissue Engineering, 2nd Edition, Prentice Hall, 2004.
2. Pamela Greenwell, Michelle McCulley, Molecular Therapeutics: 21st century medicine, 1st Edition, Sringer, 2008.
3. Primrose S & Twyman R, Principles of Gene Manipulation and Genomics, 7th Edition, Blackwell, 2006.
4. H. Rehm, Protein Biochemistry and Proteomics, 4th Edition, Academic Press, 2006.
5. Robert A. Freitas Jr., Nanomedicine, Volume I: Basic Capabilities, Landes Bioscience, Georgetown, TX, 1999.
6. Robert A. Freitas Jr., Nanomedicine, Volume IIA: Biocompatibility, Landes Bioscience, Georgetown, TX, 2003.
7. Nancy A. Monteiro – Riviere and C. Lang Tran, Nanotoxicology: Characterization, Dosing and Health Effects, Informa Healthcare. 2007.
8. Kumar, Challa S. S. R. (ed.) Nanomaterials - Toxicity, Health and Environmental Issues, Wiley-VCH, Weinheim, 2006.
9. Norris, Deborrah. Clinical Research Coordinator Handbook. Plexus Pub, 2009.
10. Portney, Leslie Gross, and Mary P. Watkins. Foundations of clinical research: applications to practice. Vol. 2. Upper Saddle River, NJ: Prentice Hall, 2000.
11. Stone, Judy. Conducting clinical research: A practical guide for physicians, nurses, study coordinators, and investigators. Mountainside MD Press, 2006.

Syllabus for B. Tech. VIII Semester
Department of Biomedical Engineering

Course Code	BMT410-3				
Course Title	Hospital Management and Entrepreneurship				
Scheme and Credits	L	T	P	Credits	Semester
	3	0	0	3	VIII

Course objectives

4. Upon the completion of the course ,the student will demonstrate the ability to
5. Develop knowledge of hospital maintenance, equipment and systems for health care.
6. Understand about effective hospital management.

Course Outcomes

After successful completion of the course, the students will be able to

5. Understand about engineering services in hospital.
6. Understand about management of different healthcare services.
7. Understand about management of different Health Care Sector in India
8. To understand the concepts of Health Care Regulation & Hospital standards

Syllabus

Unit I (6 Hours)

Engineering services in a hospital -Civil assets, Electricity supply, water supply, steam supply, piped medical gases, air and clinical vacuum delivery system, air conditioning and refrigeration, lifts and dumb waiters, public health services, lightening protection, public address system, telephones, paging system , TV and piped music system, non-conventional energy devices, and workshop facilities for repairs and maintenance.

Unit II (8 Hours)

A Conceptual Approach to Understanding the Health Care Systems – Evolution, Institutional Setting - Out Patient services – Medical Services – Surgical Services – Operating department – Pediatric services – Dental services – Psychiatric services – Casualty, Emergency services – Hospital Laboratory services – Anesthesia services – Obstetrics and Gynecology services – Neuro – Surgery service – Neurology services.

Unit III (8 Hours)

Overview of Health Care Sector in India – Primary care – Secondary care – Tertiary care – Rural Medical care – urban medical care – curative care – Preventive care – General & special Hospitals- Understanding the Hospital Management – Role of Medical, Nursing Staff, Paramedical and Supporting Staff - Health Policy - Population Policy - Drug Policy – Medical Education Policy

Unit IV (6 Hours)

Health Care Regulation – WHO, International Health regulations, IMA, MCI, State Medical Council Bodies, Health universities and Teaching Hospitals and other Health care Delivery Systems Autoclaving, Clean room, Hazards Management.

Unit V (6 Hours)

Hospital standards and design: Building requirement – Entrance & Ambulatory Zone – Diagnostic Zone – Intermediate Zone – Critical zone – Service Zone – Administrative zone – List of Utilities – Communication facility – Biomedical equipment - Voluntary & Mandatory standards – General

standards – Mechanical standards – Electrical standards – standard for centralized medical gas system – standards for biomedical waste

Unit VI (6 Hours)

Epidemiology – Aims – Principles – Descriptive, Analytical and Experimental Epidemiology - Methods - Uses

References

1) Gupta S.K, SunilKant Chandra Shekhar, R Satpathy, Modern Trends In Planning And Designing Of Hospitals
2) Syed Amin Tabish, Hospital And Nursing Homes Planning, Organisations & Management
3) G.D.Kunders, Hospitals, Facilities Planning And Management
4) Gilienfeld, "Foundation Of Epidemiology"
5) R.C. Goyal, Handbook of Hospital Personal Management, Prentice Hall of India, 1993

Syllabus for B. Tech. VIII Semester
Department of Biomedical Engineering

Course Code	**BMT411-1**				
Course Title	**Pathology and Medical Microbiology**				
Scheme and Credits	*L*	*T*	*P*	*Credits*	*Semester*
	3	*0*	*0*	*3*	*VIII*

Course Outcomes

After successful completion of the course, the students will

1. Learn to safeguard themselves and society and can work in diagnostics laboratories and hospitals. They will be able to classify and characterize diseases causing organisms like bacterial, fungal, viral etc.
2. Understand the pathogenesis, epidemiology of diseases and their causative agents. They also learn about the diagnosis of various microbial diseases.
3. Learn an introductory nature and build the concepts of how human system work in altered and diseased stage under the influence of various internal and external stimuli.
4. Understand various immunological events and actions in the body
5. Understand the role of various vitamins and minerals in human body.
6. Gain insight about cancer

SYLLABUS-

Unit I

Early discovery of pathogenic microorganisms. Pathogenicity and virulence; Quantitative measures of virulence: minimal lethal dose (MLD), LD 50, ID 50, TCID 50. Normal microbial flora of the human body; role of the resident flora. Nosocomial infection, common types of hospital infections and their diagnosis and control,

Unit II

Important diseases of human beings (short description of causal agent, pathogenesis, diagnosis and treatment) Bacterial diseases: Typhoid, Cholera, Tuberculosis, Tetanus, Botulism, Meningitis, Pneumonia,. Viral diseases: Influenza, Herpes, AIDS, Rabies, SARS, Human Pox, Mumps and Measles. Fungal diseases: Ringworm,

Unit III

Introduction & History of pathology, Basic definitions and familiarization with the common terms used in pathology, Causes and mechanisms of cell injury, reversible and irreversible injury, Introduction of hyperplasia, hypoplasia, hypertrophy, atrophy, metaplasia, necrosis and apoptosis

Unit IV

General features of acute and chronic inflammation: Vascular changes, cellular events, Cells and mediators of inflammation, Phagocytosis and its mechanism

Tissue Renewal and Repair, healing and fibrosis, cirrhosis, introduction of oedema, hyperaemia, congestion, haemorrhage, haemostasis, thrombosis, embolism, infarction, shock and hypertension

Unit V

Protein energy malnutrition, deficiency diseases of vitamins and minerals, nutritional excess and imbalances. Role

and effect of metals (Zinc, Iron and Calcium) and their deficiency diseases, arteriosclerosis, myocardial infarction, respiratory diseases (COPD), Parkinson disease Infectious

Unit VI

Cancer: Definitions, nomenclature, characteristics of benign and malignant neoplasm, metastasis, Carcinogens and cancer, concept of oncogenes, tumor suppressor genes, DNA repair genes and cancers stem cells.

Suggested Readings:

1. Harshmohan (2017), Textbook of Pathology,7th edition, Jaypee Publications
2. Robbins,(2012), Text book of Pathology, 3rd edition, Elsevier Publications
3. Infectious Disease Epidemiology: Theory and Practice by Nelson KE, Williams CM,
4. Topley and Wilson 1995. Text book on Principles of Bacteriology, Virology and Immunology. Edward Arnold, London
5. Mackie and McCartney. 1996. Medical Microbiology. Vol.1. Microbial Infection, Vol. 2. Practical Medical Microbiology. Churchill Livingstone.
6. Shanson DC. Wright PSG1982. Microbiology in Clinical Practice.

Syllabus for B. Tech. VIII Semester
Department of Biomedical Engineering

Course Code	**BMT411-2**				
Course Title	**Bioinstrumentation**				
Scheme and Credits	*L*	*T*	*P*	*Credits*	*Semester*
	3	*0*	*0*	*3*	*VIII*

Course Outcomes

Upon successful completion of the course, the student will able to:

1. Explain the analysis of cellular structure using different type of microscopies
2. Explain the techniques of vertical electrophoresis under native and SDS conditions.
3. Learn about spectroscopy.
4. Understand and correctly interpret various chromatographic techniques
5. Understand the process of separation through centrifugation

SYLLABUS

Unit I

Microscopy: Principles and use of light microscope, bright-field, dark-field, phase-contrast, fluorescent, electron microscopy (SEM, TEM), confocal microscopy and scanning probe microscopy. Specimen preparation for light microscopy and electron microscopy, staining of specific structures, fixatives and dyes, principle and uses of simple staining and differential staining

Unit II

. Principle and working of instruments used for sterilization.

Electrophoresis: zonal techniques, supporting medium, vertical, submarine, gradient and two dimensional electrophoresis. Isoelectric focusing

Unit III

Spectroscopy: Beer-Lambert relationship, components of a spectrophotometer, type of detectors; UV-Vis spectrophotometry, atomic absorption spectroscopy. Applications of spectroscopy.

Unit IV

Chromatography: Adsorption Chromatography, liquid Chromatography, Gas- liquid Chromatography, Ion exchange Chromatography, Affinity Chromatography, GC-MS, HPLC.

Unit V

Centrifugation: Basic principle, working and application of analytical and preparative centrifuges, Differential, density gradient, zonal and isopycnic.

Text Book

Bioinstrumentation by L Veerakumari ; MJP Publisher (2019)

Reference Book

1. Principles and Techniques of Biochemistry and Molecular Biology. (6thEdition) by Wilson K. & Walker J. Cambridge University Press. 2008.
2. Biochemistry (6th edition) by Berg J. M., Tymoczko J. L. &Stryer, L. W.H. Freeman and Company, New York; 2007.
3. Foundations in Microbiology (6th edition) by Talaro K. P. &Talaro A. McGraw-Hill College, Dimensi;2006.
4. Analysis of Biological Molecules: An Introduction to Principles, Instrumentation and Techniques, by Potter G. W. H. & Potter G. W. Kluwer Academic Publishers; 1995.
5. Prescott/Harley/Klein's Microbiology by Willey J., Sherwood L. and Woolverton C. McGraw Hill; 2007

Syllabus for B. Tech. VIII Semester
Department of Biomedical Engineering

Course Code	**BMT411-3**				
Course Title	**Biomedical Product Design**				
Scheme and Credits	***L***	***T***	***P***	***Credits***	***Semester***
	3	***0***	***0***	***3***	***VIII***

Course outcomes:
After completion of this course, students will demonstrate the ability to:
1. Visualize the concept of product design and innovations with respect to ergonomics and aesthetics.
2. Analyze, design and draw control panels, front panel and overall enclosure design of biomedical equipment.
3. Understand the design of product architecture, product prototype.
4. Understand the cost of biomedical product design, process of value analysis and standards.

SYLLABUS
Unit I:
Introduction to product design, Role of industrial design in the domain of industry, Generic product development process, Industrial Design process, product innovations, Introduction to Patents and Intellectual Property Rights, Process for preparing an invention disclosure.
Unit II:
Design Development and Planning, Solution Generation and Selection, Product architecture, Product prototypes, Validation and Verification Testing, Testing in Living Systems
Unit III:
Electronic product design and development Methodology, Design for Manufacturing, Ergonomics in product design, Aesthetics: Elements of aesthetics, aesthetics of control panel design. Visual Communication Techniques, Value Engineering, Costing and Pricing of Industrial design,
Unit IV:
Medical Device Standards Regulations, and Ethics.
Case Studies
Case Study 1: Control/Front panel design of an electronic instrument.
Case Study 2: Biomedical Application, Design optimization of Medical Equipment like BP measuring instrument, Pulse Oximeter, Infrared thermometer, Multi-patient monitors, IOT based devices, wearable biomedical devices, etc.

Text Books:
1. Karl T. Ulrich, Steven. D. Eppinger, "Product Design and Development", McGraw Hill Education.
2. Jospeh Tranquillo, Jay Goldberg, Robert Allen, "Biomedical Engineering Design", Academic Press, Year: 2022

Reference Books:
1. Ernest J Mccormick,"Human factors in Engineering and Design" -, McGraw-Hill Co.
2. K.F.H. Murrell, "Ergonomics: Man in his Working Environment", John Wiley & Sons, New York
3. Stephen J. Guastello, "Human Factor Engineering and Ergonomics, A System Approach" CRC Press
4. Human Factors Design Handbook -Wooden Vs. McGraw Hill New York.
5. Stephen Pheasant, Christine M. Haslegrave, Bodyspace: Anthropometry, Ergonomics and the Design of Work,

CRC Press, Third Edition, 2016.