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Item No. 4.179

UNIVERSITY OF MUMBAI

Revised syllabus (Rev- 2016) from Academic Year 2016 -17
Under

FACULTY OF TECHNOLOGY

Biomedical Engineering

Second Year with Effect from **AY 2017-18**
Third Year with Effect from **AY 2018-19**
Final Year with Effect from **AY 2019-20**

As per **Choice Based Credit and Grading System**
with effect from the AY 2016–17

From Co-ordinator's Desk:

To meet the challenge of ensuring excellence in engineering education, the issue of quality needs to be addressed, debated and taken forward in a systematic manner. Accreditation is the principal means of quality assurance in higher education. The major emphasis of accreditation process is to measure the outcomes of the program that is being accredited. In line with this Faculty of Technology of University of Mumbai has taken a lead in incorporating philosophy of outcome based education in the process of curriculum development.

Faculty of Technology, University of Mumbai, in one of its meeting unanimously resolved that, each Board of Studies shall prepare some Program Educational Objectives (PEO's) and give freedom to affiliated Institutes to add few (PEO's) and course objectives and course outcomes to be clearly defined for each course, so that all faculty members in affiliated institutes understand the depth and approach of course to be taught, which will enhance learner's learning process. It was also resolved that, maximum senior faculty from colleges and experts from industry to be involved while revising the curriculum. I am happy to state that, each Board of studies has adhered to the resolutions passed by Faculty of Technology, and developed curriculum accordingly. In addition to outcome based education, **Choice Based Credit and Grading System** is also introduced to ensure quality of engineering education.

Choice Based Credit and Grading System enables a much-required shift in focus from teacher-centric to learner-centric education since the workload estimated is based on the investment of time in learning not in teaching. It also focuses on continuous evaluation which will enhance the quality of education. University of Mumbai has taken a lead in implementing the system through its affiliated Institutes Faculty of Technology has devised a transparent credit assignment policy adopted ten points scale to grade learner's performance. Choice Based Credit and Grading System were implemented for First Year Bachelor of Engineering from the academic year 2016-2017. Subsequently this system will be carried forward for Second Year Bachelor of Engineering in the academic year 2017-2018.

Dr. Suresh K. Ukarande
Co-ordinator,
Faculty of Technology,
Member - Academic Council
University of Mumbai, Mumbai

Preamble:

The overall technical education in our country is changing rapidly in manifolds. Now it is very much challenging to maintain the quality of education with its rate of expansion. To meet present requirement a systematic approach is necessary to build the strong technical base with the quality. Accreditation will provide the quality assurance in higher education and to achieve recognition of the institution or program meeting certain specified standards. The focus of an accreditation process is to measure the program outcomes, essentially a range of skills and knowledge that a student will have at the time of graduation from the program that is being accredited. Faculty of Technology of University of Mumbai has taken a lead in incorporating philosophy of outcome based education in the process of curriculum development.

I, as Chairman, Board of Studies in Electrical Engineering of University of Mumbai, happy to state here that, Program Educational Objectives (PEOs) were finalized for the graduate program in Biomedical Engineering, more than ten senior faculty members from the different institutes affiliated to University of Mumbai were actively participated in this process. Few PEOs were finalized for graduate program in Biomedical Engineering are listed below:

Program Educational Objectives (PEOs)

1. To provide sound knowledge of basic sciences, human anatomy, human physiology, electrical and electronic systems, building a strong foundation for career advancement.

2. To develop a logical approach, analytical thinking and problem solving capabilities in order to make the learner competent to face and address the global challenges in their chosen field.

3. To impart technical knowledge and competency skills to perform in various areas like sales & marketing, product engineering, research-development, hospital administration, regulatory affairs and also to venture into entrepreneurship.

4. To develop proficiency in various soft skills and bring awareness about social obligations and professional ethics to pursue professional career in a healthcare industry.

5. Motivate to pursue research and specialization in a plethora of domains in the field of Biomedical Engineering covering disciplines such as, Medical Instrumentation, Neuroscience, Computational Engineering, Robotics Engineering, Medical Signal and Image processing, Rehabilitation Engineering, VLSI, Nanotechnology and Biosensors, etc.

Program Outcomes (POs)

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 multidisciplinary 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 multidisciplinary 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.

Dr. S. R. Deore,
Chairman,
Board of Studies in Electrical Engineering,
Member - Academic Council
University of Mumbai

Program Structure for
B.E. Biomedical Engineering
University of Mumbai
(With effect from academic year 2017 - 18)

Scheme for Semester III

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
BMC301	Applied Mathematics III	04	----	01	04	----	01	05
BMC302	Basics of Human Physiology	04	----	----	04	----	----	04
BMC303	Electrical Network Analysis and Synthesis	04	----	----	04	----	----	04
BMC304	Electronic Circuit Analysis and Design	04	----	----	04	----	----	04
BMC305	Biomaterials, Prosthetics and Orthotics	04	----	----	04	----	----	04
BML301	Object Oriented Programing	----	04#	----	----	02	----	02
BML302	Basics of Human Physiology	----	02	----	----	01	----	01
BML303	Electrical Network Analysis and Synthesis	----	02	----	----	01	----	01
BML304	Electronic Circuit Analysis and Design	----	02	----	----	01	----	01
BML305	Biomaterials, Prosthetics and Orthotics	----	02	----	----	01	----	01
Total		**20**	**12**	**01**	**20**	**06**	**01**	**27**

 # Out of four hours, 2 hours theory shall be taught to the entire class and 2 hours practical in batches.

Examination Scheme for Semester III

Course Code	Course Name	Examination Scheme												Total Marks
		Theory				Term work		Practical		Oral		Pract./Oral		
		External (UA)		Internal (CA)										
		Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	
BMC301	Applied Mathematics III	80	32	20	8	25	10	---	---	---	---	---	---	125
BMC302	Basics of Human Physiology	80	32	20	8	---	---	---	---	---	---	---	---	100
BMC303	Electrical Network Analysis and Synthesis	80	32	20	8	---	---	---	---	---	---	---	---	100
BMC304	Electronic Circuit Analysis and Design	80	32	20	8	---	---	---	---	---	---	---	---	100
BMC305	Biomaterials, Prosthetics and Orthotics	80	32	20	8	---	---	---	---	---	---	---	---	100
BML301	Object Oriented Programing	---	---	---	---	50	20	---	---	---	---	50	20	100
BML302	Basics of Human Physiology	---	---	---	---	25	10	---	---	25	10	---	---	50
BML303	Electrical Network Analysis and Synthesis	---	----	---	---	25	10	---	---	25	10	---	---	50
BML304	Electronic Circuit Analysis and Design	---	---	---	---	25	10	---	---	---	---	25	10	50
BML305	Biomaterials, Prosthetics and Orthotics	---	---	---	---	25	10	---	---	25	10	---	---	50
Total		**400**	**160**	**100**	**40**	**175**	**70**	**---**	**---**	**75**	**30**	**75**	**30**	**825**

Scheme for Semester IV

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
BMC401	Applied Mathematics IV	04	----	01	04	----	01	05
BMC402	Biomedical Transducers and Measuring Instruments	04	----	----	04	----	----	04
BMC403	Linear Integrated Circuits	04	----	----	04	----	----	04
BMC404	Digital Electronics	04	----	----	04	----	----	04
BMC405	Signals and Control Systems	04	----	----	04	----	----	04
BML401	Introduction to Simulations Tools	----	02	----	----	01	----	01
BML402	Biomedical Transducers and Measuring Instruments	----	02	----	----	01	----	01
BML403	Linear Integrated Circuits	----	02	----	----	01	----	01
BML404	Digital Electronics	----	02	----	----	01	----	01
BML405	Signals and Control Systems	----	02	----	----	01	----	01
Total		**20**	**10**	**01**	**20**	**05**	**01**	**26**

Examination Scheme for Semester IV

Course Code	Course Name	Examination Scheme												Total Marks
		Theory				Term work		Practical		Oral		Pract./Oral		
		External (UA)		Internal (CA)										
		Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	
BMC401	Applied Mathematics - IV	80	32	20	8	25	10	---	---	---	---	---	---	125
BMC402	Biomedical Transducers and Measuring Instruments	80	32	20	8	---	---	---	---	---	---	---	---	100
BMC403	Linear Integrated Circuits	80	32	20	8	---	---	---	---	---	---	---	---	100
BMC404	Digital Electronics	80	32	20	8	---	---	---	---	---	---	---	---	100
BMC405	Signals and Control Systems	80	32	20	8	---	---	---	---	---	---	---	---	100
BML401	Introduction to Simulations Tools	---	---	---	---	25	10	25	10	---	---	---	---	50
BML402	Biomedical Transducers and Measuring Instruments	---	---	---	---	25	10	---	---	25	10	---	---	50
BML403	Linear Integrated Circuits	---	----	---	---	25	10	---	---	---	---	25	10	50
BML404	Digital Electronics	---	---	---	---	25	10	---	---	---	---	25	10	50
BML405	Signals and Control Systems	---	---	---	---	25	10	---	---	25	10	---	---	50
Total		**400**	**160**	**100**	**40**	**150**	**60**	**25**	**10**	**50**	**20**	**50**	**20**	**775**

Course Code	Course Name	Teaching scheme			Credit assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
BMC301	Applied Mathematics III (Abbreviated as AM – III)	04	--	01	04	--	01	05

Course Code	Course Name	Examination Scheme								
		Theory					Term work	Pract.	Oral	Pract. / Oral	Total
		Internal Assessment			End sem	Duration (hrs)					
		Test 1	Test 2	Avg.							
BMC301	Applied Mathem-atics III (AM – III)	20	20	20	80	03	25	--	--	--	125

Course Code	Course Name	Credits
BMC301	Applied Mathematics III	05
Course Objectives	• To build the strong foundation in Mathematics of learner needed for the field of Biomedical Engineering. • To provide learner with mathematics fundamentals necessary to formulate, solve and analyses complex engineering problems. • To prepare student to apply reasoning informed by the contextual knowledge to engineering practice. • To prepare learner to work as part of teams on multi-disciplinary projects.	
Course Outcomes	• Learner will demonstrate basic knowledge of Laplace Transform. Fourier series, Bessel Functions, Vector Algebra and Complex Variable. • Learner will demonstrate an ability to identify and Model the problems of the field of Biomedical Engineering and solve it. • Learner will be able to apply the application of Mathematics in Biomedical Engineering.	

Module No	Unit No.	Topic	Hours
1		**Laplace Transform**	
	1.1	**Laplace Transform (LT) of Standard Functions:** Definition of Laplace transform, Condition of Existence of Laplace transform, Laplace transform of $e^{at}, Sin(at), \cos(at), \sinh(at), \cosh(at), t^n$ Heaviside unit step function, Dirac-delta function, Laplace transform of Periodic function	7

	1.2	**Properties of Laplace Transform:** Linearity, first shifting theorem, second shifting theorem, multiplication by t^n ,Division by t, Laplace Transform of derivatives and integrals, change of scale, convolution theorem, Evaluation of integrals using Laplace transform.	
2		**Inverse Laplace Transform & its Applications**	
	2.1	Partial fraction method, Method of convolution, Laplace inverse by derivative	**6**
	2.2	**Applications of Laplace Transform:** Solution of ordinary differential equations, Solving RLC circuit differential equation of first order and second order with boundary condition using Laplace transform (framing of differential equation is not included)	
3		**Fourier Series**	
	3.1	**Introduction:** Orthogonal and orthonormal set of functions, Introduction of Dirichlet's conditions, Euler's formulae	**11**
	3.2	**Fourier Series of Functions:** Exponential, trigonometric functions of any period =2L, even and odd functions, half range sine and cosine series	
	3.3	Complex form of Fourier series, Fourier integral representation, Fourier Transform and Inverse Fourier transform of constant and exponential function.	
4		**Vector Algebra & Vector Differentiation**	
	4.1	**Review of Scalar and Vector Product**: Scalar and vector product of three and four vectors, Vector differentiation, Gradient of scalar point function, Divergence and Curl of vector point function	**7**
	4.2	**Properties:** Solenoidal and irrotational vector fields, conservative vector field	
5		**Vector Integral**	
	5.1	Line integral	**6**
	5.2	Green's theorem in a plane, Gauss' divergence theorem and Stokes' theorem	
6		**Complex Variable & Bessel Functions**	
	6.1	**Analytic Function:** Necessary and sufficient conditions (No Proof), Cauchy Reiman equation Cartesian form (No Proof) Cauchy Reiman Equation in polar form (with Proof), Milne Thomson Method and it application, Harmonic function, orthogonal trajectories	**11**
	6.2	**Mapping:** Conformal mapping, Bilinear transformations, cross ratio, fixed points	
	6.3	**Bessel Functions:** Bessel's differential equation, Properties of Bessel function of order +1/2 and -1/2, Generating function, expression of	

		cos (xsin θ), sin (x sin θ) in term of Bessel functions	

Books Recommended:

Text Books:

1. H.K. Das, "*Advanced engineering mathematics*", S . Chand, 2008
2. A. Datta, *"Mathematical Methods in Science and Engineering",* 2012
3. B.S. Grewal, *"Higher Engineering Mathematics",* Khanna Publication

Reference Books:

1. B. V. Ramana, *"Higher Engineering Mathematics",* Tata Mc-Graw Hill Publication
2. Wylie and Barret, *"Advanced Engineering Mathematics",* Tata Mc-Graw Hill 6th Edition
3. Erwin Kreysizg, *"Advanced Engineering Mathematics",* John Wiley & Sons, Inc
4. Murry R. Spieget, *"Vector Analysis",* Schaum's outline series, Mc-Graw Hill Publication

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

Term work:

Term work shall consist of minimum eight tutorials and assignments (minimum 2).
The distribution of marks for term work shall be as follows:

Tutorials :15 marks
Assignments :05 marks
Attendance (Theory and Tutorial) :05 marks

The final certification and acceptance of term work ensures minimum passing in the term work.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining question will be randomly selected from all the modules.

Course Code	Course Name	Teaching scheme			Credit assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
BMC302	Basics of Human Physiology (Abbreviated as BHP)	04	--	--	04	--	--	04

Course Code	Course Name	Examination Scheme									
		Theory					Term work	Pract.	Oral	Pract. / Oral	Total
		Internal Assessment			End sem	Duration (hrs)					
		Test 1	Test 2	Avg.							
BMC302	Basics of Human Physiology (BHP)	20	20	20	80	03	--	--	--	--	100

Course Code	Course Name	Credits
BMC302	Basics of Human Physiology	04
Course Objectives	• To understand the human anatomy and functions of various body structures. • To understand different physiological processes taking place inside human body.	
Course Outcomes	Learners will be able to: • Understand the structure and function of cell, the action potential and muscle physiology. • Distinguish the different anatomical parts of cardiovascular and respiratory system. Understand the physiology of heart, and other organs of cardiovascular system, concept of Blood pressure and use of ECG. Understand the exchange in gases taking place in body and use of spirometer. • To know the composition of blood, blood cells with their functions, basics of cell counting, blood grouping and coagulation of blood. • Distinguish different organs of digestive and urinary system. Understand the process of digestion, secretions and their functions. Understand the process of urine formation and micturition • Understand the anatomy of nervous system, working of different parts of brain, parasympathetic and sympathetic nervous system, reflex arc and reflex action. Distinguish different parts of eyes and ear, their structure and function. Understand the hearing mechanism and image formation on the retina, understand the use of ophthalmoscope and design of hearing aid • Understand the different parts of male and female reproductive system with their working, action of sex hormones. To know all the endocrine glands with their secretion and function, and control action.	

Module	Contents	Hours
1	**Organization of Human Body:** Cell, Tissue, Organ, Organ system, Structure and functions of cell, Polarization and Depolarization of Cell, Types of tissues, Homeostasis, Positive and Negative Feedback Mechanism **Muscle Physiology:** Muscle physiology and aspects of Skin Resistance	05
2	**Cardiovascular System**: Anatomy of Cardiovascular System, Heart, Conductive Tissues of Heart, Cardiac Cycle, Heart Valves, Systemic and Pulmonary Circulation, Transmission of Cardiac Impulse, Blood Pressure, ECG, Einthoven's Triangle, Twelve Lead System and ECG Waveforms **Respiratory System:** Anatomy of Respiratory System, Ventilation, Exchange in gases in the alveoli, Spirometer (Forced Expiratory Volumes)	12
3	**Blood:** Composition of Blood – Blood cells and their functions, Haemoglobin, Blood Grouping, Coagulation, Wound Healing.	05
4	**Alimentary System:** All organs of the Digestive System, other secretions and main Functions, Deglutition and Defecation. **Urinary System:** Structure of Nephron, Function of Kidney, Urinary Bladder, Urethra, Internal/External Sphincters, Formation of Urine, Micturition	08
5	**Nervous System:** Different parts, their functions. Reflex actions and reflex are, Function of Sympathetic and Parasympathetic nervous system. Nerve conduction and action potentials. **Special Senses:** **Eyes**-Structure, Refractive Medias of the Eye, Formation of Image on the Retina. **Ear** – Structure of Cochlea, Hearing mechanism	10
6	**Reproductive System:** (Male and Female) Different Organs and their functions. Main actions of Androgens, Oestrogens and Progesterone. **Endocrine System:** All glands, their Secretions and functions. Control of secretions.	08

Books Recommended:

Text books:

1. Anatomy and Physiology in Health and Illness: Ross and Wilson. (ELBS Pub)
2. Essentials of Anatomy and Physiology: Elaine N Marieb. (Pearson Education)

Reference Books:

1. Physiology of Human Body. : Guyton. (Prism Book)
2. Review of Medical Physiology: William Ganong. (Prentice Hall Int)
3. Principles of Anatomy and Physiology: Tortora and Grabowski. (Harper collin Pub)
4. Anatomy and Physiology: Elaine N Marieb. (Pearson Education)

Assessment:
Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

Theory Examination:
3. Question paper will comprise of 6 questions, each carrying 20 marks.
4. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining question will be randomly selected from all the modules.

Course Code	Course Name	Teaching scheme			Credit assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
BMC303	Electrical Network Analysis and Synthesis (Abbreviated as ENAS)	04	--	--	04	--	--	04

Course Code	Course Name	Examination Scheme								
		Theory					Term work	Pract.	Oral	Pract. / Oral	Total
		Internal Assessment			End sem	Duration (hrs)					
		Test 1	Test 2	Avg.							
BMC303	Electrical Network Analysis and Synthesis (ENAS)	20	20	20	80	03	--	--	--	--	100

Course Code	Course Name	Credits
BMC303	Electrical Network Analysis and Synthesis	04
Course Objectives	• To learn a number of powerful engineering circuit analysis techniques such as nodal analysis, mesh analysis, source transformation and several methods of simplifying networks. • To apply concept of network theorems to the electrical circuits. • To understand the concept of graphical solution to electrical network. • To understand frequency response in electrical circuits. • To make the learner learn how to synthesize an electrical network from a given impedance/admittance function.	
Course Outcomes	Learner will be able to • Apply number of powerful engineering circuit analysis techniques such as nodal analysis, mesh analysis, source transformation and several methods of simplifying networks. • Apply the concept of circuit analysis to understand network theorems • Apply the concept of graphical solution to electrical network. • Distinguish between different one port and two port network parameters • Analyse time and frequency response of the electrical circuits. • To make the learner learn how to synthesize an electrical network from a given impedance/admittance function.	

Module	Contents	Hours
1	**Introduction:** Review of D.C. & A.C. circuits, DC Circuits: Current & Voltage Source Transformation, Source Shifting **Mesh & Node Analysis:** Mesh & Node Analysis of D.C. & A.C. circuits with independent & dependent sources. (Introduction to coupled circuits).	**07**
2	**Network Theorems (** D.C. & A.C. circuits**):** Superposition, Thevenin's & Norton's Theorem (with independent and dependent sources), Maximum power transfer theorem.	**06**
3	**Circuit Analysis:** Introduction to Graph Theory. Tree, link currents, branch voltages, cut set & tie set, Mesh & Node Analysis, Duality.	**06**
4	**Time and Frequency Response of Circuits:** First & second order Differential equations, initial conditions. Evaluation & Analysis of Transient Steady state responses using Classical Technique as well as by Laplace Transform (for simple circuits only). Transfer function, Concept of poles and zeros.	**09**
5	**Two-Port Networks:** Concept of two-port network. Driving point and Transfer Functions, Open Circuit impedance (Z) parameters, Short Circuit admittance (Y) parameters, Transmission (ABCD) parameters. Inverse Transmission (A'B'C'D') parameters. Hybrid (h) parameters. Inter Relationship of different parameters. Interconnections of two-port networks. Terminated two-port networks.	**10**
6	**Fundamentals of Network Synthesis:** Positive real functions, Driving Point functions, Properties of positive real functions. Testing Positive real functions. Testing driving point functions, Maximum modulus theorem, Properties of Hurwitz polynomials, Residue computations, Even & odd functions, Driving Point Synthesis with L-C, R-C, R-L and R-L-C networks.	**10**

Books Recommended:

Text Books:

1. Sudhakar & S.P. Shyammohan, Circuits and Networks, Tata McGraw Hill, thirteenth reprint, 2000.
2. William H. Hayt, Jack e. Kemmerly & Steven M. Durbin, Engineering Circuit Analysis, McGraw Hill International, sixth edition, 2202.
3. Raymond A. DeCarlo & Pen-Min Lin, Linear Circuit Analysis, Oxford University Press, second edition, 2001.
4. M. E. Van Valkenburg, Introduction to Modern Network Synthesis, Wiley Eastern Ltd.

Reference Books:

1. Artice M. Davis, Linear Circuit Analysis, Thomson Asia Pte. Ltd, Singapore, first edition, 2001.

2. M.E. Van Valkenburg, Network Analysis, Prentice Hall of India, third edition
3. C.L.Wadhwa, Network Analysis and Synthesis, New Age International Publisher, Third Edition.

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3: Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4: Remaining question will be randomly selected from all the modules.

Course Code	Course Name	Teaching scheme			Credit assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
BMC304	Electronic circuit analysis and design (Abbreviated as ECAD)	04	--	--	04	--	--	04

Course Code	Course Name	Examination Scheme								
		Theory					Term work	Pract.	Oral	Pract. / Oral	Total
		Internal Assessment			End sem	Duration (hrs)					
		Test 1	Test 2	Avg.							
BMC304	Electronic Circuit Analysis and Design (ECAD)	20	20	20	80	03	--	--	--	--	100

Course Code	Course Name	Credits
BMC304	Electronic Circuit Analysis and Design	04
Course Objectives	• To understand basic characteristics of semiconductor devices. • To design small signal amplifiers using BJT and FET	
Course Outcomes	Learner will be able to: • Understand the basic semiconductor components like P-N junction diodes, zener diodes and their various applications. • Understand BJT working and its various configurations and DC operating conditions • Understanding AC operating conditions and Design of single stage small signal CE amplifiers • Design of single stage small signal CS amplifiers • Understand the working of MOSFETs, its characteristics and its various applications • Understanding the concept of multistage amplifiers	

Module	Contents	Hours
1.	**Diodes Circuits:** Basics of PN junction diode - Equation, characteristics. Clipper and Clamper Circuits using diodes, Zener Diode – Characteristics and Working, Study Zener as a voltage regulator	05
2.	**Bipolar Junction Transistor**: Working of PNP and NPN Transistor. Configurations (CB, CC, CE), comparison, Q-Point, DC load line. BJT Biasing - DC analysis, Stability. (Fixed, Self, Voltage divider, Collector to base, Collector to base self). BJT as a switch.	10
3.	.**A.C. Equivalent Model** – $\mathbf{r_e}$ model, h-parameter model (Exact and Approximate), Hybrid-π model A.C. Analysis-(Using any one model): A.C. load line, A.C. analysis of CE, CB, CC amplifier configurations, Effects of R_S and R_L, Comparison between various amplifiers. Low frequency and High frequency analysis, Frequency response of Single stage amplifier. Design of single stage amplifier using BJT.	10
4.	**Junction Field Effect Transistor:** Working and basic terminology related to JFET. Configurations (CS, CG, CD), comparison, Q-Point, DC load line. JFET Biasing – Fixed, Self, Voltage divider, Concept of stability against device parameters and temperature, zero temperature drift. A.C. Equivalent model of JFET. A.C. Analysis of amplifiers using CS, CG and CD amplifier configurations, Effects of R_S and R_L, Comparison between various amplifiers. Low frequency and High frequency analysis, Frequency response of Single stage amplifier. Design of single stage amplifier using JFET.	12
5.	**MOSFET:** Working of Depletion and Enhancement type MOSFET Construction, Characteristics and equations, Basic MOSFET Applications	04
6.	**Multistage Amplifiers:** Cascade: BJT-BJT, FET-BJT. Cascode – DC and AC analysis, characteristics Darlington amplifier- DC and AC analysis, characteristics	07

Books Recommended:

Text Books:

1. Neamen Donald A., *Electronics Ckt. Analyzer & Design*, 2nd ed., Tata McGraw Hill.
2. Boylestad Robert L., Nashelsky Louis, *Electronics Devices & Circuits*, Pearson Education.
3. *Semiconductor Data Manual*, BPB Publications.

Reference Books:

1.Malvino—Electronic Principles , 6/e ,TMH
2. Millman & Halkias: Basic Electronic Principles; TMH.
3..Martin Roden, Gordon carpenter, William Wieseman, Electronic design, Fourth edtion, Sroff publishers.
4. Donald Schilling & Charles Belove, Electronic Circuits Discrete and Integrated, Third edition, Mcgraw Hill.

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3: Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4: Remaining question will be randomly selected from all the modules.

Course Code	Course Name	Teaching scheme			Credit assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
BMC305	Biomaterials , Prosthetics and Orthotics (Abbreviated as BPO)	04	--	--	04	--	--	04

Course Code	Course Name	Examination Scheme								
		Theory					Term work	Pract	Oral	Pract. / Oral	Total
		Internal Assessment			End sem	Duration (hrs)					
		Test 1	Test 2	Avg.							
BMC305	Biomaterials Prosthetics and Orthotics (BPO)	20	20	20	80	03	--	--	--	--	100

Course Code	Course Name	Credits
BMC305	Biomaterials, Prosthetics and Orthotics	04
Course Objectives	• To understand the fundamentals of materials used for manufacturing implants that has wide application in healthcare industry. • To understand design principles of prostheses and orthoses.	
Course Outcomes	• Understand the definition, classification and general applications of biomaterials. Study the surface characterization techniques. • Understand properties and applications of polymeric, degradable and composite biomaterials. • Understand properties and applications of metals and ceramic biomaterials. • Selection of materials on the basis of testing of the biomaterials done biologically, mechanically, physio-chemically and thermally before implantation in the human body. • Study anatomical levers, gait cycle and gait parameters • Understand the definition of prostheses and orthoses and its design principles.	

Module	Contents	Hours
1	**Introduction**: Introduction of Biomaterials, Classification of Biomaterials, General Applications. **Techniques for characterization of Surface properties of Biomaterials:** Electron Spectroscopy for Chemical Analysis (ESCA), Secondary Ion Mass Spectrometry(SIMS), Infrared Spectroscopy, Contact Angle Method.	**08**
2	**Properties and Applications of Polymeric and degradable Biomaterials:** Classification, polyurethanes, PTFE, Polyethylene, Polypropylene, Polyacrylates, PMMA, PHEMA, Hydrogel, Silicone rubber, Biopolymer in fabrication of biodevices and implants, Thermoplastic and thermosetting plastics. Degradable biomaterials (PGA and PLA), applications in drug delivery systems. **Composite Biomaterials:** Properties, classification and Applications of Composite Biomaterials in fabrication of biodevices and implants. Applications of biomaterials in Drug delivery systems,	**09**
3	**Properties and Applications of Metallic Biomaterials and its Biocompatibility:** Stainless steel, Titanium, Titanium based alloys, Cobalt – Chromium alloys in fabrication of bio-devices and implants. **Properties and Applications of Ceramic Biomaterials:** Classification, Alumina, Zirconia and types, Bioglass, Calcium Phosphate, Tricalcium phosphate in fabrication of biodevices and implants.	**08**
4	**Biological Testing of Biomaterials:** Physiochemical Test, Mechanical Test, Invitro and Invivo types, Different forms of corrosion, Wear, Electrochemical Corrosion Testing.	**08**
5	**Movement biomechanics** Overview of joints and movments, anatomical levers, gait cycle (stance and swing phase with stick diagram), gait parameters	**05**
6	**Prosthetics and Orthotics** Principles of three point pressure, Lower limb prostheses, partial weight bearing-PTB socket, total contact- quadrilateral socket. Upper limb prosthesis (terminal devices) Spinal orthoses.	**10**

Books Recommended:

Text Books:

1. Biomaterial Science and Engineering: J.V. Park (Plenum Press- New York)
2. Fundaments of Biomedical Engineering: G S. Sawhney (New Age International Publication)
3. Biomaterial Science: An Introduction to Materials in Medicine, Ratner & Hoffmann
4. American Atlas of Orthopedics: Prosthetics, C. V. Mosby.
5. American Atlas of Orthopedics: Orthotics, C. V. Mosby
6. Basics of Biomechanics by Ajay Bahl, Jaypee publications.

Reference Books:

1. Encyclopedia of Medical Devices and Instrumentation: John G. Webster. Vol. I, II, III, IV (Marcel Dekkar Pub).
2. Encyclopedia – Handbook of Biomaterials and Bioengineering: Part-A: Materials Vol I, II (Marcel Dekkar Pub) Part – B: Applications Vol. I, II.
3. Design Engineering on Biomaterials for medical devices: David Hill, John Willey Publication
4. Biological Performance of Materials, 2nd Edition – Jonathan Black, Marcel Dekker Inc. New York. Basel. Hong Kong

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining question will be randomly selected from all the modules.

Course Code	Course Name	Teaching scheme			Credit assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
BML301	Object Oriented Programming (Abbreviated as OOPM)	--	04#	--	--	02	--	02

 # Out of four hours, 2 hours theory shall be taught to the entire class and 2 hours practical in batches.

Course Code	Course Name	Examination Scheme								
		Theory				Term work	Pract.	Oral	Pract. / Oral	Total
		Internal Assessment			End sem					
		Test 1	Test 2	Avg.						
BML301	Object Oriented Programming (OOPM)	--	--	--	--	50	--	--	50	100

Course Code	Course Name	Credits
BML301	Object Oriented Programming	02
Course Objective	• To learn the object oriented programming concepts • To study various java programming constructs like multithreading, exception handling, packages etc. • To explain components of GUI based programming.	
Course Outcome	• To apply fundamental programming constructs. • To illustrate the concept of packages, classes and objects. • To elaborate the concept of strings, arrays and vectors. • To implement the concept of inheritance and interfaces. • To implement the notion of exception handling and multithreading. • To develop GUI based application.	

Prerequisite: Structured Programming Approach

Sr. No.	Module	Detailed Content	Hours

1	**Introduction to Object Oriented Programming**	**1.1OO Concepts:** Object, Class, Encapsulation, Abstraction, Inheritance, Polymorphism. **1.2Features of Java, JVM** **1.3 Basic Constructs/Notions:** Constants, variables and data types, Operators and Expressions,Revision of Branching and looping	02
2	**Classes, Object and Packages**	**2.1**Class,Object, Method. **2.2** Constructor, Static members and methods **2.3** Passing and returning Objects **2.4**Method Overloading **2.5** Packages in java, creating user defined packages, access specifiers.	05
3	**Array, String and Vector**	**3.1** Arrays, Strings, StringBuffer **3.2** Wrapper classes, Vector	04
4	**Inheritance and Interface**	**4.1**Types of Inheritance, super keyword, Method Overriding, abstract class and abstract method, final keyword, **4.2** Implementing interfaces, extending interfaces	03
5	**Exception Handling and Multithreadin g**	**5.1** Error vs Exception, try, catch, finally, throw, throws, creating own exception **5.2** Thread lifecycle, Thread class methods, creatingthreads, Synchronization	04
6	**GUI programming in JAVA**	**6.1 Applet:** Applet life cycle, Creating applets, Graphics class methods, Font and Color class, parameter passing. **6.2 Event Handling:** Event classes and event listener **6.3 Introduction to AWT:** Working with windows, Using AWT controls- push Buttons, Label, Text Fields, Text Area, Check Box, and Radio Buttons.	06

Note: #Out of four hours of practical two hours to be conducted as theory

List of Laboratory Experiments: (Any Fifteen experiments and three assignments)

1. Program on various ways to accept data through keyboard and unsigned right shift operator.
2. Program on branching, looping, labelled break and labelled continue.
3. Program to create class with members and methods, accept and display details for single object.
4. Program on constructor and constructor overloading
5. Program on method overloading
6. Program on passing object as argument and returning object
7. Program on creating user defined package
8. Program on 1D array

9. Program on 2D array
10. Program on String
11. Program on StringBuffer
12. Program on Vector
13. Program on single and multilevel inheritance (Use super keyword)
14. Program on abstract class
15. Program on interface demonstrating concept of multiple inheritance
16. Program on dynamic method dispatch using base class and interface reference.
17. Program to demonstrate try, catch, throw, throws and finally.
18. Program to demonstrate user defined exception
19. Program on multithreading
20. Program on concept of synchronization
21. Program on Applet to demonstrate Graphics, Font and Color class.
22. Program on passing parameters to applets
23. Program to create GUI application without event handling using AWT controls
24. Program to create GUI application with event handling using AWT controls

Books Recommended:

Text books:

1. Herbert Schildt, 'JAVA: The Complete Reference', Ninth Edition, Oracle Press.
2. Sachin Malhotra and Saurabh Chaudhary, "Programming in Java", Oxford University

Reference Books:

1. Ivor Horton, 'Beginning JAVA', Wiley India.
2. DietalandDietal, 'Java: How to Program', 8/e,PHI
3. 'JAVA Programming', Black Book, Dreamtech Press.

Assessment:

Term Work:

Term work shall consist of minimum 15 experiments and 3 Assignments
The distribution of marks for term work shall be as follows:
Laboratory work (Experiments): 20 Marks
Laboratory work (journal) : 10 Marks
Assignments : 15 Marks
Attendance : 5 Marks

The final certification and acceptance of term work ensures the satisfactory performance of laboratory work and minimum passing in the term work.

Practical and oral examination will be based on suggested practical list and entire syllabus.

Course Code	Course Name	Teaching scheme			Credit assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
BML302	Basics of Human Physiology (BHP)	--	02	--	--	01	--	01

Course Code	Course Name	Examination Scheme							
		Theory				Term work	Pract.	Oral	Pract. / Oral	Total
		Internal Assessment			End sem					
		Test 1	Test 2	Avg.						
BML302	Basics of Human Physiology (BHP)	--	--	--	--	25	--	25	--	50

Course Code	Course Name	Credits
BML302	Basics of Human Physiology	01
Course Objective	• To understand the human anatomy and functions of various body structures. • To understand different physiological processes taking place inside human body	
Course Outcome	• To measure blood pressure using occlusive cuff method • To apply blood cell counting principle for measuring blood composition. • To analyse electrical activity of heart. • To apply the knowledge of instruments used for supporting cardio-vascular system	

Syllabus: Same as that of BMC302 Basics of Human Physiology.

List of Laboratory Experiments: (Any Seven)

1. To measure Blood Pressure using sphygmomanometer using occlusive cuff method.
2. To determine hemoglobin count in the blood by Sahli's method.
3. In-vitro recognition of A, B, O blood groups by slide test.
4. To find the total Red Blood Cell count using Neubauer's haemocytometer.
5. To find the total White Blood Cell count using Neubauer's haemocytometer.
6. To study ECG Machine

7. To study electrical activity of heart
8. To measure heart-beats using PQRST Waveform of ECG.
9. To study Cardiac Pacemaker.
10. To study Defibrillator.
11. Visit to the hospital anatomy department to view specimen.
12. Presentations on the given topic.

Any other experiment based on syllabus which will help learner to understand topic/concept

Books Recommended:

Text books:

1. Anatomy and Physiology in Health and Illness: Ross and Wilson. (ELBS Pub)
2. Essentials of Anatomy and Physiology: Elaine N Marieb. (Pearson Education)

Reference Books:

1. Physiology of Human Body. : Guyton. (Prism Book)
2. Review of Medical Physiology: William Ganong. (Prentice Hall Int)
3. Principles of Anatomy and Physiology: Tortora and Grabowski. (Harper collin Pub)
4. Anatomy and Physiology: Elaine N Marieb. (Pearson Education)

Assessment:

Term Work:

Term work shall consist of minimum 7 experiments.
The distribution of marks for term work shall be as follows:
Laboratory work (Experiments) : 10 Marks
Laboratory work (programs / journal) : 10 Marks
Attendance : 5 Marks
The final certification and acceptance of term work ensures the satisfactory performance of laboratory work and minimum passing in the term work.

Oral examination will be based on suggested practical list and entire syllabus.

Course Code	Course Name	Teaching scheme			Credit assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
BML303	Electrical Network Analysis and Synthesis (ENAS)	--	02	--	--	01	--	01

Course Code	Course Name	Examination Scheme								
		Theory				Term work	Pract.	Oral	Pract. / Oral	Total
		Internal Assessment			End sem					
		Test 1	Test 2	Avg.						
BML303	Electrical Network Analysis and Synthesis (ENAS)	--	--	--	--	25	--	25	--	50

Course Code	Course Name	Credits
BML303	Electrical Network Analysis and Synthesis	01
Course Objective	• To implement several methods of simplifying networks. • To verify network theorems for analyzing electrical circuits. • To understand the concept of graphical solution to electrical network • To study frequency response in electrical circuits. • To make the learner learn how to synthesize an electrical network from a given impedance/admittance function.	
Course Outcome	Learner will be able to • Apply number of powerful engineering circuit analysis techniques such as nodal analysis, mesh analysis, source transformation and several methods of simplifying networks. • Implement network theorems to analyze the circuit • Apply the concept of graphical solution to electrical network. • Discriminate between different one port and two port network parameters • Analyze time and frequency response of the electrical circuits • Synthesize an electrical network from a given impedance/admittance function.	

Syllabus: Same as that of BMC303 Electrical Network Analysis and Synthesis.

List of Laboratory Experiments: (Any five)

1. To study superposition theorem
2. To study Norton theorem
3. To study Thevenin's theorem
4. To study and verify Maximum power theorem
5. To study transfer functions
6. a) To study Y parameters of a two-port network.
   b) To study Z parameters of a two-port network.
7. Interconnection of two-port network
8. To study Time Response of first order system
9. To study the second order frequency response of an RLC circuit

Suggested Tutorials: (Any six)

1. Mesh & Node Analysis with Independent Sources
2. Mesh & Node Analysis with Dependent Sources
3. Network Theorems
4. Circuit Analysis
5. Time and Frequency Response of Circuits (Transient Analysis)
6. Time and Frequency Response of Circuits (Laplace Transform Analysis)
7. Two-Port Networks (Two-Port Parameters)
8. Two-Port Networks (Inter Relationship of different parameters. Interconnections of two-port networks)
9. Fundamentals of Network Synthesis (Hurwitz polynomials and Positive real functions)
10. Fundamentals of Network Synthesis (Driving Point Synthesis with L-C, R-C, R-L and R-L- C networks)

Any other experiment based on syllabus which will help learner to understand topic/concept

Books Recommended:

Text Books:

1. Sudhakar & S.P. Shyammohan, Circuits and Networks, Tata McGraw Hill, thirteenth reprint, 2000.
2. William H. Hayt, Jack e. Kemmerly & Steven M. Durbin, Engineering Circuit Analysis, McGraw Hill International, sixth edition, 2202.
3. Raymond A. DeCarlo & Pen-Min Lin, Linear Circuit Analysis, Oxford University Press, second edition, 2001.
4. M. E. Van Valkenburg, Introduction to Modern Network Synthesis, Wiley Eastern Ltd.

Reference Books:

1. Artice M. Davis, Linear Circuit Analysis, Thomson Asia Pte. Ltd, Singapore, first edition, 2001.
2. M.E. Van Valkenburg, Network Analysis, Prentice Hall of India, third edition
3. C.L.Wadhwa, Network Analysis and Synthesis, New Age International Publisher, Third Edition.

Assessment:

Term Work:

Term work shall consist of minimum 5 experiments and 6 tutorials

The distribution of marks for term work shall be as follows:

Laboratory work (Experiments) : 10 Marks

Laboratory work (Tutorials) : 10 Marks

Attendance : 5 Marks

The final certification and acceptance of term work ensures the satisfactory performance of laboratory work and minimum passing in the term work.

Oral examination will be based on suggested practical list and entire syllabus.

Course Code	Course Name	Teaching scheme			Credit assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
BML304	Electronic Circuit Analysis and Design (ECAD)	--	02	--	--	01	--	01

Course Code	Course Name	Examination Scheme								
		Theory				Term work	Pract.	Oral	Pract. / Oral	Total
		Internal Assessment			End sem					
		Test 1	Test 2	Avg.						
BML304	Electronic Circuit Analysis and Design (ECAD)	--	--	--	--	25	--	--	25	50

Course Code	Course Name	Credits
BML304	Electronic Circuit Analysis and Design	01
Course Objective	• To apply the theoretical knowledge of semiconductor devices to practical circuits. • To design and implement Clippers, Clampers, Zener regulator and small signal amplifiers	
Course Outcome	Learner will be able to: • Verify the outputs of various electronic circuits such as clipper, clampers etc. • Verify the transfer characteristics of basic semiconductor devices. • Design amplifier circuits and verify their results practically. • Study frequency response of small signal amplifiers.	

Syllabus: Same as that of BMC304 Electronic Circuit Analysis and Design.

List of Laboratory Experiments: (Any seven)

1. To study Clipper circuit
2. To study Clampers circuit
3. Study of zener as a regulator
4. Study of BJT characteristics
5. Study of BJT as switch
6. Implementation of biasing circuit of BJT

7. Study of frequency response of CE amplifier
8. Study of FET characteristics
9. Implementation of biasing circuit of FET
10. Study of Frequency response of CE amplifier

Any other experiment based on syllabus which will help learner to understand topic/concept

Books Recommended:

Text Books:

1. Neamen Donald A., *Electronics Ckt. Analyzer & Design*, 2nd ed., Tata McGraw Hill.
2. Boylestad Robert L., Nashelsky Louis, *Electronics Devices & Circuits*, Pearson Education.
3. *Semiconductor Data Manual*, BPB Publications.

Reference Books:

1.Malvino—Electronic Principles , 6/e ,TMH
2. Millman & Halkias: Basic Electronic Principles; TMH.
3..Martin Roden, Gordon carpenter, William Wieseman, Electronic design, Fourth edtion, Sroff publishers.
4. Donald Schilling & Charles Belove, Electronic Circuits Discrete and Integrated, Third edition, Mcgraw Hill.

Assessment:

Term Work:

Term work shall consist of minimum 7 experiments.
The distribution of marks for term work shall be as follows:
Laboratory work (Experiments) : 10 Marks
Laboratory work (Journal) : 10 Marks
Attendance : 5 Marks
The final certification and acceptance of term work ensures the satisfactory performance of laboratory work and minimum passing in the term work.

Practical and oral examination will be based on suggested practical list and entire syllabus.

Course Code	Course Name	Teaching scheme			Credit assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
BML305	Biomaterials, Prosthetics and Orthotics (BPO)	--	02	--	--	01	--	01

Course Code	Course Name	Examination Scheme								
		Theory				Term work	Pract.	Oral	Pract. / Oral	Total
		Internal Assessment			End sem					
		Test 1	Test 2	Avg.						
BML305	Biomaterials, Prosthetics and Orthotics (BPO)	--	--	--	--	25	--	25	--	50

Course Code	Course Name	Credits
BML305	Biomaterials, Prosthetics and Orthotics	01
Course Objective	• To understand the fundamentals of materials used for manufacturing implants that has wide application in healthcare industry. • To understand design principles of prostheses and orthoses	
Course Outcome	Learners will be able to: • Understand the definition, classification and general applications of biomaterials. Study the surface characterization technique • Understand properties and applications of polymeric, degradable and composite biomaterials. • Understand properties and applications of metals and ceramic biomaterials. • Selection of materials on the basis of testing of the biomaterials done biologically, mechanically, physio-chemically and thermally before implantation in the human body. • Study anatomical levers, gait cycle and gait parameters • Understand the definition of prostheses and orthoses and its design principles.	

Syllabus: Same as that of BMC305 Biomaterials, Prosthetics and Orthotics

List of Laboratory Experiments: (Any seven)

1) Introduction of Biomaterials.
2) Techniques for characterization of Surface properties of Biomaterials.
3) Biological Testing of Biomaterials.
4) Mechanical and Physiochemical Testing of Biomaterials
5) Properties and Applications of Metallic Biomaterials and its Biocompatibility.

6) Properties and Applications of Polymeric Biomaterials.
7) Properties and Applications of Ceramic Biomaterials.
8) Properties and Applications of Composite Biomaterials.
9) Corrosion of biomaterials
10) Biomaterials for Soft Tissue Replacements.

Any other experiment based on syllabus which will help learner to understand topic/concept

Books Recommended:

Text Books:

1. Biomaterial Science and Engineering: J.V. Park (Plenum Press- New York)
2. Fundaments of Biomedical Engineering: G S. Sawhney (New Age International Publication)
3. Biomaterial Science: An Introduction to Materials in Medicine, Ratner & Hoffmann
4. American Atlas of Orthopedics: Prosthetics, C. V. Mosby.
5. American Atlas of Orthopedics: Orthotics, C. V. Mosby
6. Basics of Biomechanics by Ajay Bahl, Jaypee publications.

Reference Books:

1. Encyclopedia of Medical Devices and Instrumentation: John G. Webster. Vol. I, II, III, IV (Marcel Dekkar Pub).
2. Encyclopedia – Handbook of Biomaterials and Bioengineering: Part-A: Materials Vol I, II (Marcel Dekkar Pub) Part – B: Applications Vol. I, II.
3. Design Engineering on Biomaterials for medical devices: David Hill, John Willey Publication
4. Biological Performance of Materials, 2nd Edition – Jonathan Black, Marcel Dekker Inc. New York. Basel. Hong Kong

Assessment:

Term Work:

Term work shall consist of minimum 7 experiments / tutorials
The distribution of marks for term work shall be as follows:
Laboratory work (Experiments / Tutorials): 20 Marks
Attendance : 5 Marks
The final certification and acceptance of term work ensures the satisfactory performance of laboratory work and minimum passing in the term work.

Oral examination will be based on suggested practical list and entire syllabus.

Course Code	Course Name	Teaching scheme			Credit assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
BMC401	Applied Mathematics IV (Abbreviated as AM - IV)	04	--	01	04	--	01	05

Course Code	Course Name	Examination Scheme									
		Theory					Term work	Pract	Oral	Pract. / Oral	Total
		Internal Assessment			End sem	Duration (hrs)					
		Test 1	Test 2	Avg.							
BMC401	Applied Mathematics IV (AM - IV)	20	20	20	80	03	25	--	--	--	125

Course Code	Course Name	Credits
BMC401	Applied Mathematics IV	05
Course Objectives	• To develop analytical insight of the student to prepare them for graduates studies in Biomedical Engineering • To enhance their ability to solve and analyse Biomedical Engineering problem. • To provide learner with a strong mathematical foundation to acquire the professional competence knowledge and skills.	
Course Outcomes	• It is expected that learner will develop the proactive approach towards the selection of methods to a solution of Biomedical Engineering problems. • Learner will be able identify different probability distribution , learn sampling technique, compute Eigen values and Eigen vectors and evaluate complex integrals and use their application in Biomedical Engineering problems. • Learner will be able to know new subjects that are required to solve in industry.	

1		**Calculus of Variation:**	**06**
	1.1	Euler's Langrange equation, solution of Euler's Langrange equation (only results for different cases for Function) independent of a variable, independent of another variable, independent of differentiation of a variable and independent of both variables	
	1.2	Isoperimetric problems, several dependent variables	
	1.3	Functions involving higher order derivatives: Rayleigh-Ritz method	
2		**Linear Algebra: Vector Spaces**	**06**
	2.1	Vectors in n-dimensional vector space: properties, dot product, cross product, norm and distance properties in n-dimensional vector space.	
	2.2	Vector spaces over real field, properties of vector spaces over real field, subspaces.	
	2.3	The Cauchy-Schwarz inequality, Orthogonal Subspaces, Gram-Schmidt process.	
3		**Linear Algebra: Matrix Theory**	**10**
	3.1	Characteristic equation, Eigen values and Eigen vectors, properties of Eigen values and Eigen vectors	
	3.2	Cayley-Hamilton theorem (without proof), examples based on verification of Cayley- Hamilton theorem.	
	3.3	Similarity of matrices, Diagonalisation of matrices.	
	3.4	Functions of square matrix, derogatory and non-derogatory matrices.	
4		**Probability**	**10**
	4.1	Baye's Theorem (without proof)	
	4.2	Random variable: Probability distribution for discrete and continuous random variables, Density function and distribution function, expectation, variance.	
	4.3	Moments, Moment Generating Function.	
	4.4	Probability distribution: Binomial distribution, Poisson & normal distribution (For detailed study)	
5		**Correlation**	**04**
	5.1	Karl Pearson's coefficient of correlation, Covariance, Spearman's Rank correlation,	
	5.2	Lines of Regression.	
6		**Complex integration**	**12**
	6.1	Complex Integration: Line Integral, Cauchy's Integral theorem for simply connected regions, Cauchy's Integral formula.	
	6.2	Taylor's and Laurent's Series	
	6.3	Zeros, singularities, poles of f(z), residues, Cauchy's Residue theorem.	
	6.4	Applications of Residue theorem to evaluate real Integrals of different types.	

Books Recommended:

Text books:

1. H.K. Das, "*Advanced engineering mathematics*", S . Chand, 2008
2. A. Datta, *"Mathematical Methods in Science and Engineering",* 2012
3. B.S. Grewal, *"Higher Engineering Mathematics",* Khanna Publication
4. P.N.Wartilar & J.N.Wartikar, "*A Text Book of Applied Mathematics*" Vol. I & II, Vidyarthi Griha Prakashan., Pune.

Reference Books:

1. B. V. Ramana, *"Higher Engineering Mathematics",* Tata Mc-Graw Hill Publication
2. Wylie and Barret, *"Advanced Engineering Mathematics",* Tata Mc-Graw Hill 6th Edition
3. Erwin Kreysizg, *"Advanced Engineering Mathematics",* John Wiley & Sons, Inc
4. Seymour Lipschutz "*Beginning Linear Algebra*" Schaum's outline series, Mc-Graw Hill Publication
5. Seymour Lipschutz "*Probability*" Schaum's outline series, Mc-Graw Hill Publication

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

Term Work:

Term work shall consist of minimum 8 tutorials
The distribution of marks for term work shall be as follows:
Tutorials : 20 Marks
Attendance : 5 Marks
The final certification and acceptance of term work ensures the satisfactory performance of laboratory work and minimum passing in the term work.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3 Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked
4: Remaining question will be randomly selected from all the modules.

Course Code	Course Name	Teaching scheme			Credit assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
BMC402	Biomedical Transducers and Measuring Instruments (Abbreviated as BTMI)	04	--	--	04	--	--	04

Course Code	Course Name	Examination Scheme									
		Theory					Term work	Pract	Oral	Pract. / Oral	Total
		Internal Assessment			End sem	Duration (hrs)					
		Test 1	Test 2	Avg.							
BMC402	Biomedical Transducers and Measuring Instruments (BTMI)	20	20	20	80	03	--	--	--	--	100

Course Code	Course Name	Credits
BMC402	Biomedical Transducers and Measuring Instruments	04
Course Objectives	• To provide the knowledge of basic concepts such as measuring instruments and generalized instrumentation system, general properties of input transducers, static and dynamic characteristics of transducers and sensors. • To provide a thorough understanding of principle and working of transducers and sensors used for displacement, motion, pressure and temperature measurement, bio-potential electrodes, chemical sensors, biosensors, fiber optic sensors, and radiation sensors. • To study the biomedical applications of the above transducers and sensors. • To perform experiments based on some of the above transducers and sensors.	
Course Outcomes	• To clearly understand generalized medical instrumentation system, general properties of transducers, static and dynamic characteristics of transducers and sensors. • Understand the fundamental principles and applications of various types of sensors including motion, displacement and pressure sensors. • Present different transduction methods for measuring temperature. • To understand principle of various biopotential electrodes • Understand principle and working of chemical sensor • To understand principle of various biosensors, and differentiate various amperometric and potentiometric sensors.	

Module	Contents	Hours
1	**Introduction:** Generalized Instrumentation System, General Properties Of Input Transducer. Static Characteristics: Accuracy, Precision, Resolution, Reproducibility, Sensitivity, Drift, Hysteresis, Linearity, Input Impedance and Output Impedance. Dynamic Characteristics: First Order and Second Order Characteristics, Time Delay, Error Free Instrument, Transfer Functions. Design Criteria, Generalized Instrument Specifications.	**04**
2	**Medical Instruments:** **Electronic and Digital Voltmeter** Types: FET Voltmeter, Peak and Average Responding voltmeter, True RMS responding voltmeter. Digital to Analog Converter: Binary weighted and R-2R ladder. Analog to digital converter: Ramp type, Dual Slope type, Successive Approximation type ADC, DVM: Ramp type, Dual Slope type, Successive Approximation type, Flash type DVM. Resolution & Sensitivity. Multimeter: Working, Specifications. **Oscilloscopes:** Block Diagram of C.R.O (in details). Requirements of Time base, Delayed Time Base, Post deflection acceleration, triggering. Description of Panel Layout and working of controls. Specifications of CRO. Applications: Measurement of voltage, current. Types: Dual trace, Dual beam, Digital Storage – Block diagram, working, application, comparison.	**14**
3	**Displacement, motion and Pressure Measurement**: (with applications) Resistive: Potentiometers, Strain Gauges and Bridge Circuits. Inductive: Variable Inductance and LVDT Capacitive type, Piezoelectric Transducers. Types of Diaphragms, Bellows, Bourdon Tubes.	**10**
4	**Temperature Measurement:** Thermistor, Thermocouple, Resistive Temperature Detector, IC based Temperature Measurement Radiation Sensors	**06**
5	**Bio potential Electrodes:** Electrodes Electrolyte Interface, Half-Cell Potential, Polarization, Polarizable and Non Polarizable, Electrodes, Calomel Electrode, Electrode Circuit Model, Electrode Skin-Interface and Motion Artifact. Body Surface Electrodes. Internal Electrodes: Needle and Wire Electrodes (Different Types). Microelectrodes: Metal, Supported Metal Micropipette (Metal Filled Glass And Glass Micropipette Electrodes)	**06**
6	**Chemical Sensors:** Blood gas and Acid- Base Physiology, Potentiometric Sensors (pH, pCO_2 Electrodes, Amperometric Sensors (pO_2), ISFETS, Transcutaneous Arterial O_2 and CO_2 Tension Monitoring. **Fiber Optic Sensors:** Principle of Fiber Optics, Fiber Optic Sensors - Temperature, Chemical, Pressure. **Biosensor:** Classifications and types with examples.	**08**

Books Recommended:

Text Books:

1. Kalasi H.S.- Electronic Instrumentation
2. A.K. Sawhney- Electrical & Electronic Measurement & Instrumentation.
3. Medical Instrumentation-Application and Design by John G. Webster.
4. Instrument Transducer – An Intro to their performance and design, Hermann K P. Neubert.
5. Biomedical sensors – fundamentals and application by Harry N, Norton.
6. Biomedical Transducers and Instruments, Tatsuo Togawa, Toshiyo Tamma and P. Ake Öberg.
7. Electronics in Medicine and Biomedical Instrumentation by Nandini K. Jog PHI Second Edition 2013.

Reference Books:

1. Principles of applied Biomedical Instrumentation by La Geddes and L.E. Baker.
2. Biomedical Instrumentation and Measurement by Leslie Cromwell, Fred. J. Weibell and Pfeiffer.
3. Principles of Biomedical Instrumentation and Measurement, Richard Aston, Merril Publishing Co., Columbus, 1990.
4. Measurement Systems, Application and Design, Ernest O. Doeblin, McGraw-Hill, 1985.
5. Handbook of Modern Sensors – Physics, Design and Application, Jacob Fraden, AIP press.
6. Transducers for Biomedical Measurements: Principles and Applications, Richard S.C. Cobbold, John Wiley & Sons, 1974.

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining question will be randomly selected from all the modules

Course Code	Course Name	Teaching scheme			Credit assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
BMC403	Linear Integrated Circuits (Abbreviated as LIC)	04	--	--	04	--	--	04

Course Code	Course Name	Examination Scheme									
		Theory					Term work	Pract	Oral	Pract. / Oral	Total
		Internal Assessment			End sem	Duration (hrs)					
		Test 1	Test 2	Avg.							
BMC403	Linear Integrated Circuits (LIC)	20	20	20	80	03	--	--	--	--	100

Course Code	Course Name	Credits
BMC403	Linear Integrated Circuits	04
Course Objectives	• To provide concepts of differential, operational and power amplifiers with their applications and design methodology • To cover analysis of circuits with negative feedback	
Course Outcomes	Learner will be able to: • Analyse different types of differential amplifiers • Demonstrate basics of operational amplifiers • Analyse and design operational amplifier to perform mathematical operations • Analyse and design operational amplifier as oscillators • Illustrate basics of negative feedback and perform analysis on different types of circuits with negative feedback • Exhibit working of power amplifiers, its types and DC and AC analysis and designing	

Module	Contents	Hours
1.	**Differential Amplifiers:** • Basic Concept • Types: Dual Input Balanced Output, Dual Input Unbalanced Output, Single Input Balanced Output And Single Input Unbalanced Output. • Common mode and Differential mode analysis - DC and AC analysis. • Differential amplifiers with Swamping Resistor • Constant current source, current mirror circuits	**05**
2.	**Introduction to operational Amplifier :** • Introduction to an Ideal Operational Amplifier, Block Diagram, DC and AC Characteristics, Equivalent circuit of Op-amp • Op-amp IC 741 characteristics, frequency response and concept of virtual ground.	**05**
3.	**Applications of operational Amplifier :** • Adder, Subtractor /differential Amplifier, Voltage follower, Integrator (practical and Ideal), Differentiator (practical and Ideal), Instrumentation amplifier • Voltage to Current and Current to Voltage converters, Active Half wave rectifiers, Active Full wave rectifier, Clipper, Clampers, Log and Antilog amplifiers, Sample & hold circuits, Peak detector, Multipliers and Dividers, • Schmitt Trigger (Regenerative comparator), Voltage comparators, zero crossing detector.	**15**
4.	**Oscillators using Operational Amplifier:** • Concepts of Oscillation. Barkhausen's criteria for an oscillator. • Types of oscillators: RC Phase shift Oscillator, Wien Bridge oscillator, Colpitt's Oscillator, Hartley Oscillator, Crystal Oscillator, Clapp Oscillator, (Phase shift, Frequency of oscillation, condition of sustained oscillation, circuit operation and Amplitude stability in the above oscillators).	**08**
5.	**Negative Feedback:** • Introduction to Feedback • Negative feedback characteristics: Gain Sensitivity, Bandwidth Extension, Noise Sensitivity, Reduction of Non-Linear Distortion. • Feedback Topologies, Series-Shunt, Shunt-Series, Series-Series, Shunt-Shunt Configurations • Negative feedback amplifiers: Voltage Amplifiers, Current Amplifiers, Trans-Conductance Amplifiers, Trans-Resistance Amplifiers (DC and AC analysis.	**10**
6.	**Power Amplifiers :** • Classes of Power amplifiers, Class-A, Class-B, Class AB, Class C • Analysis: Class-A Power Amplifiers (Direct coupled and Transformer coupled), Class-B Power Amplifiers, Class-AB Push Pull and Complementary Symmetry Power amplifier • Power amplifier design, Heat Sinks and its design	**05**

Books Recommended:

Text Books:

1.. Electronic Circuit Analysis and Design- Donald A Neamen,
2. Electronic Devices and circuits – R Bolystead.
3. Op-Amps and linear integrated circuits – R. Gayakwad
4. Linear Integrated Circuits: Roy Chaudhary

Reference Books:

1. Integrated Electronics –Millman & Halkias
2. Opamps and linear integrated circuits, Theory and Applications- James Fiore

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining question will be randomly selected from all the modules.

Course Code	Course Name	Teaching scheme			Credit assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
BMC404	Digital Electronics (Abbreviated as DE)	04	--	--	04	--	--	04

Course Code	Course Name	Examination Scheme									
		Theory					Term work	Pract	Oral	Pract. / Oral	Total
		Internal Assessment			End sem	Duration (hrs)					
		Test 1	Test 2	Avg.							
BMC404	Digital Electronics (DE)	20	20	20	80	03	--	--	--	--	100

Course Code	Course Name	Credits
BMC404	Digital Electronics	04
Course Objectives	• To make learner aware of basics of Digital circuits, logic design, various Logic Families and Flip-flops. • Learner should be able to design of various counters, registers and their applications.	
Course Outcomes	Learner will be able to: • Understand various number systems and its arithmetic (BCD, Binary, Octal, Hexadecimal etc.) • Solve sums on K-maps, Boolean algebra and SOP-POS implementations. • Design code converter circuits, parity generator-checker circuits and magnitude comparator circuits. • Design circuits using multiplexers, demultiplexers, and decoders. • Design synchronous and asynchronous counters and registers using flip flops. • Design various gates using various logic families.	

Module	Contents	Hours
1.	**Introduction:** Number system, Binary, Octal, Hexadecimal and other. Conversion from One system to another, Binary, BCD and Hexadecimal. Binary Arithmetic (addition, subtraction, multiplication, division) Hexadecimal and octal arithmetic, first and second complement methods. **Binary Codes:** Weighted Reflective, Sequential, Gray, Error detecting codes, Odd, Even parity, Hamming Codes, Alphanumeric, Morse, Teletypewriter ASCII, EBCDIC codes, Converting Binary to Gray & Gray to Binary, Conversion from BCD to XS3. Application of gray code, shaft position encoding. **Boolean Algebra Logic Gates:** AND, OR, NOT, XOR, XNOR, operation NAND, NOR used of the universal gate for Performing different operation. Laws of Boolean algebra. De- Morgan's theorems. Relating a Truth Table to a Boolean Expression. Multi level circuits.	**05**
2.	**Combinational Circuits:** K-MAPS and their use in specifying Boolenan Expressions, Minterm, Maxterm SOP and POS Implementation. Implementation a logic function using universal gates. Variable entered maps For five and six variable functions Quine Mc Clusky tabular techniques.	**05**
3.	**Combinational Logic Circuit Design:** Designing code converter circuits e.g. Binary to Gray, BCD to Seven Segments, Parity Generator. Binary Arithmetic circuits:- Adders, Subtractors (Half and full) BCD adder- Subtractor, carry Lookaheard adder, Serial adder, Multiplier Magnitude Comparators, 7485 comparator, Arithmetic Logic units. **Use of Multiplexers in Logic Design:** Multiplexer (ULM) Shannon's theorem. ULM trees. De- Multiplexers, Line decoders, Designing using ROMs and ULMs. Hazards in combinational circuits.	**15**
4.	**Sequential Logic Circuits:** Comparison of Combinational & Sequential Circuits, Multi-vibrators (Astable, Monostable And Bistable) Flip-Flops, SR, T, D, JK, Master Slave JK, Converting one Flip-Flop to another, State transition diagrams, Use of Denounce switch. Counter Modulus of a counter, Ripple counter, Up/Down Counter, Designing sequential counters using gate IC and counter IC by drawing state transition Diagram & state transition table. Ring counter Johnson counter, twisted ring counter, Pseudo Random number generator, Unused states and locked conditions.	**08**
5.	**Registers:** Serial input serial output, serial input parallel output, Left Right shift register, Use of register ICs for sequence generator and counter. Bidirectional shift register, Universal shift register	**10**
6.	**Logic Families:** RTL, DTL, TTL, schotkey clamped TTL, Tristate gate ECL, IIL, MOS device CMOS Comparison of logic families, interfacing different families. TTL with CMOS, NMOS, TTL, ECL, & TTL, IIL, & TTL.	**05**

Books Recommended:

Text Books:

1. R.P.Jain, "Modern Digital Electronics," Tata McGraw Hill, 1984
2. M Morris Mono, "Digital Design," Prentice Hall International-1984.
3. Malvino & Leach, "Digital Principal and Applications", Tata McGraw Hill, 1991.
4. Malvino, "Digital Electronics", Tata McGraw Hill, 1997.

Reference Books:

1. James Bignell & Robert Donovan, “Digital Electronics”, Delmar, Thomas Learning,
2. Jog N.K, “Logic Circuits”, 2nd edition, Nandu Publisher & Printer Pvt .Ltd. 1998.
3. Alan b. Marcovitz, “Introduction to Logic Design “, McGraw Hill International 2002.

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining question will be randomly selected from all the modules

Course Code	Course Name	Teaching scheme			Credit assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
BMC405	Signals and Control System (Abbreviated as SCS)	04	--	--	04	--	--	04

Course Code	Course Name	Examination Scheme									
		Theory					Term work	Pract	Oral	Pract. / Oral	Total
		Internal Assessment			End sem	Duration (hrs)					
		Test 1	Test 2	Avg.							
BMC405	Signals and Control System (Abbreviated as SCS)	20	20	20	80	03	--	--	--	--	100

Course Code	Course Name	Credits
BMC405	Signals and Control Systems	04
Course Objectives	• To introduce the concepts and techniques associated with the understanding of signals and systems such as the basic parameters, properties and interaction of signals and system. • To familiarize with techniques suitable for analysing and synthesizing signals and systems in continuous domain.	
Course Outcomes	• Represent signals and system mathematically • Represent integral of LTI systems, properties of system in terms of impulse response • Determine Fourier series representation of CT, properties of Fourier series • Derive and determine Laplace transform, region of convergence, application of Laplace transform, Inverse Laplace transform. • Analyse given systems and suggest modifications.	

Module	Contents	Hours
1	**Introduction to Signals:** Basic of continuous time signals like unit step, ramp, exponential, operation on signals like flipping, shifting, scaling, and multiplication. Classification of signals: Periodic /Aperiodic, Power and Energy, Even and Odd.	07
2	**Introduction to Systems:** System representation in the continuous and discrete time domain. Classification of systems on the basis of Causal/non-Causal, Time variance/Time invariance, Linear/Non-Linear, Stable/Unstable. Continuous convolution	07

3	**Fourier Analysis of Continuous time Signals** Orthogonal functions, Representation of signals in terms of weighted orthogonal basis functions, Coefficient calculation on the basis of minimum square error**.** Fourier series: Representation of Fourier series in terms of sine, cosine, exponential functions. The complex Fourier spectrum, Properties of Fourier series, convergence of Fourier series, Gibbs phenomenon. Fourier transform and its properties. Fourier transform of singular functions. Energy density spectrum	**07**
4	**Laplace Transform:** Double sided Laplace transforms, Region of Convergence, properties, Unilateral Laplace Transform, properties, applications of Laplace transform to the solution of differential equations. Inverse Laplace Transform.	**08**
5	**Introduction to Control Systems**: Basic concepts of control systems, open loop and closed loop systems, difference between open loop and closed loop systems, signal flow graph.	**07**
6	**Time domain and Frequency domain behaviour of Systems** Time domain analysis of first order and second order systems. Condition of BIBO stability in time domain. Frequency response of linear systems. Stability and Routh array, Bode plots, Root Locus	**12**

Books Recommended:

Text Books:

1. Oppenheim A. V. & Alan S.Wllisky, Signals and Systems, Pearson Education
2. Simon Haykin & Barry Van Veen, Signals and Systems, Wiley-India
3. Modern Control Engineering : D.Roy Choudhury, PHI
4. Modem Control Engineering : K. Ogata , PHI
5. Control Systems Engineering: L.J. Nagrath, M. Gopal, Third Edition, New Age International Publishers.

Reference Books:

1. ProakisJ. G. & Manolakis D. G., Digital Signal Processing, Principles, algorithms & applications, Pearson Education
2. Ramesh Babu P., Signals and Systems, Scitech Publications (India) Pvt. Ltd.
3. Charles L. Phillips,John M. Parr & Eve A Riskin, Signals, Systems and Transforms, Pearson Education
4. Control System, Theory & Applications : Samarjit Ghosh, Pearson Education
5. System Dynamic and Control : Eroni Umez Erani., PWS Publishing, International Thompson Publishing Company

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining question will be randomly selected from all the modules.

Course Code	Course Name	Teaching scheme			Credit assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
BML401	Introduction to Simulations Tools (IST)	--	02	--	--	01	--	01

Course Code	Course Name	Examination Scheme								
		Theory				Term work	Pract.	Oral	Pract. / Oral	Total
		Internal Assessment			End sem					
		Test 1	Test 2	Avg.						
BML401	Introduction to Simulations Tools (IST)	--	--	--	--	25	25	--	--	50

Course Code	Course Name	Credits
BML401	Introduction to Simulations Tools	01
Course objective	• To study Simulation software • Study Proteus	
Course Outcome	Learner will be able to: • Understand various tools of simulation software • Write Programme in Programming Software • Simulate Digital and analog circuits • Understand use of Proteus software • Simulate differential equations	

List of Laboratory Experiments: (Any seven)

1. Study of Various simulation software Commands
2. Plotting variable using software
3. Study of various Proteus commands.
4. Simulating Inverting and Non inverting Amplifier in Proteus
5. Implementing logic gates using Proteus
6. Decade Counter using flip-flop in Proteus
7. Simulating differential Equations
8. Simulate basic electrical circuit using pspice

Any other experiment using these simulation tools which will help learner to understand the application of these tools during their B.E project work

Assessment:

Term Work:

Term work shall consist of minimum 7 experiments.

The distribution of marks for term work shall be as follows:

Laboratory work (Experiments) : 10 Marks

Laboratory work (Journal) : 10 Marks

Attendance : 5 Marks

The final certification and acceptance of term work ensures the satisfactory performance of laboratory work and minimum passing in the term work.

Practical examination will be based on suggested practical list.

Course Code	Course Name	Teaching scheme			Credit assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
BML402	Biomedical Transducers and Measuring Instruments (BTMI)	--	02	--	--	01	--	01

Course Code	Course Name	Examination Scheme								
		Theory				Term work	Pract.	Oral	Pract. / Oral	Total
		Internal Assessment			End sem					
		Test 1	Test 2	Avg.						
BML402	Biomedical Transducers and Measuring Instruments (BTMI)	--	--	--	--	25	--	25	--	50

Course Code	Course Name	Credits
BML402	Biomedical Transducers and Measuring Instruments	01
Course objective	• To display and record signals using CRO. • To implement digital to analog converter. • To analyse step response of a thermometer and measure temperature using various temperature transducers. • To measure displacement using various displacement transducers. • To measure pressure using a pressure transducer. • To measure pH of a solution using pH electrodes.	
Course Outcome	Learner will be able to: • Record and display signals using CRO. • Convert analog data into digital form. • Analyse step response of a thermometer and measure temperature using various temperature transducers. • Measure displacement using various displacement transducers. • Measure pressure using a pressure transducer. • Measure pH of a solution using pH electrodes.	

Syllabus: Same as that of BMC402 Biomedical Transducers and Measuring Instruments

List of Laboratory Experiments: (Any seven)

1. Study of Front panel of CRO
2. A to D converter
3. To study the dynamic behaviour of thermometer system.
4. To study the characteristics of a thermistor.
5. To study thermistor linearization.
6. To study the characteristics of a light dependent resister.

7. To study the principle and working of a thermocouple.
8. To study principle and working of LVDT.
9. To study principle and working of a capacitive Transducer.
10. To study principle and working of a strain gage sensor.
11. To study principle and working of a pressure sensor.
12. To study pH electrode.

Any other experiment based on syllabus which will help learner to understand topic/concept

Books Recommended:

Text Books:

1. Kalasi H.S.- Electronic Instrumentation
2. A.K. Sawhney- Electrical & Electronic Measurement & Instrumentation.
3. Medical Instrumentation-Application and Design by John G. Webster.
4. Instrument Transducer – An Intro to their performance and design, Hermann K P. Neubert.
5. Biomedical sensors – fundamentals and application by Harry N, Norton.
6. Biomedical Transducers and Instruments, Tatsuo Togawa, Toshiyo Tamma and P. Ake Öberg.
7. Electronics in Medicine and Biomedical Instrumentation by Nandini K. Jog PHI Second Edition 2013.

Reference Books:

1. Principles of applied Biomedical Instrumentation by La Geddes and L.E. Baker.
2. Biomedical Instrumentation and Measurement by Leslie Cromwell, Fred. J. Weibell and Pfeiffer.
3. Principles of Biomedical Instrumentation and Measurement, Richard Aston, Merril Publishing Co., Columbus, 1990.
4. Measurement Systems, Application and Design, Ernest O. Doeblin, McGraw-Hill, 1985.
5. Handbook of Modern Sensors – Physics, Design and Application, Jacob Fraden, AIP press.
6. Transducers for Biomedical Measurements: Principles and Applications, Richard S.C. Cobbold, John Wiley & Sons, 1974.

Assessment:

Term Work:

Term work shall consist of minimum 7 experiments.

The distribution of marks for term work shall be as follows:

Laboratory work (Experiments) : 10 Marks

Laboratory work (Journal) : 10 Marks

Attendance : 5 Marks

The final certification and acceptance of term work ensures the satisfactory performance of laboratory work and minimum passing in the term work.

Oral examination will be based on suggested practical list and entire syllabus.

Course Code	Course Name	Teaching scheme			Credit assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
BML403	Linear Integrated Circuits (LIC)	--	02	--	--	01	--	01

Course Code	Course Name	Examination Scheme								
		Theory				Term work	Pract.	Oral	Pract. / Oral	Total
		Internal Assessment			End sem					
		Test 1	Test 2	Avg.						
BML403	Linear Integrated Circuits (LIC)	--	--	--	--	25	--	--	25	50

Course Code	Course Name	Credits
BML403	Linear Integrated Circuits	01
Course Objective	• To provide designing methodology and implementation technique for differential, operational and power amplifiers.	
Course Outcome	• To design and implement various mathematical operations using operational amplifier • To implement waveform generation using operational amplifier • To implement circuits of differential amplifiers, power amplifiers and negative feedback.	

Syllabus: Same as that of BMC403 Linear Integrated Circuits

List of Laboratory Experiments: (Any seven)

1. Differential amplifier
2. Inverting amplifier
3. Non-inverting amplifier
4. Designing circuit using operational amplifier for given mathematical equation
5. Integrator
6. Differentiator
7. Half wave rectifier
8. RC-phase shift oscillator
9. Wein bridge oscillator
10. Instrumentation amplifier
11. Negative feedback

12. Schmitt trigger
13. Comparator
14. Zero crossing detector
15. Class B push pull power amplifier

Any other experiment based on syllabus which will help learner to understand topic/concept

Books Recommended:

Text Books:

1.. Electronic Circuit Analysis and Design- Donald A Neamen,
2. Electronic Devices and circuits – R Bolystead.
3. Op-Amps and linear integrated circuits – R. Gayakwad
4. Linear Integrated Circuits: Roy Chaudhary

Reference Books:

1. Integrated Electronics –Millman & Halkias
2. Opamps and linear integrated circuits, Theory and Applications- James Fiore

Assessment:

Term Work:

Term work shall consist of minimum 7 experiments.
The distribution of marks for term work shall be as follows:
Laboratory work (Experiments) : 10 Marks
Laboratory work (Journal) : 10 Marks
Attendance : 5 Marks
The final certification and acceptance of term work ensures the satisfactory performance of laboratory work and minimum passing in the term work.

Practical and oral examination will be based on suggested practical list and entire syllabus.

Course Code	Course Name	Teaching scheme			Credit assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
BML404	Digital Electronics	--	02	--	--	01	--	01

Course Code	Course Name	Examination Scheme								
		Theory				Term work	Pract.	Oral	Pract. / Oral	Total
		Internal Assessment			End sem					
		Test 1	Test 2	Avg.						
BML404	Digital Electronics	--	--	--	--	25	--	--	25	50

Course Code	Course Name	Credits
BML404	Digital Electronics	01
Course Objective	• To make learner aware of basics of digital circuits, logic design and Flip-flops. • Learner should be able to design of various counters, registers and their applications.	
Course Outcome	Learners will be able to: 1. Understand various ICs used for basic gates,EX-OR and EX-NOR gates 2. Design code converter circuits. 3. Design parity generator-checker circuits, adder-subtractor circuits and magnitude comparator circuits 4. Design circuits using multiplexers, demultiplexers, and decoders. 5. Design synchronous and asynchronous counters using flipflops. 6. Design various registers using flip flops.	

Syllabus: Same as that of BMC404 Digital Electronics

List of Laboratory Experiments: (Any seven)

1. To study the various Logic gates.
2. To design various gates using Universal gates.
3. To design binary to gray code converter and gray to binary converter.
4. To design BCD to Excess3 converter.
5. To design parity generator and parity checker circuits.
6. To design adder and subtractor circuits.

7. To design various circuits using multiplexers.
8. To design various circuits using de-multiplexer.
9. To study S-R , J-K, T and D Flip flops.
10. To design Asynchronous counter.
11. To design decade counter
12. To design Synchronous counter.

Any other experiment based on syllabus which will help learner to understand topic/concept

Books Recommended:

Text Books:

1. R.P.Jain, "Modern Digital Electronics," Tata McGraw Hill, 1984
2. M Morris Mono, "Digital Design," Prentice Hall International-1984.
3. Malvino & Leach, "Digital Principal and Applications", Tata McGraw Hill, 1991.
4. Malvino, "Digital Electronics", Tata McGraw Hill, 1997.

Reference Books:

1. James Bignell & Robert Donovan, "Digital Electronics", Delmar, Thomas Learning,
2. Jog N.K, "Logic Circuits", 2nd edition, Nandu Publisher & Printer Pvt .Ltd. 1998.
3. Alan b. Marcovitz, "Introduction to Logic Design ", McGraw Hill International 2002.

Assessment:

Term Work:

Term work shall consist of minimum 7 experiments.
The distribution of marks for term work shall be as follows:
Laboratory work (Experiments) : 10 Marks
Laboratory work (Journal) : 10 Marks
Attendance : 5 Marks
The final certification and acceptance of term work ensures the satisfactory performance of laboratory work and minimum passing in the term work.

Practical and oral examination will be based on suggested practical list and entire syllabus.

Course Code	Course Name	Teaching scheme			Credit assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
BML405	Signals and Control Systems (SCS)	--	02	--	--	01	--	01

Course Code	Course Name	Examination Scheme								
		Theory				Term work	Pract.	Oral	Pract. / Oral	Total
		Internal Assessment			End sem					
		Test 1	Test 2	Avg.						
BML405	Signals and Control Systems (SCS)	--	--	--	--	25	--	25	--	50

Course Code	Course Name	Credits
BML405	Signals and Control Systems	01
Course objective	• To introduce the concepts and techniques associated with the understanding of signals and systems such as the basic parameters, properties and interaction of signals and system. • To familiarize with techniques suitable for analyzing and synthesizing signals and systems in continuous domain.	
Course Outcome	• Represent signals and system mathematically • Represent integral of LTI systems, properties of system in terms of impulse response • Determine Fourier series representation of CT, properties of Fourier series • Derive and determine Laplace transform, region of convergence, application of Laplace transform, Inverse Laplace transform. • Analyze given systems and suggest modifications.	

Syllabus: Same as that of BMC405 Signals and Control Systems

List of Laboratory Experiments: (Any Five)

1. Introduction to signals and plotting of signals
2. Operations on Signal
3. Classification of Signals
4. Open Loop and Closed loop
5. Stability
6. Bode Plot
7. Root Locus
8. Convolution
9. Pole Zero plot

List of suggested Tutorials: (Any Six)

1. Introduction to signals and systems
2. Fourier Series
3. Laplace Transform
4. Inverse Laplace Transform
5. Application of Laplace Transform
6. Open Loop and Closed loop
7. Signal Flow graph
8. Stability
9. Bode Plot
10. Root Locus
11. Time domain analysis

Any other practical and tutorial based on syllabus which will help learner to understand topic/concept

Assessment:

Term Work:

Term work shall consist of minimum 7 experiments.
The distribution of marks for term work shall be as follows:
Laboratory work (Experiments) : 10 Marks
Laboratory work (Tutorial) : 10 Marks
Attendance : 5 Marks
The final certification and acceptance of term work ensures the satisfactory performance of laboratory work and minimum passing in the term work.

Oral examination will be based on suggested practical list and entire syllabus.

Program Structure for
TE Biomedical Engineering
University of Mumbai
(With effect from academic year 2018 - 19)

Scheme for Semester V

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
BMC501	Diagnostic & Therapeutic Instruments	04	----	----	04	----	----	04
BMC502	Analog and Digital Circuit Design	04	----	----	04	----	----	04
BMC503	Principles of Communication Engineering	04	----	----	04	----	----	04
BMC504	Biomedical Digital Image Processing	04	----	----	04	----	----	04
BMDLO501X	Department Level Optional Course – I	04	----	----	04	----	----	04
BML501	Business Communication and Ethics	----	02*+02	----	----	02	----	02
BML502	Diagnostic and Therapeutic Instruments	----	02	----	----	01	----	01
BML503	Integrated and Communication Circuit Design	----	02	----	----	01	----	01
BML504	Biomedical Digital Image Processing	----	02	----	----	01	----	01
BMDLL501X	Department Level Optional Course Laboratory – I	----	02	----	----	01	----	01
Total		**20**	**12**	----	**20**	**06**	----	**26**

***2 hrs. theory shall be taught to the entire class.**

Examination Scheme for Semester V

Course Code	Course Name	Examination Scheme												Total Marks
		Theory				Term work		Practical		Oral		Pract./Oral		
		External (UA)		Internal (CA)										
		Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	
BMC501	Diagnostic & Therapeutic Instruments	80	32	20	8	---	---	---	---	---	---	---	---	100
BMC502	Analog and Digital Circuit Design	80	32	20	8	---	---	---	---	---	---	---	---	100
BMC503	Principles of Communication Engineering	80	32	20	8	---	---	---	---	---	---	---	---	100
BMC504	Biomedical Digital Image Processing	80	32	20	8	---	---	---	---	---	---	---	---	100
BMDLO 501X	Department Level Optional Course – I	80	32	20	8	---	---	---	---	---	---	---	---	100
BML501	Business Communication and Ethics	---	---	---	---	50	20	---	---	---	---	---	---	50
BML502	Diagnostic and Therapeutic Instruments	---	---	---	---	25	10	---	---	25	10	---	---	50
BML503	Integrated and Communication Circuit Design	---	----	---	---	25	10	25	10	---	---	---	---	50
BML504	Biomedical Digital Image Processing	---	---	---	---	25	10	---	---	---	---	25	10	50
BMDLL 501X	Department Level Optional Course Laboratory – I	---	---	---	---	25	10	---	---	25	10	---	---	50
Total		**400**	**160**	**100**	**40**	**150**	**60**	**25**	**10**	**50**	**20**	**25**	**10**	**750**

Scheme for Semester VI

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
BMC601	Biomedical Monitoring Equipment	04	----	----	04	----	----	04
BMC602	Microprocessors and Microcontrollers	04	----	----	04	----	----	04
BMC603	Digital Image Processing	04	----	----	04	----	----	04
BMC604	Medical Imaging-I	04	----	----	04	----	----	04
BMDLO602X	Department Level Optional Course – II	04	----	----	04	----	----	04
BML601	Biomedical Monitoring Equipment	----	02	----	----	01	----	01
BML602	Microprocessors and Microcontrollers	----	02	----	----	01	----	01
BML603	Digital Image Processing	----	02	----	----	01	----	01
BML604	Medical Imaging-I	----	02	----	----	01	----	01
BMDLL602X	Department Level Optional Course Laboratory – II	----	02	----	----	01	----	01
Total		**20**	**10**	----	**20**	**05**	----	**25**

Examination Scheme for Semester VI

Course Code	Course Name	Examination Scheme												Total Marks
		Theory				Term work		Practical		Oral		Pract./Oral		
		External (UA)		Internal (CA)										
		Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	
BMC601	Biomedical Monitoring Equipment	80	32	20	8	---	---	---	---	---	---	---	---	100
BMC602	Microprocessors and Microcontrollers	80	32	20	8	---	---	---	---	---	---	---	---	100
BMC603	Digital Image Processing	80	32	20	8	---	---	---	---	---	---	---	---	100
BMC604	Medical Imaging-I	80	32	20	8	---	---	---	---	---	---	---	---	100
BMDLO 602X	Department Level Optional Course – II	80	32	20	8	---	---	---	---	---	---	---	---	100
BML601	Biomedical Monitoring Equipment	---	---	---	---	25	10	---	---	---	---	25	10	50
BML602	Microprocessors and Microcontrollers	---	---	---	---	25	10	---	---	---	---	25	10	50
BML603	Digital Image Processing	---	----	---	---	25	10	---	---	---	---	25	10	50
BML604	Medical Imaging-I	---	---	---	---	25	10	---	---	25	10	---	---	50
BMDLL 602X	Department Level Optional Course Laboratory – II	---	---	---	---	25	10	---	---	25	10	---	---	50
Total		**400**	**160**	**100**	**40**	**125**	**50**	**---**	**---**	**50**	**20**	**75**	**30**	**750**

Program Structure for
BE Biomedical Engineering
University of Mumbai
(With effect from academic year 2019 - 20)

Scheme for Semester VII

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
BMC701	Life Saving and Surgical Equipment	04	----	----	04	----	----	04
BMC702	Very Large Scale Integrated System	04	----	----	04	----	----	04
BMC703	Medical Imaging-II	04	----	----	04	----	----	04
BMDLO703X	Department Level Optional Course – III	04	----	----	04	----	----	04
ILO701X	Institute Level Optional Course – I	03	----	----	03	----	----	03
BML701	Life Saving and Surgical Equipment	----	02	----	----	01	----	01
BML702	Very Large Scale Integrated System	----	02	----	----	01	----	01
BML703	Medical Imaging-II	----	02	----	----	01	----	01
BMDLL703X	Department Level Optional Course Laboratory – III	----	02	----	----	01	----	01
BML704	Project Stage I	----	06	----	----	03	----	03
Total		**19**	**14**	----	**19**	**07**	----	**26**

Examination Scheme for Semester VII

Course Code	Course Name	Examination Scheme												Total Marks
		Theory				Term work		Practical		Oral		Pract./Oral		
		External (UA)		Internal (CA)										
		Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	
BMC701	Life Saving and Surgical Equipment	80	32	20	8	---	---	---	---	---	---	---	---	100
BMC702	Very Large Scale Integrated System	80	32	20	8	---	---	---	---	---	---	---	---	100
BMC703	Medical Imaging-II	80	32	20	8	---	---	---	---	---	---	---	---	100
BMDLO 703X	Department Level Optional Course - III	80	32	20	8	---	---	---	---	---	---	---	---	100
ILO701 X	Institute Level Optional Course – I	80	32	20	8	---	---	---	---	---	---	---	---	100
BML701	Life Saving and Surgical Equipment	---	---	---	---	25	10	---	---	25	10	---	---	50
BML702	Very Large Scale Integrated System	---	---	---	---	25	10	---	---	25	10	---	---	50
BML703	Medical Imaging-II	---	----	---	---	25	10	---	---	25	10	---	---	50
BMDLL 703X	Department Level Optional Course Laboratory – III	---	---	---	---	25	10	---	---	25	10	---	---	50
BML704	Project Stage I	---	---	---	---	25	10	---	---	25	10	---	---	50
Total		**400**	**160**	**100**	**40**	**125**	**50**	**---**	**---**	**125**	**50**	**---**	**---**	**750**

Scheme for Semester VIII

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
BMC801	Biomedical Microsystems	04	----	----	04	----	----	04
BMC802	Hospital Management	04	----	----	04	----	----	04
BMDLO804X	Department Level Optional Course – IV	04	----	----	04	----	----	04
ILO802X	Institute Level Optional Course – II	03	----	----	03	----	----	03
BML801	Biomedical Microsystems	----	02	----	----	01	----	01
BML802	Hospital Management	----	02	----	----	01	----	01
BMDLL804X	Department Level Optional Course Laboratory – IV	----	02	----	----	01	----	01
BML803	Project Stage II	----	12	----	----	06	----	06
Total		**15**	**18**	----	**15**	**09**	----	**24**

Examination Scheme for Semester VIII

Course Code	Course Name	Examination Scheme												Total Marks
		Theory				Term work		Practical		Oral		Pract./Oral		
		External (UA)		Internal (CA)										
		Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	
BMC801	Biomedical Microsystems	80	32	20	8	---	---	---	---	---	---	---	---	100
BMC802	Hospital Management	80	32	20	8	---	---	---	---	---	---	---	---	100
BMDLO 804X	Department Level Optional Course - IV	80	32	20	8	---	---	---	---	---	---	---	---	100
ILO802X	Institute Level Optional Course –II	80	32	20	8	---	---	---	---	---	---	---	---	100
BML801	Biomedical Microsystems	---	---	---	---	25	10	---	---	25	10	---	---	50
BML802	Hospital Management	---	---	---	---	25	10	---	---	25	10	---	---	50
BMDLL 801X	Department Level Optional Course Laboratory – IV	---	----	---	---	25	10	---	---	25	10	---	---	50
BML803	Project Stage II	---	---	---	---	50	20	---	---	---	---	100	40	150
Total		**320**	**128**	**80**	**32**	**125**	**50**	**---**	**---**	**75**	**30**	**100**	**40**	**700**

Department Level Optional Courses

Course Code	Department level Optional Course - I
BMDLO5011	Healthcare Database Management
BMDLO5012	Biostatistics
BMDLO5013	Rehabilitation Engineering

Course Code	Department level Optional Course - II
BMDLO6021	Healthcare Software
BMDLO6022	Lasers and Fibre Optics
BMDLO6023	Biological Modelling and Simulation

Course Code	Department level Optional Course - III
BMDLO7031	Networking and Information in Medical System
BMDLO7032	Advanced Image Processing
BMDLO7033	Embedded Systems

Course Code	Department level Optional Course - IV
BMDLO8041	Health Care Informatics
BMDLO8042	Robotics in Medicine
BMDLO8043	Nuclear Medicine

Institute Level Optional Courses

Course Code	Institute level Optional Course - I
ILO7011	Product Lifecycle Management
ILO7012	Reliability Engineering
ILO7013	Management Information System
ILO7014	Design of Experiments
ILO7015	Operation Research
ILO7016	Cyber Security and Laws
ILO7017	Disaster Management and Mitigation Measures
ILO7018	Energy Audit and Management
ILO7019	Development Engineering

Course Code	Institute level Optional Course - II
ILO8021	Project Management
ILO8022	Finance Management
ILO8023	Entrepreneurship Development and Management
ILO8024	Human Resource Management
ILO8025	Professional Ethics and Corporate Social Responsibility (CSR)
ILO8026	Research Methodology
ILO8027	IPR and Patenting
ILO8028	Digital Business Management
ILO8029	Environmental Management