AC : 23/07/2020

Item No.: 139

UNIVERSITY OF MUMBAI

Bachelor of Engineering

in

Biomedical Engineering

Second Year with Effect from AY 2020-21

Third Year with Effect from AY 2021-22

Final Year with Effect from AY 2022-23

(REV- 2019 'C' Scheme) from Academic Year 2019 – 20

Under

FACULTY OF SCIENCE & TECHNOLOGY

(As per AICTE guidelines with effect from the academic year 2019–2020)

AC: 23/07/2020
Item No.: 139

Syllabus for Approval

Sr. No.	Heading	Particulars
1	Title of the Course	**Second Year B.E. Biomedical Engineering**
2	Eligibility for Admission	**After Passing First Year Engineering as per the Ordinance 0.6242**
3	Passing Marks	**40%**
4	Ordinances / Regulations (if any)	**Ordinance 0.6242**
5	No. of Years / Semesters	**8 semesters**
6	Level	~~P.G.~~ / **U.G.**/ ~~Diploma / Certificate~~ (Strike out which is not applicable)
7	Pattern	~~Yearly~~ / **Semester** (Strike out which is not applicable)
8	Status	**New** / ~~Revised~~ (Strike out which is not applicable)
9	To be implemented from Academic Year	**With effect from Academic Year: 2020-2021**

Date

Dr. S. K. Ukarande
Associate Dean
Faculty of Science and Technology
University of Mumbai

Dr Anuradha Muzumdar
Dean
Faculty of Science and Technology
University of Mumbai

Preamble

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 Science and Technology (in particular Engineering)of University of Mumbai has taken a lead in incorporating philosophy of outcome based education in the process of curriculum development.

Faculty resolved that course objectives and course outcomes are 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. 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 and not in teaching. It also focuses on continuous evaluation which will enhance the quality of education. Credit assignment for courses is based on 15 weeks teaching learning process, however content of courses is to be taught in 12-13 weeks and remaining 2-3 weeks to be utilized for revision, guest lectures, coverage of content beyond syllabus etc.

There was a concern that the earlier revised curriculum more focused on providing information and knowledge across various domains of the said program, which led to heavily loading of students in terms of direct contact hours. In this regard, faculty of science and technology resolved that to minimize the burden of contact hours, total credits of entire program will be of 170, wherein focus is not only on providing knowledge but also on building skills, attitude and self learning. Therefore in the present curriculum skill based laboratories and mini projects are made mandatory across all disciplines of engineering in second and third year of programs, which will definitely facilitate self learning of students. The overall credits and approach of curriculum proposed in the present revision is in line with AICTE model curriculum.

The present curriculum will be implemented for Second Year of Engineering from the academic year 2020-21. Subsequently this will be carried forward for Third Year and Final Year Engineering in the academic years 2021-22, 2022-23, respectively.

Dr. S. K. Ukarande

Associate Dean

Faculty of Science and Technology

Member, Academic Council, RRC in Engineering

University of Mumbai

Incorporation and implementation of Online Contents from NPTEL/ Swayam Platform

The curriculum revision is mainly focused on knowledge component, skill based activities and project based activities. Self learning opportunities are provided to learners. In the revision process this time in particular Revised syllabus of 'C ' scheme wherever possible additional resource links of platforms such as NPTEL, Swayam are appropriately provided. In an earlier revision of curriculum in the year 2012 and 2016 in Revised scheme 'A' and 'B' respectively, efforts were made to use online contents more appropriately as additional learning materials to enhance learning of students.

In the current revision based on the recommendation of AICTE model curriculum overall credits are reduced to 171, to provide opportunity of self learning to learner. Learners are now getting sufficient time for self learning either through online courses or additional projects for enhancing their knowledge and skill sets.

The Principals/ HoD's/ Faculties of all the institute are required to motivate and encourage learners to use additional online resources available on platforms such as NPTEL/ Swayam. Learners can be advised to take up online courses, on successful completion they are required to submit certification for the same. This will definitely help learners to facilitate their enhanced learning based on their interest.

Dr. S. K. Ukarande

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Preface By BoS

Engineering is an innovative field, the origin of ideas leading to everything from automobile to aerospace, skyscrapers to sonar. **Biomedical Engineering** focuses on the advances that improve human health and health care at all levels. Biomedical engineering is an interdisciplinary field with application of the principles of Basic Sciences, Mathematics, Engineering fundamentals and Biology for problem-solving.

The curriculum is designed to meet the challenges by include new age courses on Machine Learning, Artificial Intelligence, Data Analytics and other emerging technologies, dismantling the walls between engineering and scientific disciplines. The key to generate a new paradigm shift for careers in Biomedical Engineering for the next generation of talented minds lies in imparting high-quality education in Engineering.

Every course in the curriculum lists the course objectives and course outcomes for the learners to understand the skills that the learner will acquire after completing that course. Program outcomes are the skills and knowledge that a student will acquire during the course of four years of this engineering program. In line with this, Faculty of Technology of University of Mumbai has taken a lead in incorporating the philosophy of outcome based education in the process of curriculum development.

As the Chairman, Board of Studies in Biomedical Engineering of the University of Mumbai, I am happy to state here that, the Program Educational Objectives for undergraduate program were thoughtfully framed by faculty members from different affiliated institutes of the university. They are Heads of Departments and senior representatives from the Department of Biomedical Engineering.

The Program Educational Objectives for the undergraduate program in Biomedical engineering are listed below;

1. To prepare the learner with a sound foundation in the Human Physiology, Mathematics, Electronics, Computer Programming and engineering fundamentals.

2. To motivate the learner for self-learning, logical & analytical thinking and use of modern tools for solving real life problems.

3. To impart technical knowledge, competency skills, professional and ethical attitude, good leadership qualities to contribute in the field of healthcare.

4. To prepare the Learner for a successful career in healthcare industry such as sales & marketing, research & development, hospital administration and also to venture into higher education and entrepreneurship.

Board of Studies in Biomedical Engineering

Dr. Manali J. Godse : Chairman

Dr. Prem C. Pandey : Member

Dr. Mita Bhowmick : Member

Dr. Mrunal R. Rane : Member

Dr. Vaibhavi A. Sonetha : Member

Program Structure for Second Year Engineering
Semester III & IV
UNIVERSITY OF MUMBAI
(With Effect from 2020-2021)

Semester III

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	**Pract.**	**Tut.**	**Theory**	**Pract.**	**Tut.**	**Total**
BMC301	Engineering Mathematics - III	3	--	1	3	--	1	4
BMC302	Human Anatomy and Physiology for Engineers	3		--	3		--	3
BMC303	Medical Sensors	3	--	--	3	--	--	3
BMC304	Electronic Circuits Analysis and Design	4	--	--	4	--	--	4
BMC305	Digital Electronics	3	--	--	3	--	--	3
BML301	Human Anatomy and Physiology for Engineers Lab	--	2	--	--	1	--	1
BML302	Medical Sensors Lab	--	2	--	--	1	--	1
BML303	Electronic Circuits Analysis and Design Lab	--	2	--	--	1	--	1
BML304	Electronics Lab (SBL)	--	4	--	--	2	--	2
BMM301	Mini Project – 1 A	--	4$	--	--	2	--	2
Total		**16**	**14**	**1**	**16**	**07**	**1**	**24**

Course Code	Course Name	Examination Scheme							
		Theory							
		Internal Assessment			**End Sem. Exam**	**Exam. Duration (in Hrs)**	**Term Work**	**Pract/ oral**	**Total**
		Test 1	**Test 2**	**Avg.**					
BMC301	Engineering Mathematics - III	20	20	20	80	3	25	--	125
BMC302	Human Anatomy and Physiology for Engineers	20	20	20	80	3	--	--	100
BMC303	Medical Sensors	20	20	20	80	3	--	--	100
BMC304	Electronic Circuits Analysis and Design	20	20	20	80	3	--	--	100
BMC305	Digital Electronics	20	20	20	80	3	--	--	100
BML301	Human Anatomy and Physiology for Engineers Lab	--	--	--	--	--	25	--	25
BML302	Medical Sensors Lab	--	--	--	--	--	25	25	50
BML303	Electronic Circuits Analysis and Design Lab	--	--	--	--	--	25	25	50
BML304	Electronics Lab (SBL)	--	--	--	--	--	25	25	50
BMM301	Mini Project – 1 A	--	--	--	--	--	25	--	25
Total		**--**	**--**	**100**	**400**	**--**	**150**	**75**	**725**

$ indicates work load of Learner (Not Faculty), for Mini Project - 1 A.

Faculty Load :1 hour per week per 4 mini project groups.

Program Structure for Second Year Engineering
UNIVERSITY OF MUMBAI
(With Effect from 2020-2021)

Semester IV

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
BMC401	Engineering Mathematics - IV	3	--	1	3	--	1	4
BMC402	Integrated Circuit Design	3	--	--	3	--	--	3
BMC403	Principles of Control Systems	3	--	--	3	--	--	3
BMC404	Medical Imaging – I	3	--	--	3	--	--	3
BMC405	Biomaterials and Artificial Organs	3	--	--	3	--	--	3
BML401	Integrated Circuit Design Lab	--	2	--	--	1	--	1
BML402	Principles of Control Systems Lab	--	2	--	--	1	--	1
BML403	Medical Imaging – I Lab	--	2	--	--	1	--	1
BML404	Computing Lab (SBL)	--	4	--	--	2	--	2
BMM401	Mini Project – 1 B	--	4$	--	--	2	--	2
Total		**15**	**14**	**1**	**15**	**7**	**1**	**23**

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Pract/ oral	Total
		Internal Assessment			End Sem. Exam.	Exam. Duration (in Hrs)			
		Test 1	Test 2	Avg.					
BMC401	Engineering Mathematics - IV	20	20	20	80	3	25	--	125
BMC402	Integrated Circuit Design	20	20	20	80	3	--	--	100
BMC403	Principles of Control Systems	20	20	20	80	3	--	--	100
BMC404	Medical Imaging – I	20	20	20	80	3	--	--	100
BMC405	Biomaterials and Artificial Organs	20	20	20	80	3	--	--	100
BML401	Integrated Circuit Design Lab	--	--	--	--	--	25	25	50
BML402	Principles of Control Systems Lab	--	--	--	--	--	25	--	25
BML403	Medical Imaging – I Lab	--	--	--	--	--	25	25	50
BML404	Computing Lab (SBL)	--	--	--	--	--	25	25	50
BMM401	Mini Project – 1 B	--	--	--	--	--	25	25	50
Total		**--**	**--**	**100**	**400**	**--**	**150**	**100**	**750**

$ indicates work load of Learner (Not Faculty), for Mini Project - 1 B.

Faculty Load :1 hour per week per 4 mini project groups.

Semester – III

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	TW/Pract	Tut.	Total
BMC301	**Engineering Mathematics-III**	03	-	01	03	-	01	**04**

Course Code	Course Name	Examination Scheme							
		Theory				Term Work	Pract	Oral	Total
		Internal Assessment			End Sem Exam				
		Test1	Test2	Avg of Test 1 & 2					
BMC301	**Engineering Mathematics-III**	20	20	20	80	25	-	-	**125**

Pre-requisite: Engineering Mathematics-I, Engineering Mathematics-II, Scalar and Vector Product: Scalar and Vector product of three and four vectors.

Course Code	Course Name	Credits
BMC301	**Engineering Mathematics - III**	**04**
Course Objectives	• To familiarize with the Laplace Transform, Inverse Laplace Transform of various functions, and its applications. • To acquaint with the concept of Fourier Series, its complex form and enhance the problem solving skills • To familiarize the concept of complex variables, C-R equations, harmonic functions, its conjugate and mapping in complex plane. • To understand the basics of Linear Algebra and its applications • To use concepts of vector calculus to analyze and model engineering problems.	
Course Outcomes	On successful completion of course learner will be able to: • Apply the concept of Laplace transform to solve the real integrals in engineering problems. • Apply the concept of inverse Laplace transform of various functions in engineering problems. • Expand the periodic function by using Fourier series for real life problems and complex engineering problems. • Find orthogonal trajectories and analytic function by using basic concepts of complex variables. • Illustrate the use of matrix algebra to solve the engineering problems. • Apply the concepts of vector calculus in real life problems.	

Module	Detailed Contents	Hrs.
01	**Module: Laplace Transform** 1.1 Definition of Laplace transform, Condition of Existence of Laplace Transform. 1.2 Laplace Transform (L) of standard functions like e^{at}, $sin(at)$, $cos(at)$, $sinh(at)$, $cosh(at)$ and $t^n, n \geq 0$. 1.3 Properties of Laplace Transform: Linearity, First Shifting Theorem, Second Shifting Theorem, Change of Scale Property, Multiplication by *t*, Division by *t*, Laplace Transform of derivatives and integrals (Properties without proof). 1.4 Evaluation of integrals by using Laplace Transformation. **Self-learning Topics:** Heaviside's Unit Step function, Laplace Transform of Periodic functions, Dirac Delta Function.	**7**
02	**Module: Inverse Laplace Transform** 2.1 Inverse Laplace Transform, Linearity property, use of standard formulae to find inverse Laplace Transform, finding Inverse Laplace Transform using derivatives. 2.2 Partial fractions method to find inverse Laplace Transform. 2.3 Inverse Laplace Transform using Convolution theorem (without proof). **Self-learning Topics:** Applications to solve initial and boundary value problems involving ordinary differential equations.	6
03	**Module: Fourier Series:** 3.1 Dirichlet's conditions, Definition of Fourier series and Parseval's Identity (without proof). 3.2 Fourier series of periodic function with period 2π and $2l$. 3.3 Fourier series of even and odd functions. 3.4 Half range Sine and Cosine Series. **Self-learning Topics:** Complex form of Fourier Series, Orthogonal and orthonormal set of functions. Fourier Transform.	7
04	**Module: Complex Variables:** 4.1 Function *f*(z) of complex variable, limit, continuity and differentiability of *f*(z)Analytic function, necessary and sufficient conditions for *f*(z) to be analytic (without proof). 4.2 Cauchy-Riemann equations in cartesian coordinates (without proof). 4.3 Milne-Thomson method to determine analytic function *f*(z)when real part (u) or Imaginary part (v) or its combination (u+v or u-v) is given. 4.4 Harmonic function, Harmonic conjugate and orthogonal trajectories. **Self-learning Topics:** Conformal mapping, linear, bilinear mapping, cross ratio, fixed points and standard transformations.	7
05	**Module: Linear Algebra: Matrix Theory** 5.1 Characteristic equation, Eigen values and Eigen vectors, Example based on properties of Eigen values and Eigen vectors.(Without Proof). 5.2 Cayley-Hamilton theorem (Without proof), Examples based on verification of Cayley- Hamilton theorem and compute inverse of Matrix. 5.3 Similarity of matrices, Diagonalization of matrices, Functions of square matrix. **Self-learning Topics:** Application of Matrix Theory in machine learning and google page rank algorithms, derogatory and non-derogatory matrices**.**	6
06	**Module: Vector Differentiation and Integra**l 6.1 **Vector differentiation**: Basics of Gradient, Divergence and Curl (Without	6

	Proof). 6.2 **Properties of vector field:** Solenoidal and Irrotational (conservative) vector fields. 6.3 **Vector integral:** Line Integral, Green's theorem in a plane (Without Proof), Stokes' theorem (Without Proof) only evaluation. **Self-learning Topics:** Gauss' divergence Theorem and applications of Vector calculus.	

Term Work:

General Instructions:

1. Students must be encouraged to write at least 6 class tutorials on entire syllabus.
2. A group of 4-6 students should be assigned a self-learning topic. Students should prepare a presentation/problem solving of 10-15 minutes. This should be considered as mini project in Engineering mathematics. This project should be graded for 10 marks depending on the performance of the students.

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

Class Tutorials on entire syllabus : 10 Marks
Mini project : 10 Marks
Attendance (Theory and Tutorial) : 5 Marks

Assessment:

Internal Assessment Test:

Assessment consists of two class tests of 20 marks each. The first-class test (Internal Assessment I) is to be conducted when approximately 40% syllabus is completed and second class test (Internal Assessment II) when additional 35% syllabus is completed. Duration of each test shall be one hour.

End Semester Theory Examination:

1. Question paper will comprise of total 06 questions, each carrying 20 marks.
2. Total 04 questions need to be solved.
3. Question No: 01 will be compulsory and based on entire syllabus wherein 4 sub-questions of 5 marks each will be asked.
4. Remaining questions will be randomly selected from all the modules.
5. Weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.

References:-

1. Advanced engineering mathematics, H.K. Das, S.Chand, Publications
2. Higher Engineering Mathematics, B. V. Ramana, Tata Mc-Graw Hill Publication
3. Advanced Engineering Mathematics, R. K. Jain and S. R. K. Iyengar, Narosa publication
4. Advanced Engineering Mathematics, Wylie and Barret, Tata Mc-Graw Hill.
5. Theory and Problems of Fourier Analysis with applications to BVP, Murray Spiegel, Schaum's Outline Series
6. Vector Analysis Murry R. Spiegel, Schaum's outline series, Mc-Graw Hill Publication
7. Beginning Linear Algebra, Seymour Lipschutz, Schaum's outline series, Mc-Graw Hill Publication
8. Higher Engineering Mathematics, Dr. B. S. Grewal, Khanna Publication

Course Code	Course Name	Teaching scheme			Credit assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
BMC302	Human Anatomy and Physiology for Engineers (Abbreviated as HAPE)	03	--	--	03	--	--	03

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	Human Anatomy and Physiology for Engineers (Abbreviated as HAPE)	20	20	20	80	03	--	--	--	--	100

Course Code	Course Name	Credits
BMC302	Human Anatomy and Physiology for Engineers	03
Course Objectives	• To understand the anatomical structures of the human body and their relationship to each other. • To understand the different physiological processes taking place inside the human body.	
Course Outcomes	Learners will be able to: • Explain the organization of the human body, homeostasis and its maintenance, structure and functions of a cell and basic tissues. • Explain the components of blood and their functions. • Explain the anatomical parts and physiological processes of the cardiovascular system and respiratory system. • Explain the anatomical parts and physiological processes of the alimentary system and renal system. • Explain the structure and functions of nervous system, eye and skin along with the secretions and functions of all endocrine glands.	

Module	Contents	Hours
1.	**Introduction to the Human Body:** Levels of structural organization; Characteristics of living human organism; Homeostasis and its maintenance. **Cells and Tissues**: Structure and functions of a cell; Transport across the plasma membrane; membrane potentials; Tissues: epithelial, connective, muscle and nervous.	**04**
2.	**Cardiovascular System**: Anatomy of the heart; Heart valves, systemic and pulmonary circulation; Conduction system of the heart; Cardiac action potential, electrocardiogram (ECG); Cardiac cycle; Cardiac output; Blood pressure. **Respiratory System:** Anatomy of respiratory system; Pulmonary ventilation, lung volumes and capacities; Gas laws - Dalton's law and Henry's law, external respiration, internal respiration.	**10**
3.	**Blood:** Composition of Blood, blood cells and their functions, haemoglobin; Blood Grouping; Haemostasis.	**04**
4.	**Alimentary System:** Anatomy of the alimentary system; Secretions of different organs of the alimentary system and their main functions. **Renal System:** Anatomy of the renal system; Functions of kidney (urine formation, electrolyte balance and *pH* balance); composition of urine; Micturition.	**10**
5.	**Nervous System:** Divisions of the nervous system (central and peripheral nervous system); Structure and functions of the brain and spinal cord; Reflex actions and reflex arc; Functions of sympathetic and parasympathetic nervous system; Nerve action potential and nerve conduction.	**05**
6.	**Special Senses:** Structure of the eye; Physiology of vision; Structure and functions of the skin. **Endocrine System:** All Glands of the endocrine system, their secretions and functions.	**06**

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.

Books Recommended:

Text books:
1. Anatomy and Physiology in Health and Illness: Ross and Wilson. (ELBS Publication)
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)

NPTEL/Swayam Course:
Course: Animal Physiology by Prof. Mainak Das - IIT Kanpur
https://nptel.ac.in/courses/102/104/102104058/
https://swayam.gov.in/nd1_noc20_bt42/preview

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 subquestions 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	Medical Sensors (Abbreviated as MS)	03	--	--	03	--	--	03

Course Code	Course Name	Examination Scheme									
		Theory					Term work	Pract.	Oral	Pract. / Oral	Total
		Internal Assessment			End sem	Dur-ation (hrs)					
		Test 1	Test 2	Avg.							
BMC303	Medical Sensors (Abbreviated as MS)	20	20	20	80	03	--	--	--	--	100

Course Code	Course Name	Credits
BMC303	Medical Sensors	03
Course Objectives	• To provide the knowledge of basic concepts such as generalized medical instrumentation system, input transducer properties, and instrument characteristics. • To provide a thorough understanding of principle and working of transducers and sensors used for measuring displacement, motion, force, pressure, temperature, bio-potentials, biochemical concentrations. • To study the medical applications of the above transducers and sensors. • To perform experiments based on some of the above transducers and sensors.	
Course Outcomes	The learner will be able to : • Explain different components of a generalized medical instrumentation system, input transducer properties, and instrument characteristics. • Apply the knowledge of principles of various types of transducers and sensors including motion, displacement, force, pressure sensors to different medical applications. • Apply the knowledge of principles of various types of temperature sensors to different medical applications. • Apply the knowledge of the various biopotential electrodes for measuring different types of biopotentials. • Apply the principles of various chemical sensors for measuring concentration of biochemical analytes. • Explain the principles of various biosensors and their medical applications.	

Module	Contents	Hours
1.	**Introduction**: Generalized medical instrumentation system; General properties of input transducers; Static characteristics: Accuracy, precision, resolution, reproducibility, sensitivity, drift, hysteresis, linearity, input impedance and output impedance; Dynamic characteristics: Transfer functions, first order and second order systems, time delay; Design criteria.	**04**
2.	**Displacement, Motion, Force and Pressure Sensors and their Medical Applications**: Displacement measurement: Potentiometers, strain gauges, bridge circuits, inductive sensor – L.V.D.T., capacitive sensors; Acceleration and force measurement: Piezoelectric sensor, load cell; Pressure sensing elements: Diaphragms, bellows, bourdon tubes.	**08**
3.	**Temperature Sensors and their Medical Applications:** Temperature measurement: Thermistor, thermocouple, resistive temperature detector; IC-based temperature measurement; Radiation sensors: Thermal sensors, quantum sensors, and radiation thermometry.	**06**
4.	**Biopotential electrodes**: Electrode-electrolyte interface, half-cell potential, polarization, polarizable and non-polarizable electrodes, calomel electrode; Electrode circuit model, electrode-skin interface and motion artefacts; Body surface electrodes; Internal electrodes: Needle and wire electrodes (different types); Microelectrodes: Metal and supported metal micropipette (metal filled glass and glass micropipette) electrodes.	**06**
5.	**Chemical Sensors and their Medical Applications:** Blood gas and acid- base physiology; pH, Pco_2, Po_2 electrodes; ISFETs; Transcutaneous arterial O_2 and CO_2 tension monitoring. **Fiber optic Sensors and their Medical Applications**: Principle of fiber optics; Fiber optic sensor types - Temperature, chemical, and pressure.	**07**
6.	**Biosensors**: Types of biosensors - electrochemical biosensors, optical biosensors, piezoelectric biosensors; Biorecognition elements and their immobilization techniques; Medical applications of biosensors.	**08**

Books Recommended:

Text Books:

1. Medical Instrumentation-Application and Design, John G. Webster, Wiley India Private Limited.
2. Instrument Transducers: An Introduction to Their Performance and Design, Hermann K. P. Neubert, Oxford University Press.
3. Biomedical Sensors: Fundamentals and Applications, Harry N. Norton, Noyes Publications.
4. Biomedical Transducers and Instruments, Tatsuo Togawa, Toshiyo Tamura and P. Ake Öberg, CRC Press.
5. Electronics in Medicine and Biomedical Instrumentation by Nandini K. Jog, Prentice-Hall of India Pvt. Limited.
6. Biosensors: Fundamentals and Applications, Bansi Dhar Malhotra and Chandra Mouli Pandey, Smithers Rapra Technology.

Reference Books:

1. Principles of Applied Biomedical Instrumentation, L.A. Geddes and L.E. Baker, Wiley India Pvt Ltd.
2. Biomedical Instrumentation and Measurements, Leslie Cromwell, Erich A. Pfeiffer and Fred J. Wiebell, Prentice-Hall of India Pvt. Ltd.

3. Principles of Biomedical Instrumentation and Measurement, Richard Aston, Merril Publishing Company.
4. Measurement Systems, Application and Design, Ernest O. Doeblin, McGraw Hill Higher Education.
5. Handbook of Modern Sensors – Physics, Design and Application, Jacob Fraden, Springer Publishing Company.
6. Transducers for Biomedical Measurements: Principles and Applications, Richard S. C. Cobbold, John Wiley & Sons.

NPTEL/Swayam Course:

Course: Industrial Instrumentation by Prof. Alok Barua - IIT Kharagpur
https://nptel.ac.in/courses/108/105/108105064/

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 the 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 transfer characteristics of semiconductor devices and to analyse basic application circuits. • To make learners aware about the mathematical models of BJT and its use in analysing the circuits. • To make the learners aware about different types of coupling and the concept of multistage amplifiers. • Learners will be able to design power amplifier. • To learn types and applications of MOSFET.	
Course Outcomes	Learner will be able to: • Explain the transfer characteristics in analysing the electronic circuits which use diode, BJT etc. • Explain equivalent circuits of BJT and apply them to analyse and design BJT based amplifier circuits • Apply the knowledge of mathematical model to analyse multistage amplifiers. • Design and analyse power amplifiers. • Apply the concept of transfer characteristics, D.C. load line, A.C. load line to analyse MOSFET amplifiers.	

Module	Contents	Hours
1.	**Basics of Diodes:** Construction, Working, Characteristics, Current Equation & Equivalent circuits of P-N Junction Diode as well as Zener Diode; Applications of Diode: Clipper & Clamper.	06
2.	**Basics & DC analysis of BJT:** Construction; Working and Characteristics of 3 different configurations of BJT; Quiescent point, DC load line, BJT Biasing techniques (Fixed, Self, Voltage Divider, Collector to base, Collector to base self) and BJT as a switch.	10
3.	**BJT as an Amplifier:** A.C. Equivalent Model: r_e model, h-parameter model (Exact and Approximate) and 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 & $R_{L,}$ Low frequency and High frequency analysis of Single stage amplifiers; Design of single stage amplifier using BJT.	10
4.	**Multistage Amplifier:** Need of cascading; Types of coupling; D.C. and A.C. analysis of CS-CE cascade configuration, Cascode amplifier, Darlington amplifier**.**	08
5.	**Power Amplifiers:** Classes of Power amplifiers; Class-A Power Amplifiers (Direct coupled and Transformer coupled), Class-B Power Amplifiers, Crossover distortion, Harmonic distortion, Class-AB Push Pull and Complementary Symmetry Power amplifier, Class-C Power Amplifier, Class A and B/AB Power amplifier design, Heat Sinks and its design.	08
6.	**MOSFET:** Comparison of BJT & FET, Classification, Characteristics, Biasing of MOSFET, MOSFET as an amplifier & MOSFET as a switch.	10

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.

Books Recommended:
Textbooks:
1. Electronics Circuit. Analysis & Design, 2nd ed., Donald A. Neamen, McGraw Hill, 2001
2. Electronics Devices & Circuits Theory, by by Robert L. Boylestad and Louis Nashelsky, Pearson Education.
3. Semiconductor Data Manual, BPB Publications.

Reference Books:
1. Electronic Principles, by Albert Paul Malvino 6th edition, McGraw Hill
2. Electronic Devices and Circuits, by Jacob Milliman McGraw Hill.
3. Electronic Design, by Martin Roden, Gordon L.Carpenter, William Wieseman, Fourth edition, Shroff Publishers & Distributors Pvt. Ltd..
4. Electronic Circuits Discrete and Integrated, by Donald Schilling & Charles Belove, Third edition, McGraw Hill.

NPTEL/Swayam Course:
Course: Analog Electronic Circuits by Prof. Pradip Mandal - IIT Kharagpur
https://nptel.ac.in/courses/108/105/108105158/

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	Digital Electronics (Abbreviated as DE)	03	--	--	03	--	--	03

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	Digital Electronics (DE)	20	20	20	80	03	--	--	--	--	100

Course Code	Course Name	Credits
BMC305	Digital Electronics	03
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 various counters, registers and know their applications. • Learner should be able to design sequential circuits as a state machine.	
Course Outcomes	Learner will be able to: • Describe various number systems, logic gates and logic families. • Apply Boolean algebra, K-maps for Logic reduction and implementations in SOP and POS form • Develop combinational circuits such as code converter circuits, parity generator checker circuits and magnitude comparator circuits. Also, circuits using multiplexers, de-multiplexers, and decoders. • Design synchronous sequential circuits and asynchronous counters using flip flops • Design various registers using flip flops.	

Module	Contents	Hours
1.	**Fundamentals of Digital Design:** **Introduction:** Number system: Binary, Octal, Hexadecimal and other. Conversion from One system to another. **Binary Codes:** Weighted, Reflective, Sequential, Gray, Error detecting codes, Odd, Even parity, Hamming Codes etc. **Logic Gates and Families:** AND, OR, NOT, XOR, XNOR, operation NAND, NOR used of the universal gate for performing different operations. TTL and CMOS logic families.	**04**
2.	**Combinational Logic Design:** **Boolean Algebra**: Laws of Boolean algebra, De- Morgan's theorems, Relating a Truth Table to a Boolean Expression, Multilevel circuits. **Logic Reduction Techniques**: K-MAPS and their use in specifying Boolean Expressions, Prime-implicant, Minterm, Maxterm, SOP and POS Implementation. Implementation of logic function using universal gates. Application of gray code, Hazards in combinational circuits.	**08**
3.	**MSI Combinational Circuits:** **Elementary Designs:** Designing code converter circuits e.g. Binary to Gray, BCD to Seven Segments, Parity Generator and Parity Checker (3 bit). **Binary Arithmetic Circuits**: Binary Addition, Binary Subtraction (ones and twos complement), (Half & Full) Adders, (Half & Full) Subtractors, BCD adder, BCD-Subtractor (9's complement method), Serial adder, Multiplier, Magnitude Comparators, 7485 comparator, Arithmetic Logic Units. **Use of Multiplexers in Logic Design:** Multiplexer (ULM) Shannon's theorem. De-Multiplexers, Line decoders.	**11**
4.	**Fundamentals of Sequential Logic Circuits:** **Flip-Flops:** Comparison of Combinational & Sequential Circuits, Flip-Flops, SR, T, D, JK, Master Slave JK, Converting one Flip-Flop to another **Counters:** Modulus of a counter, Designing of synchronous and asynchronous counter using flip flop, Concept of drawing state transition diagram & state transition table. Minimum cost and minimum risk approach in design.	**08**
5.	**Sequential Circuit Designs:** State machine analysis, State machine design as Mealy and Moore machines, basic design of sequence detector.	**04**
6.	**Sequential Logic Designs:** **Registers:** Serial input serial output, serial input parallel output, Left Right shift register, Bidirectional shift register, Universal shift register. Ring Counter, Twisted Ring Counter, Sequence generator.	**04**

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.

Books Recommended:

Text Books:

1. Modern Digital Electronics, by R.P.Jain Tata McGraw Hill, 1984
2. Digital Design,by M Morris Mono Prentice Hall International-1984.
3. Digital Principal and Applications, by Malvino& Leach, Tata McGraw Hill, 1991.
4. Digital Electronics, by Malvino, Tata McGraw Hill, 1997.
5. Digital Logic: Applications and Design,by John Yarbourugh Cengage Learning
6. Fundamentals of Digital Circuits,by A. Anand Kumar, Prentice-Hall of India Pvt.Ltd;
7. Digital Design: Principles & Practices, by John F. Wakerly, Prentice Hall

Reference Books:

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

NPTEL/Swayam Course:

Course: 1. Digital Circuits by Prof. Santanu Chattopadhyay - IIT Kharagpur
https://nptel.ac.in/courses/108/105/108105113/
https://swayam.gov.in/nd1_noc20_ee70/preview
Course: 2. Switching Circuits and Logic Design by Prof. Indranil Sengupta - IIT Kharagpur
https://nptel.ac.in/noc/courses/noc20/SEM2/noc20-cs67/
https://swayam.gov.in/nd1_noc20_cs67/preview

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	Human Anatomy and Physiology for Engineers (HAPE)	--	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.						
BML301	Human Anatomy and Physiology for Engineers (HAPE)	--	--	--	--	25	--	--	--	25

Course Code	Course Name	Credits
BML301	Human Anatomy and Physiology for Engineers	01
Course Objective	• To understand the anatomical structures of the human body and their relationship to each other. • To gain the knowledge of measurement of various physiological parameters of the human body.	
Course Outcome	The learner will be able to : • Demonstrate measurement of blood pressure using occlusive cuff method. • Apply blood cell counting principles for measuring blood composition. • Demonstrate the measurement of electrical activity of heart and the related parameters. • Demonstrate the measurement of various lung volumes and capacities. • Appropriately utilize laboratory equipment, such as microscopes, general lab ware, and virtual simulations. • Locate and identify anatomical structures.	

Syllabus: Same as that of BMC302, Human Anatomy and Physiology for Engineers.

List of Laboratory Experiments: (Any Seven)

1. To measure blood pressure using sphygmomanometer.
2. To find the total red blood cell count using pre-prepared slides.
3. To find the total white blood cell count using pre-prepared slides.
4. To study the conduction system of the heart.
5. To study the twelve lead electrode scheme and operation of the ECG Machine.
6. To record ECG and measure its various parameters (amplitude, intervals/segment).
7. To record lung volumes and capacities using a spirometer.
8. Visit to the anatomy department of a hospital to view specimens (cardiovascular & respiratory systems).
9. Visit to the anatomy department of a hospital to view specimen (alimentary & renal systems).
10. Visit to the anatomy department of a hospital to view specimen (nervous system).
11. Present a case study on a given disease/abnormality that requires medical instruments for diagnosis/treatment.
12. Present case a study on a given disease/abnormality that requires medical instruments for diagnosis/treatment.

Any other experiment/visit to the hospital/case study based on syllabus which will help learner to understand a 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 (Journal) : 10 Marks

Attendance : 05 Marks

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

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)

NPTEL/Swayam Course:

Course: Animal Physiology by Prof. Mainak Das - IIT Kanpur
https://nptel.ac.in/courses/102/104/102104058/
https://swayam.gov.in/nd1_noc20_bt42/preview

Course Code	Course Name	Teaching Scheme			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
BML302	Medical Sensors (Abbreviated as MS)	--	02	--	--	01	--	01

Course Code	Course Name	Examination Scheme								
		Theory								
		Internal Assessment			End Sem	Term work	Pract.	Oral	Pract. / Oral	Total
		Test 1	Test 2	Avg.						
BML302	Medical Sensors (Abbreviated as MS)	--	--	--	--	25	--	25	--	50

Course Code	Course Name	Credits
BML302	Medical Sensors	01
Course Objectives	• To analyse the transient response of a first-order system. • To measure displacement using various displacement sensors. • To measure pressure using a pressure sensor. • To measure force using a force sensor. • To measure temperature using various temperature sensors. • To measure pH of a solution using a pH electrode.	
Course Outcomes	The learner will be able to: • Analyse step response of a first-order system. • Demonstrate the measurement of displacement using various displacement sensors. • Demonstrate the measurement of force and pressure using a force sensor and a pressure sensor respectively. • Demonstrate the measurement of temperature using various temperature sensors. • Distinguish various biopotential electrodes. • Demonstrate the measurement of pH of a solution using a pH electrode.	

Syllabus: Same as that of BMC303 Medical Sensors.

List of Laboratory Experiments: (Any seven)

1. To study the transient response of a first-order system.
2. To study the resistance versus temperature characteristics of a thermistor.
3. To study the thermistor linearization technique.
4. To study the characteristics of a light dependent resister.
5. To study the principle and working of a thermocouple.
6. To study principle and working of L.V.D.T.
7. To study principle and working of a capacitive sensor.
8. To study principle and working of a strain gage sensor.
9. To study principle and working of a pressure sensor.
10. To study the principle and working of a force sensor.
11. To study the various biopotential electrodes.
12. To study the pH electrode.

Any other experiment/student presentation based on the syllabus which will help the learner to understand a topic/concept.

Books Recommended:

Text Books:

1. Medical Instrumentation-Application and Design, John G. Webster, Wiley India Private Limited.
2. Instrument Transducers: An Introduction to Their Performance and Design, Hermann K. P. Neubert, Oxford University Press.
3. Biomedical Sensors: Fundamentals and Applications, Harry N. Norton, Noyes Publications.
4. Biomedical Transducers and Instruments, Tatsuo Togawa, Toshiyo Tamura and P. Ake Öberg, CRC Press.
5. Electronics in Medicine and Biomedical Instrumentation by Nandini K. Jog, Prentice-Hall of India Pvt. Limited.
6. Biosensors: Fundamentals and Applications, Bansi Dhar Malhotra and Chandra Mouli Pandey, Smithers Rapra Technology.

Reference Books:

1. Principles of Applied Biomedical Instrumentation, L.A. Geddes and L.E. Baker, Wiley India Pvt Ltd.
2. Biomedical Instrumentation and Measurements, Leslie Cromwell, Erich A. Pfeiffer and Fred J. Wiebell, Prentice-Hall of India Pvt. Ltd.
3. Principles of Biomedical Instrumentation and Measurement, Richard Aston, Merril Publishing Company.
4. Measurement Systems, Application and Design, Ernest O. Doeblin, McGraw Hill Higher Education.
5. Handbook of Modern Sensors – Physics, Design and Application, Jacob Fraden, Springer Publishing Company.
6. Transducers for Biomedical Measurements: Principles and Applications, Richard S. C. Cobbold, John Wiley & Sons.

NPTEL/Swayam Course:

Course: Industrial Instrumentation by Prof. Alok Barua - IIT Kharagpur

https://nptel.ac.in/courses/108/105/108105064/

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
BML303	Electronic Circuit Analysis and Design Lab (ECAD Lab)	--	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	Electronic Circuit Analysis and Design Lab (ECAD Lab)	--	--	--	--	25	--	--	25	50

Course Code	Course Name	Credits
BML303	Electronic Circuit Analysis and Design Lab	01
Course Objective	• To practically verify characteristics of different electronic components like diodes, BJT, MOSFET etc • To practically verify outputs of few applications of diodes, BJT, MOSFET. • To design and implement small signal amplifier.	
Course Outcome	Learner will be able to: • Explain the transfer characteristics of basic semiconductor devices. • Design and verify the outputs of various electronic circuits such as clipper, clampers etc using bread boards and various lab equipments. • Design amplifier circuits and plot its frequency response.	

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

List of Laboratory Experiments: (Any Eight)

1. To verify semiconductor diode and Zener diode characteristics.
2. To implement various clipper circuits and verify output.
3. To implement various clamper circuits and verify output.
4. To study line regulation and load regulation of voltage regulator using Zener diode.
5. To verify input and output characteristics of BJT.
6. To implement a switch using BJT.
7. To implementation different biasing circuit of BJT
8. To design and implement CE amplifier.
9. To study frequency response of CE amplifier.
10. To verify input and output characteristics of MOSFET.
11. To implementation different biasing circuit of MOSFET
12. To Study frequency response of an MOSFET amplifier.

Any other experiment based on syllabus can be included in the term work which will help learner to understand topic/concept.

Assessment:

Term Work:

Term work shall consist of minimum 8 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.

Books Recommended:

Textbooks:

1. Electronics Circuit. Analysis & Design, 2nd ed., Donald A. Neamen, McGraw Hill, 2001
2. Electronics Devices & Circuits Theory, by by Robert L. Boylestad and Louis Nashelsky, Pearson Education.
3. Semiconductor Data Manual, BPB Publications.

Reference Books:

1. Electronic Principles, by Albert Paul Malvino 6th edition, McGraw Hill
2. Electronic Devices and Circuits, by Jacob Milliman McGraw Hill.
3. Electronic Design, by Martin Roden, Gordon L.Carpenter, William Wieseman , Fourth edition, Shroff Publishers & Distributors Pvt. Ltd..
4. Electronic Circuits Discrete and Integrated, by Donald Schilling & Charles Belove, Third edition, McGraw Hill.

NPTEL/Swayam Course:

Course: Analog Electronic Circuits by Prof. Pradip Mandal - IIT Kharagpur
https://nptel.ac.in/courses/108/105/108105158/

Practical exam consists of performance of any one practical from the conducted experiments within the semester and oral based on entire syllabus.

Course Code	Course Name	Teaching scheme			Credit assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
BML304	Electronics Lab (Skill Based Lab)	--	04	--	--	02	--	02

Course Code	Course Name	Examination Scheme								
		Theory				Term work	Pract.	Oral	Pract. / Oral	Total
		Internal Assessment			End sem					
		Test 1	Test 2	Avg.						
BML304	Electronics Lab (Skill Based Lab)	--	--	--	--	25	--	--	25	50

Course Code	Course Name	Credits
BML304	Electronics Lab (Skill Based Lab)	02
Course Objective	• To design and implement voltage regulator circuits. • To design and implement digital circuits. • To learn skills of soldering. • To learn simulation of circuits using one of the simulation software.	
Course Outcome	Learner will be able to: • Design and implement analog and digital electronic circuits on bread board and verify the outputs. • Learn one of the tools for simulating different circuits. • Know the limitations of ideal environment of simulations and also importance of simulation in designing the circuits. • Learn soldering skills for implementing the circuits on PCB.	

List of experiments from Analog electronics:

Skill 1-Soldering the components on PCB (Any 4)

1. Implement diode as full-wave rectifier using centre tap transformer.
2. Implement diode as full-wave rectifier using bridge circuit.
3. Use of Filter components with rectifier circuit.
4. Implement voltage regulators using IC 79XXand/or IC 78XX
5. Implement voltage regulators using IC 317/IC 723
6. Implement of logic gates using diodes.

Skill 2-Simulations using simulation software like Multisim, Pspice etc (Any 4)

1. Simulate CASCODE amplifier.
2. Simulate Darlington amplifier.
3. Simulate power Amplifier
4. Simulate DIAC for transfer characteristics.
5. Simulate TRIAC for transfer characteristics.
6. Simulate UJT for transfer characteristics.

List of experiments from Digital Electronics (Perform using Breadboard or Logisim S/W etc):

(Any 8)

1. A step in space vehicle checkout depends on FOUR sensors S1, S2, S3 and S4. Every circuit is working properly if sensor S1 and at least two of the other three sensors are at logic 1. Implement the system using NAND gates only, the output is connected to a red LED which must glow if the circuit is not working properly and the output is connected to a green LED which must glow if the circuit is working properly.
2. To design binary to gray code converter and gray to binary converter.

3. To design parity generator and parity checker circuits.
4. To design adder and subtractor circuits.
5. To design various circuits using multiplexers.
6. To design various circuits using de-multiplexer.
7. To design Asynchronous counter.
8. To design decade counter
9. To design Synchronous counter.
10. To implement shift register and ring counter using MSI shift register.
11. To implement Moore/ Mealy machine.
12. A given finite state machine has an input W and output Z. During four consecutive clock pulses a sequence of four values of W signal is applied. Design a machine that produces Z = 1 when it detects either of sequence W: 0010 or W: 1110 otherwise Z=0. After the fourth clock pulse the machine has to be again in the reset state ready for next sequence.

Any other experiment based on syllabus can be included in the term work which will help learner to understand topic/concept.

Assessment:

Term Work:

Term work shall consist of minimum 8 experiments from Analog electronics and 8 experiments from digital electronics.

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

Laboratory work (Lab work and journal):10 Marks
Soldering skills :05 Marks
Simulation skills :05 marks
Attendance :05 Marks

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

Books Recommended:

Text Books:

1. Op-Amps and linear integrated circuits – Ramakant Gayakwad, Prentice Hall
2. Electronics Devices & Circuits, by Boylestad Robert L., Louis Nashelsky, Pearson Education.
3. Modern Digital Electronics, by R.P.Jain, Tata McGraw Hill, 1984
4. Digital Design, M Morris Mono, Prentice Hall International-1984.

Reference Books:

1. Electronic Principles, by Albert Paul Malvino, 6/e, McGraw Hill
2. Semiconductor Data Manual, BPB Publications.
3. Electronic design, by Martin Roden, Gordon L. Carpenter, William Wieseman Fourth edition, Shroff Publishers &Distributors Pvt. Ltd.
4. Digital Design, by M Morris Mono Prentice Hall International 1984

Practical exam consists of performance of any one practical from digital electronics experiments conducted within the semester and oral based on digital electronics syllabus.

Course code	Course Name	Credits
BMM301	Mini Project - 1 A	02

Course Code	Course Name	Credits
BMM301	Mini Project – 1 A	02
Course Objective	• To acquaint with the process of identifying the needs and converting it into the problem. • To familiarize the process of solving the problem in a group. • To acquaint with the process of applying basic engineering fundamentals to attempt solutions to the problems. • To inculcate the process of self-learning and research.	
Course Outcome	Learner will be able to: • Identify problems based on societal /research needs. • Apply Knowledge and skill to solve societal problems in a group. • Develop interpersonal skills to work as member of a group or leader. • Draw the proper inferences from available results through theoretical/ experimental/simulations. • Analyse the impact of solutions in societal and environmental context for sustainable development. • Use standard norms of engineering practices • Excel in written and oral communication. • Demonstrate capabilities of self-learning in a group, which leads to life long learning. • Demonstrate project management principles during project work.	

Guidelines for Mini Project

- Students shall form a group of 3 to 4 students, while forming a group shall not be allowed less than three or more than four students, as it is a group activity.
- Students should do survey and identify needs, which shall be converted into problem statement for mini project in consultation with faculty supervisor/head of department/internal committee of faculties.
- Students hall submit implementation plan in the form of Gantt/PERT/CPM chart, which will cover weekly activity of mini project.
- A log book to be prepared by each group, wherein group can record weekly work progress, guide/supervisor can verify and record notes/comments.
- Faculty supervisor may give inputs to students during mini project activity; however, focus shall be on self-learning.
- Students in a group shall understand problem effectively, propose multiple solution and select best possible solution in consultation with guide/ supervisor.
- Students shall convert the best solution into working model using various components of their domain areas and demonstrate.

- The solution to be validated with proper justification and report to be compiled in standard format of University of Mumbai.
- With the focus on the self-learning, innovation, addressing societal problems and entrepreneurship quality development within the students through the Mini Projects, it is preferable that a single project of appropriate level and quality to be carried out in two semesters by all the groups of the students. i.e. Mini Project 1 in semester III and IV. Similarly, Mini Project 2 in semesters V and VI.
- However, based on the individual students or group capability, with the mentor's recommendations, if the proposed Mini Project adhering to the qualitative aspects mentioned above gets completed in odd semester, then that group can be allowed to work on the extension of the Mini Project with suitable improvements/modifications or a completely new project idea in even semester. This policy can be adopted on case by case basis.

Guidelines for Assessment of Mini Project:

Term Work

- The review/ progress monitoring committee shall be constituted by head of departments of each institute. The progress of mini project to be evaluated on continuous basis, minimum two reviews in each semester.
- In continuous assessment focus shall also be on each individual student, assessment based on individual's contribution in group activity, their understanding and response to questions.
- Distribution of Term work marks for both semesters shall be as below;
    - Marks awarded by guide/supervisor based on log book : 10
    - Marks awarded by review committee : 10
    - Quality of Project report : 05

Review/progress monitoring committee may consider following points for assessment based on either one year or half year project as mentioned in general guidelines.

One-year project:

- In first semester entire theoretical solution shall be ready, including components/system selection and cost analysis. Two reviews will be conducted based on presentation given by students group.
    - First shall be for finalisation of problem
    - Second shall be on finalisation of proposed solution of problem.
- In second semester expected work shall be procurement of component's/systems, building of working prototype, testing and validation of results based on work completed in an earlier semester.
    - First review is based on readiness of building working prototype to be conducted.
    - Second review shall be based on poster presentation cum demonstration of working model in last month of the said semester.

Half-year project:

- In this case in one semester students' group shall complete project in all aspects including,
    - Identification of need/problem
    - Proposed final solution
    - Procurement of components/systems

- Building prototype and testing
- Two reviews will be conducted for continuous assessment,
  - First shall be for finalisation of problem and proposed solution
  - Second shall be for implementation and testing of solution.

Assessment criteria of Mini Project.

Mini Project shall be assessed based on following criteria;

1. Quality of survey/ need identification
2. Clarity of Problem definition based on need.
3. Innovativeness in solutions
4. Feasibility of proposed problem solutions and selection of best solution
5. Cost effectiveness
6. Societal impact
7. Innovativeness
8. Cost effectiveness and Societal impact
9. Full functioning of working model as per stated requirements
10. Effective use of skill sets
11. Effective use of standard engineering norms
12. Contribution of an individual's as member or leader
13. Clarity in written and oral communication

- In **one year, project**, first semester evaluation may be based on first six criteria's and remaining may be used for second semester evaluation of performance of students in mini project.
- In case of **half year project** all criteria's in generic may be considered for evaluation of performance of students in mini project.

Guidelines for Assessment of Mini Project Practical/Oral Examination:

- Report should be prepared as per the guidelines issued by the University of Mumbai.
- Mini Project shall be assessed through a presentation and demonstration of working model by the student project group to a panel of Internal and External Examiners preferably from industry or research organizations having experience of more than five years approved by head of Institution.
- Students shall be motivated to publish a paper based on the work in Conferences/students competitions.

Mini Project shall be assessed based on following points;

1. Quality of problem and Clarity
2. Innovativeness in solutions
3. Cost effectiveness and Societal impact
4. Full functioning of working model as per stated requirements
5. Effective use of skill sets
6. Effective use of standard engineering norms
7. Contribution of an individual's as member or leader
8. Clarity in written and oral communicate

Semester - IV

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	TW/Pract.	Tut.	Total
BMC401	Engineering Mathematics-IV	03	-	01	03	-	01	04

Course Code	Course Name	Examination Scheme							
		Theory				Term Work	Pract.	Oral	Total
		Internal Assessment			End Sem Exam				
		Test 1	Test 2	Avg of Test 1 & 2					
BMC401	Engineering Mathematics-IV	20	20	20	80	25	-	-	125

Pre-requisite: Engineering Mathematics-I, Engineering Mathematics-II, Engineering Mathematics-III, Binomial Distribution.

Course Code	Course Name	Credits
BMC401	Engineering Mathematics – IV	04
Course Objectives	• To study the line and contour integrals and expansion of complex valued function in a power series. • To understand the basic techniques of statistics for data analysis, Machine learning and AI. • To study the probability distributions and expectations. • To acquaint with the concepts of vector spaces used in the field of machine learning and engineering problems. • To familiarize with the concepts of Quadratic forms and Singular value decomposition. • To learn the concepts of Calculus of Variations.	
Course Outcomes	On successful completion of course, learner will be able to: • Use the concepts of Complex Integration for evaluating integrals, computing residues & evaluate various contour integrals. • Demonstrate the use of Correlation and Regression to the engineering problems in data science, machine learning and AI. • Illustrate understanding of the concepts of probability and expectation for getting the spread of the data and distribution of probabilities. • Apply the concept of vector spaces and orthogonalization process in Engineering Problems. • Use the concept of Quadratic forms and Singular value decomposition in various Engineering applications. • Find the extremals of the functional using the concept of Calculus of variation.	

Module	Detailed Contents	Hrs.
01	**Module: Complex Integration** 1.1 Line Integral, Cauchy's Integral theorem for simple connected and multiply connected regions (without proof), Cauchy's Integral formula (without proof). 1.2 Taylor's and Laurent's series (without proof). 1.3 Definition of Singularity, Zeroes, poles of *f(z)*, Residues, Cauchy's Residue Theorem (without proof). **Self-learning Topics:** Application of Residue Theorem to evaluate real integrations ,Z- Transform.	7
02	**Module: Statistical Techniques** 2.1 Karl Pearson's Coefficient of correlation (r) . 2.2 Spearman's Rank correlation coefficient (R) (repeated and non-repeated ranks) 2.3 Lines of regression. 2.4 Fitting of first and second degree curves. **Self-learning Topics:** Covariance, fitting of exponential curve.	6
03	**Module: Probability Distributions** 2.1 Baye's Theorem, Random variable: Probability distribution for discrete and continuous random variables, Density function and distribution function. 3.2 Expectation, mean and variance. 3.3 Probability distribution: Poisson & normal distribution. **Self-learning Topics:** Moments, Moment Generating Function, Applications of Probability Distributions in Engineering.	7
04	**Module: Linear Algebra: Vector Spaces:-** 4.1 Vectors in n-dimensional vector space, norm, dot product, The CauchySchwarz inequality (with proof), Unit vector. 4.2 Orthogonal projection, Orthonormal basis, Gram-Schmidt process for vectors. 4.3 Vector spaces over real field, subspaces. **Self-Learning Topics**:- Linear combinations, linear Dependence and Independence, QR decomposition.	6
05	**Module: Linear Algebra: Quadratic Forms** 5.1 Quadratic forms over real field, Linear Transformation of Quadratic form, Reduction of Quadratic form to diagonal form using congruent transformation. 5.2 Rank, Index and Signature of quadratic form, Sylvester's law of inertia, Value-class of a quadratic form-Definite, Semidefinite and Indefinite. 5.3 Reduction of Quadratic form to a canonical form using congruent transformations. 5.4 Singular Value Decomposition. **Self-learning Topics:** Orthogonal Transformations**,** Applications of Quadratic forms and SVD in Engineering.	7
06	**Module: Calculus of Variations:** 6.1 Euler- Lagrange equation (Without Proof), When F does not contain y, When F does not contain x, When F contains x, y, y'. 6.2 Isoperimetric problems- Lagrange Method. 6.3 Functions involving higher order derivatives: Rayleigh-Ritz Method. **Self-Learning Topics:-** Brachistochrone Problem, Variational Problem, Hamilton Principle, Principle of Least action , Several dependent variables.	6

Term Work:

General Instructions:

1. Batch wise tutorials are to be conducted. The number of students per batch should be as per University pattern for practicals.
2. Students must be encouraged to write at least 6 class tutorials on entire syllabus.
3. A group of 4-6 students should be assigned a self-learning topic. Students should prepare a presentation/problem solving of 10-15 minutes. This should be considered as mini project in Engineering mathematics. This project should be graded for 10 marks depending on the performance of the students.

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

Class Tutorials on entire syllabus	: 10 Marks
Mini project	: 10 Marks
Attendance (Theory and Tutorial)	: 5 Marks

Assessment:

Internal Assessment Test:
Assessment consists of two class tests of 20 marks each. The first-class test (Internal Assessment I) is to be conducted when approx. 40% syllabus is completed and second class test (Internal Assessment II) when additional 35% syllabus is completed. Duration of each test shall be one hour.

End Semester Theory Examination:

1. Question paper will comprise of total 06 questions, each carrying 20 marks.
2. Total 04 questions need to be solved.
3. Question No: 01 will be compulsory and based on entire syllabus wherein 4 sub-questions of 5 marks each will be asked.
4. Remaining questions will be randomly selected from all the modules.
5. Weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.

References:

1. Complex Variables and Applications, Brown and Churchill, McGraw-Hill education.
2. Probability, Statistics and Random Processes, T. Veerarajan, McGraw-Hill education.
3. Advanced engineering mathematics H.K. Das, S . Chand, Publications.
4. Higher Engineering Mathematics B. V. Ramana, Tata Mc-Graw Hill Publication
5. Advanced Engineering Mathematics, R. K. Jain and S. R. K. Iyengar, Narosa publication
6. Advanced Engineering Mathematics Wylie and Barret, Tata Mc-Graw Hill.
7. Beginning Linear Algebra Seymour Lipschutz Schaum's outline series, Mc-Graw Hill Publication
8. Higher Engineering Mathematics, Dr. B. S. Grewal, Khanna Publication

Course Code	Course Name	Teaching scheme			Credit assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
BMC402	Integrated Circuit Design (Abbreviated as ICD)	03	--	--	03	--	--	03

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	Integrated Circuit Design (Abbreviated as ICD)	20	20	20	80	03	--	--	--	--	100

Course Code	Course Name	Credits
BMC402	Integrated Circuit Design	03
Course Objectives	• To provide concepts of operational amplifier (Op-Amp) with their applications and design methodology. • To cover analysis of circuits using various ICs. • To design and develop various circuits for biomedical applications and to develop analytical thinking of students.	
Course Outcomes	Learner will be able to: • Demonstrate basics of operational amplifiers. • Analyse different types of Op-Amp based circuits. • Analyse and design operational amplifier to perform mathematical operations. • Design operational amplifier based oscillators. • Learn various waveform generation ICs and their applications to use effectively in projects. • Apply the knowledge of various special function ICs and special purpose diodes for designing practical applications.	

Module	Contents	Hours
1.	**Introduction to Operational Amplifier (Op-Amp):** Introduction to Differential Amplifier; Introduction to an Ideal Operational Amplifier, Block Diagram, DC & AC Characteristics and Equivalent circuit of Op-amp; Op-amp IC 741 characteristics, frequency response and concept of virtual ground.	**05**
2.	**Linear Application of Op-Amp:** Adder, Subtractor /differential Amplifier, Voltage follower, Integrator (Ideal and practical), Differentiator (Ideal and practical), Instrumentation amplifier and Instrumentation amplifier IC (AD620); Voltage to Current and Current to Voltage converters.	**05**
3.	**Non-Linear Applications of operational Amplifier:** Voltage comparators, zero crossing detector and Schmitt Trigger (Regenerative comparator); Active Half wave rectifiers, Active Full wave rectifier, Clipper, Clampers, Log and Antilog amplifiers, Sample & hold circuits, Peak detector, Peak to Peak detector and Generalized Impedance Convertor; Introduction to additional Op-Amp ICs and their features: CA3140E, TL081CN, TL061CP, TL071CP, MC33171N, TL0xx, MCP601 and OPA602.	**10**
4.	**Oscillators using Operational Amplifier:** Concepts of feedback, types of feedback and various topologies of negative feedback; Concepts of Oscillation and Barkhausen's criteria for an oscillator; Types of oscillators: RC Phase shift Oscillator, Wien Bridge oscillator, Colpitt's Oscillator, Hartley Oscillator, Crystal Oscillator and Clapp Oscillator (For all the above oscillators; working, Frequency of oscillation, condition for sustained oscillation and design of each oscillator).	**09**
5.	**Special Function ICs - 1:** IC 555 Functional Block diagram and Circuit diagram; IC 555 in Astable Multivibrator(AMV) functional diagram, circuit diagram with applications; IC 555 in Monostable Multivibrator (MMV) functional diagram, circuit diagram with applications.	**05**
6.	**Special Function ICs – 2:** Function Generator (IC 8038 or equivalent) Circuit diagram and its applications; VCO (IC 566) Circuit diagram and applications; F-V convertors and V-F convertors; Circuit diagram and its applications; Introduction to PLL	**05**

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.

Books Recommended:

Textbooks:

1. Integrated Circuits K.R. Botkar
2. Design with Operational Amplifiers and Analog Integrated Circuits, by Sergio Franco, McGraw Hill, 2002
3. Op-Amps and linear integrated circuits by Ramakant. Gayakwad Prentice Hall
4. Linear Integrated Circuits, by D Choudhury Roy, New Age International Publishers

Reference Books:

1. Analog Integrated Circuit Design, by, Tony Chan Carusone, David Johns, Kenneth William Martin Wiley, 2012
2. Op-amps and linear integrated circuits, Theory and Applications- James Fiore, Delmar Thomson Learning, 2001

NPTEL/Swayam Link:
Course: Integrated Circuits, MOSFETs, Op-Amps and their Applications by Prof. Hardik Jeetendra Pandya - IISc Bangalore
https://nptel.ac.in/courses/108/108/108108111/

Theory Examination:

5. Question paper will comprise of 6 questions, each carrying 20 marks.
6. Total four questions need to be solved.
7. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
8. 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	Principles Control System (Abbreviated as PCS)	03	--	--	03	--	--	03

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	Principles Control System (Abbreviated as PCS)	20	20	20	80	03	--	--	--	--	100

Course Code	Course Name	Credits
BMC403	Principles of Control Systems	3
Course Objectives	• To make the learner aware of fundamental concepts of Control systems and mathematical modelling of the system. • To make learner study the state variable representation of control system • To make learner know the concept of time response and frequency response of the system. • The learner should be able to do stability analysis of the system and aware of PID controllers	
Course Outcomes	• To describe basic concepts of control system such as open loop, closed loop, feedback and feed forward systems • To develop the mathematical model of different type of systems • To analyze systems using state space techniques • To analyse stability in time domain using root locus and BIBO stability • To examine correlation between stability analysis of systems in time and frequency domain • To analyse effect of PID controller in control design	

Module No.	Contents	Hours
1	**Introduction to Control System Analysis:** Open loop and closed loop systems; Feedback and feed forward control structure; Examples of control systems.	03
2	**Mathematical Modelling of Systems:** Transfer function models of systems**,** Models of electrical systems, Block diagram reduction; Signal flow graph and the Mason's gain rule. Standard test signals; Transient and steady state behaviour of first and second order systems; Type and order of feedback control systems and steady state error analysis	08
3	**State Variable Models :** State variable models of systems. Concept of state transition matrix; Properties of state transition matrix; Solution of homogeneous systems. Concept of controllability and observability; Controllability & Observability analysis of LTI systems using Kalman approach.	08
4	**Stability Analysis in Time Domain:** Concept of absolute, Relative and robust stability; Routh Hurwitz stability criterion; Root-locus concepts; General rules for constructing root-locus; Root locus analysis of control systems.	08
5	**Stability Analysis in Frequency Domain:** Frequency domain specifications; Response peak and peak resonating frequency; Relationship between time and frequency domain of systems; Stability margins. Magnitude and phase plot; Method of plotting Bode plot; Stability margins on the Bode plots; Stability analysis using Bode plot.	09
6	**Concept of feedback controllers:** Concept of proportional, PI and PID Controllers	03

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.

Books Recommended:

Text Books:

1. Modern Control Engineering : D.Roy Choudhury, PHI
2. Modem Control Engineering : K. Ogata , PHI
3. Control Systems Engineering: I.J. Nagrath, M. Gopal, Third Edition, New Age International Publishers.
4. Control Systems: Principle and design, by M. Gopal Tata McGraw Hill, First Edition, 1998
5. Automatic Control Systems – Kuo
6. Modern Control System, Pearson, Richard C. Dorf and Robert H. Bishop, Eleventh Edition, 2013.

Reference Books:

1. Modern Control Technology, Components & Systems – Kilian
2. Analog And Digital Control System Design – Chen
3. Linear Control System Analysis and Design – Sheldon
4. Schaum's Outline of Theory and Problems - Schaum's
5. Automated Continuous Process Control and Multivariable Control – Smith
6. Robust Control System Design State Space Method – Tsui

NPTEL /Swayam Link:
Course 1: Control systems by Prof. C.S.Shankar Ram - IIT Madras
https://nptel.ac.in/courses/107/106/107106081/
https://swayam.gov.in/nd1_noc20_ee90/preview
Course 2: Control Engineering by Prof. Ramkrishna Pasumarthy - IIT Madras
https://nptel.ac.in/courses/108/106/108106098/
https://swayam.gov.in/nd1_noc20_ee62/preview

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	Medical Imaging-I (Abbreviated as MI-I)	03	--	--	03	--	--	03

Course Code	Course Name	Examination Scheme									
		Theory					Term work	Pract	Oral	Pract. / Oral	Total
		Internal Assessment			End sem	Dura tion (hrs)					
		Test 1	Test 2	Avg.							
BMC404	Medical Imaging-I (Abbreviate as MI-I)	20	20	20	80	03	--	--	--	--	100

Course Code	Course Name	Credits
BMC404	Medical Imaging-I	03
Course Objectives	• To familiarize the learners with the various Imaging modalities in medicine, their operating principles and quality control aspects. • To keep the learners abreast with the technological developments in the field of Medical Imaging.	
Course Outcomes	Learner will be able to: • Discuss different parts of a X-Ray Equipment and outline process of X-Ray Interaction with matter. • Explain concepts of Radiography techniques such as Computed Radiography (CR), Digital Radiography (DR) and Mammography with focus on its clinical applications. • Explain working principle of Fluoroscopic Imaging and Digital Subtraction Angiography and outline its clinical applications. • Describe system configuration of Computed Tomography, Apply CT Image Reconstruction Algorithms and enlist its clinical applications. • Highlight the key advancements in CT Technology and demonstrate its application in area of Clinical angiography and Cardiac CT	

Module	Contents	Hours
1.	**X- Ray Imaging:** Properties of X-Rays, Production of X-Rays, X-Ray interaction with matter, Attenuation of X-Rays. Total Radiographic System: X – Ray tubes, Rating of X-Ray tubes, X-Ray generators, Filters, Grids, Beam Restrictors, Control Panel and X-Ray Films.	**12**
2.	**Radiography Techniques & Applications:** Principle and working of Computed Radiography, Digital Radiography and Mammography with its clinical applications.	**06**
3.	**Fluoroscopic Imaging:** X-Ray Image Intensifier, Principle and Working of C-Arm, Digital Subtraction Angiography and its clinical applications.	**04**
4.	**Principle of Computed Tomography:** Scanner Configurations/Generations, CT System: Scanning unit(gantry), Detectors, CT Number, Data Acquisition System. Spiral CT: Technology and clinical applications, CT artifacts and Clinical applications of CT	**08**
5.	**CT Reconstruction Techniques**: Radon Transform, Iterative, Filtered Back Projection and Fourier reconstruction.	**04**
6.	**Advancements in CT:** Multi-Detector Computed Tomography (MDCT), Flat Panel Detectors, Contrast agents in CT, CT-Angiography & Cardiac CT.	**05**

Internal 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.

Books Recommended:
Textbooks:

1. Christensen's Physics of Diagnostic Radiology: Thomas Curry, James Dowdey, Robert Murry (Publisher- Lea & Febiger)
2. Medical Imaging Physics: William R. Hendee (Publisher- Wiley-Blackwell)
3. The Physics of Diagnostic Imaging: David Dowsett (Publisher- CRC Press)

Reference Books:

1. Biomedical Technology and Devices: James Moore, Duncan Maitland (Publisher- CRC Press)
2. The Biomedical Engineering Handbook: Ed. Joseph D. Bronzino (Publisher-CRC Press LLC)
3. Encyclopedia of Medical Devices and Instrumentation: John G. Webster. Vol. I, II, III, IV (Marcel Dekkar Pub).

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.

Links:
Course 1: *Introduction to Biomedical Imaging*
https://www.edx.org/course/introduction-to-biomedical-imaging
Course 2: *Fundamentals of Biomedical Imaging: Ultrasounds, X-ray, positron emission tomography (PET) and applications*
https://www.edx.org/course/fundamentals-of-biomedical-imaging-ultrasounds-x-r

Course Code	Course Name	Teaching scheme			Credit assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
BMC405	Biomaterials and Artificial Organs (Abbreviated as BMAO)	03	--	--	03	--	--	03

Course Code	Course Name	Examination Scheme									
		Theory					Term work	Pract	Oral	Pract. / Oral	Total
		Internal Assessment			End sem	Dur-ation (hrs)					
		Test 1	Test 2	Avg.							
BMC405	Biomaterials and Artificial Organs (Abbreviated as BMAO)	20	20	20	80	03	--	--	--	--	100

Course Code	Course Name	Credits
BMC405	Biomaterials and Artificial Organs	03
Course Objectives	• To understand the fundamentals of biomaterials used for manufacturing implants that has wide application in healthcare industry. • To understand design considerations and materials used for manufacturing of various artificial organs.	
Course Outcomes	Learners will be able to • Classify various biomaterials and select biomaterials for specific application • Explain biological, mechanical and physio-chemical tests conducted on biomaterials before implantation in the human body. • Explain properties and applications of metals and ceramic biomaterials. • Explain properties and applications of polymeric, degradable and composite biomaterials. • Explain design aspects and materials used in the fabrication of artificial organs.	

Module	Contents	Hours
1.	**Introduction to Biomaterials and Surface Properties of Biomaterials:** Introduction of biomaterials: Classification of biomaterials, general applications; Corrosion and wear of biomaterials; Biocompatibility**:** Definition, interaction of tissues with biomaterials; Surface properties of biomaterials**;** Surface characterization techniques**:** Electron **s**pectroscopy for chemical analysis (ESCA), secondary ion mass spectrometry (SIMS), infrared spectroscopy, contact angle method.	**06**
2.	**Testing of Biomaterials:** Mechanical Testing; Physiochemical Testing; Biological Testing: In-vitro testing, In-vivo testing of Biomaterials.	**06**
3.	**Metallic Biomaterials:** Properties, applications and biocompatibility of stainless steel, titanium, titanium based alloys and cobalt – chromium alloys in fabrication of bio-devices and implants.	**04**
4.	**Ceramic Biomaterials:** Classification of ceramic biomaterials; Properties, applications and biocompatibility of alumina, zirconia, bioglass, calcium phosphate and tricalcium phosphate in fabrication of biodevices and implants.	**04**
5.	**Polymeric Biomaterials:** Classification of polymeric biomaterials, Thermoplastic and Thermosetting plastics; Properties and applications of polyurethanes, PTFE, polyethylene, polypropylene, polyacrylates, PMMA, PHEMA, hydrogel, silicone rubber, degradable polymeric biomaterials (PGA and PLA) and biopolymer in fabrication of biodevices and implants. **Composite Biomaterials:** Classification, properties, and applications of composite biomaterials in fabrication of biodevices and implants.	**09**
6.	**Artificial Organs:** Design considerations and biomaterials involved in development of artificial heart and cardiac assist devices, heart valves, vascular grafts, peritoneal dialysis, artificial lungs, artificial liver, artificial pancreas, artificial blood, artificial skin; 3D bioprinting for manufacturing of artificial skin, cornea, collagen.	**10**

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.

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 (Elsevier Publications)
4. The Biomedical Engineering HandBook: Ed. Joseph D. Bronzino (CRC Press LLC)
5. Artificial Organs: Gerald E. Miller (Morgan and Claypool)
6. 3D Printing in Medicine: Deepak M Kalaskar (Woodhead Publishing)

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 Part – B: Applications Vol. I, II. (Marcel Dekkar Pub)
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.)

NPTEL/Swayam Links:
Course: Medical Biomaterials by Prof. Mukesh Doble - IIT Madras
https://nptel.ac.in/courses/102/106/102106057/

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	Integrated Circuit Design Lab (ICD Lab)	--	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	Integrated Circuit Design Lab (ICD Lab)	--	--	--	--	25	--	--	25	50

Course Code	Course Name	Credits
BML401	Integrated Circuit Design Lab	01
Course Objective	• To study op-amp parameters and understand the data sheet. • To provide designing methodologies for basic circuits like amplifiers, filters, oscillators etc. using operational amplifiers. • To implement the circuits on bread boards for verifying the outputs and obtain frequency response.	
Course Outcome	Learner will be able to: • Read the data sheet of different ICs, compare the parameters to select appropriate IC. • To design and implement various building blocks of different biomedical instruments.	

Syllabus: Same as that of BMC403 Linear Integrated Circuits

List of Laboratory Experiments: (Any seven)

1. To study op-amp parameters.
2. To design and verify outputs of inverting amplifier, noninverting amplifier and voltage follower.
3. Design and verify the outputs of adder and subtractor.
4. To design and verify output of instrumentation amplifier.
5. To study frequency response of an integrator
6. To study frequency response of differentiator.
7. To study peak detector circuit.
8. To study half wave rectifier and full wave rectifier.
9. To study RC-phase shift oscillator.
10. To study Wein bridge oscillator.
11. To study comparators and zero crossing detector.
12. To design and study band pass filter using op-amp
13. To design and study notch filter.
14. To study monostable multivibrator using IC 555
15. To study astable multivibrator using IC555
16. To verify outputs of IC 8038

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

Assessment:

Term Work:

Term work shall consist of minimum 10 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.

Books Recommended:

Textbooks:

1. Integrated Circuits K.R. Botkar
2. Design with Operational Amplifiers and Analog Integrated Circuits, by Sergio Franco, McGraw Hill, 2002
3. Op-Amps and linear integrated circuits by Ramakant. Gayakwad Prentice Hall
4. Linear Integrated Circuits, by D Choudhury Roy, New Age International Publishers

Reference Books:

1. Analog Integrated Circuit Design, by, Tony Chan Carusone, David Johns, Kenneth William Martin Wiley, 2012
2. Op-amps and linear integrated circuits, Theory and Applications- James Fiore, Delmar Thomson Learning, 2001

NPTEL/Swayam Link:

Course: Integrated Circuits, MOSFETs, Op-Amps and their Applications by Prof. Hardik Jeetendra Pandya - IISc Bangalore
https://nptel.ac.in/courses/108/108/108108111/

Practical exam consists of performance of any one practical from the conducted experiments within the semester and oral based on entire syllabus.

Course Code	Course Name	Teaching scheme			Credit assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
BML402	Principles of Control Systems Lab (PCS)	--	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	Principles of Control Systems Lab (PCS)	--	--	--	--	25	--	--	--	25

Course Code	Course Name	Credits
BML402	Principles of Control Systems Lab	01
Course Objectives	• To make the learner aware of fundamental concepts of Control systems and mathematical modelling of the system. • To make learner study the state variable representation of control system • To make learner know the concept of time response and frequency response of the system. • The learner should be able to do stability analysis of the system and aware of PID controllers	
Course Outcomes	• To describe basic concepts of control system such as open loop, closed loop, feedback and feed forward systems • To develop the mathematical model of different type of systems • To analyse systems using state space techniques • To analyse stability in time domain using root locus and BIBO stability • To examine correlation between stability analysis of systems in time and frequency domain • To analyse effect of PID controller in control design	

List of Experiments: Any 7

1. Time response of first and second order RLC Circuits and systems
2. Frequency response of first and second order system
3. Plotting transient response by varying damping ratio using MATLAB/SCILAB
4. Type of a system and error coefficients
5. Design of standard test signal generators
6. Effect of adding Poles/Zeros in transient response and stability using MATLAB/SCILAB
7. Plot of Root locus using MATLAB/SCILAB

8. To determine frequency response of a second order system and evaluation of frequency domain specifications.
9. Frequency response of Lag and lead compensators
10. Bode Plot and stability using MATLAB/SCILAB
11. Checking Controllability and observability using MATLAB/SCILAB
12. Transient response/Solution of state equation of state space model using MATLAB/SCILAB
13. To study the effect of P, PI, PD and PID controller on step response of a feedback control system
14. PID Controller using SIMULINK

Students can perform any other experiment/Mini project based on the theory syllabus

Assessment:

***Term Work*:**

Term work shall consist of minimum 7experiments.

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

Laboratory work (Experiments performance): 10 Marks

Laboratory work (Journal/Mini project): 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.

Books Recommended:

Text Books:

1. Modern Control Engineering : D.Roy Choudhury, PHI
2. Modem Control Engineering : K. Ogata , PHI
3. Control Systems Engineering: I.J. Nagrath, M. Gopal, Third Edition, New Age International Publishers.
4. Control Systems: Principle and design, by M. Gopal Tata McGraw Hill, First Edition, 1998
5. Automatic Control Systems – Kuo
6. Modern Control System, by Richard C. Dorf and Robert H. Bishop Pearson, Eleventh Edition, 2013.

Reference Books:

1. Modern Control Technology, Components & Systems – Kilian
2. Analog And Digital Control System Design – Chen
3. Linear Control System Analysis and Design – Sheldon
4. Schaum's Outline of Theory and Problems - Schaum's
5. Automated Continuous Process Control and Multivariable Control – Smith
6. Robust Control System Design State Space Method – Tsui

NPTEL /Swayam Link:

Course 1: Control systems by Prof. C.S.Shankar Ram - IIT Madras

https://nptel.ac.in/courses/107/106/107106081/

https://swayam.gov.in/nd1_noc20_ee90/preview

Course 2: Control Engineering by Prof. Ramkrishna Pasumarthy - IIT Madras

https://nptel.ac.in/courses/108/106/108106098/

https://swayam.gov.in/nd1_noc20_ee62/preview

Course Code	Course Name	Teaching scheme			Credit assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
BML403	Medical Imaging-I (Abbreviated as MI-I)	--	02	--	--	01	--	01

Course Code	Course Name	Examination Scheme									
		Theory									
		Internal Assessment			End sem	Duration (hrs)	Term work	Pract	Oral	Pract. / Oral	Total
		Test 1	Test 2	Avg.							
BML403	Medical Imaging-I (Abbreviated as MI-I)	--	--	--	--	--	25	--	25	--	50

Course Code	Course Name	Credits
BML403	Medical Imaging-I	01
Course Objectives	• To familiarize the learners with the various Imaging modalities in medicine, their operating principles and quality control aspects. • To keep the learners abreast with the technological developments in the field of Medical Imaging.	
Course Outcomes	Learner will be able to: • Discuss different parts of a X-Ray Equipment and outline process of X-Ray Interaction with matter. • Explain concepts of Radiography techniques such as Computed Radiography (CR), Digital Radiography (DR) and Mammography with focus on its clinical applications. • Explain working principle of Fluoroscopic Imaging and Digital Subtraction Angiography and outline its clinical applications. • Describe system configuration of Computed Tomography, Apply CT Image Reconstruction Algorithms and enlist its clinical applications. • Highlight the key advancements in CT Technology and demonstrate its application in area of Clinical angiography and Cardiac CT	

Syllabus: Same as that of BMC404 Medical Imaging – I (Abbreviated as MI-I)

Suggested List of Laboratory Experiments (Any Seven)

1. Study of X-Ray tube & Tube Housing
2. Prototype of X-Ray Generator Circuits
3. Design of X-Ray Timer
4. Comparative study of modern X-Ray machines manufactured by different companies
5. Simulation of Digital Subtraction Angiography using MATLAB
6. Comparative study of CT Machines manufactured by different companies
7. Case study on any disease/abnormality which require imaging modality for diagnosis
8. To perform CT windowing on an Image using MATLAB
9. To perform back projection on an Image using MATLAB
10. To generate pseudo colour image using MATLAB
11. Hospital Visit may be conducted to Radiology Department (Report by student is expected)
12. Technical paper review on the advanced topic (Report by student is expected)
13. Seminar talk by experts from industries (Report by student is expected)

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

Mandatory Activity: Group Presentations on the Latest Technology and Improvements in Medical Imaging (Report by student is expected)

Assessment:

Term Work:

Laboratory work shall consist of minimum 7 experiments. The distribution of marks for term work shall be as follows:
Laboratory work (Experiments & Journal): 10 Marks
Assignments: 05 Marks
Presentation: 05 Marks
Attendance: 05 Marks
Total: 25Marks

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

Books Recommended:

Textbooks:

1. Christensen's Physics of Diagnostic Radiology: Thomas Curry, James Dowdey, Robert Murry (Publisher- Lea & Febiger)
2. Medical Imaging Physics: William R. Hendee (Publisher- Wiley-Blackwell)
3. The Physics of Diagnostic Imaging: David Dowsett (Publisher- CRC Press)

Reference Books:

1. Biomedical Technology and Devices: James Moore, Duncan Maitland (Publisher- CRC Press)
2. The Biomedical Engineering Handbook: Ed. Joseph D. Bronzino (Publisher-CRC Press LLC)
3. Encyclopedia of Medical Devices and Instrumentation: John G. Webster. Vol. I, II, III, IV (Marcel Dekkar Pub).

Course Code	Course Name	Teaching scheme			Credit assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
BML404	Computing Lab (Skill Based Lab)	--	04	--	--	02	--	02

Course Code	Course Name	Examination Scheme								
		Theory				Term work	Pract.	Oral	Pract. / Oral	Total
		Internal Assessment			End sem					
		Test 1	Test 2	Avg.						
BML404	Computing Lab (Skill Based Lab)	--	--	--	--	25	--	--	25	50

Course Code	Course Name	Credits
BML404	Computing Lab (Skill Based Lab)	02
Course Objective	• To understand basic concepts of Python programming language. • To understand decision controls and functions • To understand the utilization of various libraries in Python	
Course Outcome	Learner will be able to: • Describe Numbers, Strings, Lists, Tuples, Dictionaries, Array and Math functions in Python • Express different Decision Making statements and Functions • Illustrate different file handling operations • Interpret object oriented programming in Python • Develop proficiency in handling Python libraries	

Module	Contents	Hours
1	**Introduction to Python** Installation and resources; Introduction of the Python object types: Numbers, Strings, Lists, Tuples, Dictionaries, Arrays; Numeric types; Assignments; Expressions; Print statements and formats.	**08**
2	**Decision Control Statements and Functions:** if and else statement, if-elif-else statement, Loop Statement: While loops, for loops, Break, Continue, and Pass, Functions: Defining and calling functions, Return statements, Passing the arguments, Lambda Functions, Recursive functions.	**10**
3	**Files Handling:** Types of Files in Python, Opening a File, Closing a File. Writing Text Files, Knowing Whether a File Exists or Not, Working with Binary Files, Appending Text to a File, Reading Text Files, File Exceptions, The with Statement	**10**
4	**Object Oriented Programming:** Introduction to OOP: Classes and Objects, Public and Private Members, Class Declaration and Object Creation, Object Initialization, Class Variables and methods, Accessing Object and Class Attributes; Inheritance; Constructors; Exception handling.	**08**
5	**Numpy, Matplotlib:** Introduction to Numpy: Creating and Printing Ndarray, Class and Attributes of Ndarray, Basic operation, Copy and view, Mathematical Functions of Numpy. Introduction to Matplotlib library: Line properties, Plots and subplots, Types of Plots.	**10**
6	**Pandas, Seaborn:** Introduction to Pandas: Understanding Dataframe, View and Select Data, Missing Values, Data Operations, File read and write operation. Introduction to Seaborn.	**06**

List of experiments

1. Write python programs to understand expressions, variables, quotes, basic math operation.
2. Write a Python program to remove elements from the list.
3. Write a Python program to understand concept of tuple and dictionary. (creating, accessing elements and deleting elements)
4. Write a Python program to demonstrate if-else, for loop and while loop.
5. Write a Python program to demonstrate continue, break and pass statement.
6. Write a Python program to read, write and copy write from a file.
7. Write a Python program to perform different file handling functions
8. Write a Python program to demonstrate working of classes and objects and members.
9. Write a Python program to demonstrate class method & static method.
10. Write a Python program to demonstrate constructors.
11. Write a Python program to demonstrate inheritance.
12. Write a Python program to demonstrate sorting in numpy.
13. Write a Python program to perform merging, joining and concatenating using Panda.
14. Write a Python program to plot the data using matplotlib

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

Assessment:

Term Work:

Term work shall consist of minimum 12 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.

Books Recommended:

Text Books:

1. Introduction to computing and problem solving using python, E Balagurusamy, McGraw Hill Education
2. Core Python Programming, Dr. R. Nageswara Rao, Dreamtech Press
3. John Grayson, "Python and Tkinter Programming", Manning Publications (1 March 1999).
4. Dusty Phillips, "Python 3 object-oriented Programming", Second Edition PACKT Publisher August 2015.
5. Yashavant Kanetkar, "Let us Python: Python is Future, Embrace it fast", BPB Publications; 1 edition (8 July 2019).
6. Beginning Python: Using Python 2.6 and Python 3.1. James Payne, Wrox publication

Reference Books:

1. Python Cookbook: Recipes for Mastering Python 3,by David Beazley, Brian K. Jones O'Reilly Media; 3 edition (10 May 2013).
2. Learn Python the Hard Way: A Very Simple Introduction to the Terrifyingly Beautiful World of Computers and Code, by Zed A. Shaw Addison Wesley; 3 edition (1 October 2013).
3. Introduction to Machine Learning with Python, by Andreas C. Mueller O′Reilly; 1 edition (7 October 2016)
4. Python Crash Course A hands-on, Project Based Introduction to programming, by Eric Matthes No Starch Press; 1 edition (8 December 2015).
5. Tkinter GUI Application Development Blueprints: Master GUI programming in Tkinter as you design, implement, and deliver 10 real world application, by Bhaskar Chaudhary Packt Publishing (November 30, 2015)
6. Head First Python, by Paul Barry O′Reilly; 2 edition (16 December 2016)

NPTEL/Swayam Links:

Course: Programming, Data Structures and Algorithms using Python by Prof. Madhavan Mukund -IIT Madras
https://nptel.ac.in/courses/106/106/106106145/

Course code	Course Name	Credits
BMM401	Mini Project - 1 B	02

Course Code	Course Name	Credits
BMM401	Mini Project – 1 B	02
Course Objective	• To acquaint with the process of identifying the needs and converting it into the problem. • To familiarize the process of solving the problem in a group. • To acquaint with the process of applying basic engineering fundamentals to attempt solutions to the problems. • To inculcate the process of self-learning and research.	
Course Outcome	Learner will be able to: • Identify problems based on societal /research needs. • Apply Knowledge and skill to solve societal problems in a group. • Develop interpersonal skills to work as member of a group or leader. • Draw the proper inferences from available results through theoretical/ experimental/simulations. • Analyse the impact of solutions in societal and environmental context for sustainable development. • Use standard norms of engineering practices • Excel in written and oral communication. • Demonstrate capabilities of self-learning in a group, which leads to life long learning. • Demonstrate project management principles during project work.	

Guidelines for Mini Project

- Students shall form a group of 3 to 4 students, while forming a group shall not be allowed less than three or more than four students, as it is a group activity.
- Students should do survey and identify needs, which shall be converted into problem statement for mini project in consultation with faculty supervisor/head of department/internal committee of faculties.
- Students shall submit implementation plan in the form of Gantt/PERT/CPM chart, which will cover weekly activity of mini project.
- A log book to be prepared by each group, wherein group can record weekly work progress, guide/supervisor can verify and record notes/comments.
- Faculty supervisor may give inputs to students during mini project activity; however, focus shall be on self-learning.
- Students in a group shall understand problem effectively, propose multiple solution and select best possible solution in consultation with guide/ supervisor.
- Students shall convert the best solution into working model using various components of their domain areas and demonstrate.

- The solution to be validated with proper justification and report to be compiled in standard format of University of Mumbai.
- With the focus on the self-learning, innovation, addressing societal problems and entrepreneurship quality development within the students through the Mini Projects, it is preferable that a single project of appropriate level and quality to be carried out in two semesters by all the groups of the students. i.e. Mini Project 1 in semester III and IV. Similarly, Mini Project 2 in semesters V and VI.
- However, based on the individual students or group capability, with the mentor's recommendations, if the proposed Mini Project adhering to the qualitative aspects mentioned above gets completed in odd semester, then that group can be allowed to work on the extension of the Mini Project with suitable improvements/modifications or a completely new project idea in even semester. This policy can be adopted on case by case basis.

Guidelines for Assessment of Mini Project:

Term Work

- The review/ progress monitoring committee shall be constituted by head of departments of each institute. The progress of mini project to be evaluated on continuous basis, minimum two reviews in each semester.
- In continuous assessment focus shall also be on each individual student, assessment based on individual's contribution in group activity, their understanding and response to questions.
- Distribution of Term work marks for both semesters shall be as below;
    - Marks awarded by guide/supervisor based on log book : 10
    - Marks awarded by review committee : 10
    - Quality of Project report : 05

Review/progress monitoring committee may consider following points for assessment based on either one year or half year project as mentioned in general guidelines.

One-year project:

- In first semester entire theoretical solution shall be ready, including components/system selection and cost analysis. Two reviews will be conducted based on presentation given by students group.
    - First shall be for finalisation of problem
    - Second shall be on finalisation of proposed solution of problem.
- In second semester expected work shall be procurement of component's/systems, building of working prototype, testing and validation of results based on work completed in an earlier semester.
    - First review is based on readiness of building working prototype to be conducted.
    - Second review shall be based on poster presentation cum demonstration of working model in last month of the said semester.

Half-year project:

- In this case in one semester students' group shall complete project in all aspects including,
    - Identification of need/problem
    - Proposed final solution
    - Procurement of components/systems

- Building prototype and testing
- Two reviews will be conducted for continuous assessment,
  - First shall be for finalisation of problem and proposed solution
  - Second shall be for implementation and testing of solution.

Assessment criteria of Mini Project.

Mini Project shall be assessed based on following criteria;

1. Quality of survey/ need identification
2. Clarity of Problem definition based on need.
3. Innovativeness in solutions
4. Feasibility of proposed problem solutions and selection of best solution
5. Cost effectiveness
6. Societal impact
7. Innovativeness
8. Cost effectiveness and Societal impact
9. Full functioning of working model as per stated requirements
10. Effective use of skill sets
11. Effective use of standard engineering norms
12. Contribution of an individual's as member or leader
13. Clarity in written and oral communication

- In **one year, project**, first semester evaluation may be based on first six criteria's and remaining may be used for second semester evaluation of performance of students in mini project.
- In case of **half year project** all criteria's in generic may be considered for evaluation of performance of students in mini project.

Guidelines for Assessment of Mini Project Practical/Oral Examination:

- Report should be prepared as per the guidelines issued by the University of Mumbai.
- Mini Project shall be assessed through a presentation and demonstration of working model by the student project group to a panel of Internal and External Examiners preferably from industry or research organisations having experience of more than five years approved by head of Institution.
- Students shall be motivated to publish a paper based on the work in Conferences/students competitions.

Mini Project shall be assessed based on following points;

1. Quality of problem and Clarity
2. Innovativeness in solutions
3. Cost effectiveness and Societal impact
4. Full functioning of working model as per stated requirements
5. Effective use of skill sets
6. Effective use of standard engineering norms
7. Contribution of an individual's as member or leader
8. Clarity in written and oral communication