University of Mumbai

वेबसाईट – mu.ac.in
ईमेल - आयडी - dr.aams@fort.mu.ac.in
aams3@mu.ac.in

विद्याविषयक प्राधिकरणे
सभा आणि सेवा विभाग(ए.ए.एम.एस)
रूम नं. १२८ एम.जी.रोड, फोर्ट,
मुंबई – ४०० ०३२
टेलिफोन नं. – ०२२ – ६८३२००३३

(नॅक पुनर्मूल्यांकनाद्वारे ३.६५ (सी.जी.पी.ए.) सह अ++ श्रेणी
विद्यापीठ अनुदान आयोगाद्वारे श्रेणी १ विद्यापीठ दर्जा)

क्र.वि.प्रा.स.से./आयसीडी/२०२५-२६/३७ दिनांक : २७ मे, २०२५

परिपत्रक:-

सर्व प्राचार्य/संचालक, संलग्नित महाविद्यालये/संस्था, विद्यापीठ शैक्षणिक विभागांचे संचालक/ विभाग प्रमुख यांना कळविण्यात येते की, राष्ट्रीय शैक्षणिक धोरण २०२० च्या अमंलबजावणीच्या अनुषंगाने **शैक्षणिक वर्ष २०२५-२६** पासून **पदवी व पदव्युत्तर अभ्यासक्रम** विद्यापरिषदेच्या दिनांक २८ मार्च २०२५ व २० मे, २०२५ च्या बैठकीमध्ये मंजूर झालेले सर्व अभ्यासक्रम मुंबई विद्यापीठाच्या www.mu.ac.in या संकेत स्थळावर NEP २०२० या टॅब वर उपलब्ध करण्यात आलेले आहेत.

(डॉ. प्रसाद कारंडे)
कुलसचिव

मुंबई – ४०० ०३२
२७ मे, २०२५

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4	The Deputy Registrar, Appointment Unit, Vidyanagari dr.appointment@exam.mu.ac.in
5	The Deputy Registrar, CAP Unit, Vidyanagari cap.exam@mu.ac.in
6	The Deputy Registrar, College Affiliations & Development Department (CAD), deputyregistrar.uni@gmail.com
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11	The Deputy Registrar, College Teachers Approval Unit (CTA), concolsection@gmail.com
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15	The Assistant Registrar, School of Engg. & Applied Sciences, Kalyan, ar.seask@mu.ac.in
16	The Assistant Registrar, Ratnagiri Sub-centre, Ratnagiri, ratnagirisubcentar@gmail.com
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18	Director, Innovation, Incubation and Linkages, Dr. Sachin Laddha pinkumanno@gmail.com
19	Director, Department of Lifelong Learning and Extension (DLLE), dlleuniversityofmumbai@gmail.com

Copy for information :-	
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2	P.A to Pro-Vice-Chancellor pvc@fort.mu.ac.in
3	P.A to Registrar, registrar@fort.mu.ac.in
4	P.A to all Deans of all Faculties
5	P.A to Finance & Account Officers, (F & A.O), camu@accounts.mu.ac.in

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2	**Faculty of Humanities,** **Offg. Dean** 1. Prof.Anil Singh Dranilsingh129@gmail.com **Offg. Associate Dean** 2. Prof.Manisha Karne mkarne@economics.mu.ac.in 3. Dr.Suchitra Naik Naiksuchitra27@gmail.com
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3	Chairman, Board of Studies,
4	The Director, Board of Examinations and Evaluation, dboee@exam.mu.ac.in
5	The Director, Board of Students Development, dsd@mu.ac.in DSW direcotr@dsw.mu.ac.in
6	The Director, Department of Information & Communication Technology, director.dict@mu.ac.in

AC – 20/5/2025
Item No. – 6.22 (N)

As Per NEP 2020

University of Mumbai

Syllabus for Major Vertical – 1, 4, 5 & 6		
Name of the Programme – B.E. (Biomedical Engineering)		
Faculty of Engineering		
Board of Studies in Biomedical Engineering		
U.G. Second Year Programme	**Exit Degree**	**U.G. Diploma in Biomedical Engineering.**
Semester		**III & IV**
From the Academic Year		**2025-26**

University of Mumbai

(As per NEP 2020)

Sr. No.	Heading	Particulars
1	**Title of program** **O:_____**	**B.E. (Biomedical Engineering)**
2	**Exit Degree**	**U.G. Diploma in Biomedical Engineering**
3	**Scheme of Examination** **R: _____**	NEP 40% Internal 60% External, Semester End Examination Individual Passing in Internal and External Examination
4	**Standards of Passing** **R: _____**	**40%**
5	**Credit Structure** **R. TEU-515C** **R. TEU-515D**	**Attached herewith**
6	**Semesters**	**Sem. III & IV**
7	**Program Academic Level**	**5.00**
8	**Pattern**	**Semester**
9	**Status**	**New**
10	**To be implemented from Academic Year**	**2025-26**

Sd/-	**Sd/-**	**Sd/-**
Dr. Ghanshyam D Jindal	**Dr. Deven Shah**	**Prof. Shivram S. Garje**
BoS-Chairman, Biomedical Engineering	**Associate Dean**	**Dean**
Faculty of Technology	**Faculty of Science & Technology**	**Faculty of Science & Technology**

Preamble

To meet the challenge of ensuring excellence and NEP 2020 policy in engineering education, the issue of quality needs to be addressed, debated, and taken forward systematically. Accreditation is the principal means of quality assurance in higher education. The major emphasis of the 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 the University of Mumbai has taken the lead in incorporating the philosophy of NEP 2020 education in the process of curriculum development.

The second-year engineering course is a core training program to impart scientific and logical thinking training to learners in general, with a choice of course selection from the program core course, multidisciplinary minor, and vocational skill-enhanced course. Simultaneously, the objectives of NEP 2020 demand nurturing the core program and skills required for the branch of Bio-Medical Engineering in the learner. Keeping this in view, a pool of courses is offered in Core Courses covering fundamentals required to understand core and modern engineering practices and emerging trends in technology. Considering the shift in pedagogy and the convenience of a stress-free learning process, a choice-based subject pool is offered in the coursework under the heads of Bio-Medical Engineering for open electives (OE) and multi-disciplinary minor (MDM) courses in the third and fourth semesters. Essentially, to give a glimpse of trends in the industry under vocational and enhanced skill practices, the pool is offered to nurture and develop creative skills in contemporary industrial practices. Criteria met in the structure is the opportunity for learners to choose the course of their interest in all disciplines.

Program Core Courses cover courses constituents to Bio-Medical Engineering program. Also Open Elective and Multi-Disciplinary Minor are given for selection from a pool of subjects. Considering the present scenario, diverse choices need to be made available to fulfill the expectation of a learner to aspire for a career in the field of current trends of Technology and interdisciplinary research. Ability enhancement can be achieved in Undergraduate training by giving an objective viewpoint to the learning process and transitioning a learner from a rote learner to a creative professional. For this purpose, Design Thinking is introduced in the Third Semester to orient a journey from a learner to a skilled professional. Considering the NEP-2020 structure of award of Certificate & Diploma at multiple exit- point pools of Vocational skills is arranged for giving exposure to the current Industry needs.

The faculty resolved that course objectives and course outcomes are to be clearly defined for every course so that all faculty members in affiliated higher education institutes understand the depth and approach of the course to be taught, which will enhance the learner‟s learning process. NEP 2020 grading system enables a much-required shift in focus from teacher-centric to continuous-based 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 a 15-week teaching-learning process for NEP 2020, however, the content of courses is to be taught in initial 12-13 weeks, leaving 2-3 weeks to be utilized for revision, tutorial, guest lectures, coverage of content beyond the syllabus, etc.

There was a concern that in the present system, the second-year syllabus must not be heavily loaded to the learner and it is of utmost importance that the learner entering into the second year of an engineering course should feel at ease by lowering the burden of syllabus and credits. This is necessary for a learner to get accustomed to the new environment of a college and to create a bond between the teacher and the learner. The present curriculum will be implemented for the Second Year of Engineering from the academic year 2025-26. Subsequently, this system will be carried forward for Third and Final Year of Engineering in the academic years 2026-27 and 2027-28 respectively.

Sd/-	**Sd/-**	**Sd/-**
Dr. Ghanshyam D Jindal **BoS-Chairman-Biomedical Engineering** **Faculty of Technology**	**Dr. Deven Shah** **Associate Dean** **Faculty of Science & Technology**	**Prof. Shivram S. Garje** **Dean** **Faculty of Science & Technology**

Under Graduate Diploma in Bio-Medical Engineering

Credit Structure (Sem. III & IV)

	R. TEU-515C								
Level	**Semester**	**Major**		**Minor**	**OE**	**VSC, SEC (VSEC)**	**AEC, VEC, IKS**	**OJT, FP, CEP, CC,RP**	**Cum. Cr. / Sem.**	**Degree/ Cum. Cr.**
		Mandatory	**Electives**							
5.0	III	PCC311:3 PCC312:3 PCC313:3 PCC314:3 PCL315:1 PCL316:1	--	--	OE:2	--	VEC: 2 HSL: 2	CEP: 2	22	**UG Diploma 45**
	R. TEU-515D									
	IV	PCC411:3 PCC412:3 PCC413:3 PCL414:1 PCL415:1	--	MDM: 4	OE:2	VSEC:2	VEC: 2 EEM:2	--	23	
	Cum Cr.	25	--	4	4	2	*2+2+2+2*	2	45	

Exit option: Award of UG Diploma in Major and MDM with 90 credits and additional 4 credits core **one** theory subject with 3 credits and **one** lab with 1 credit from one third year from where they want to take Exit degree. Along with theory and practical course student must compulsory do internship for **one month or 160 hours** which internship is equal to 4 credits.

[Abbreviations: OE – Open Electives, VSC – Vocation Skill Course, SEC – Skill Enhancement Course, (VSEC), AEC – Ability Enhancement Course, VEC – Value Education Course, IKS – Indian Knowledge System, OJT – On Job Training, FP – Field Project, CEP – Continuing Education Program, CC – Co-Curricular, RP – Research Project]

Sem. – III & IV

S.E.BME
Scheme

Program Structure for Second Year of Bio-Medical Engineering

UNIVERSITY OF MUMBAI (With Effect from 2025-2026)

SEMESTER III

Course Code	Course Description	Teaching Scheme (Contact Hours)			Credit Assigned			
		Theory	Practical	Tutorial	Theory	Tutorial	Practical	Total Credits
2053111	Biomedical Signals & Systems	2	--	1	2	1	–	3
2053112	Applied Electronics for Biomedical Engineers	3	–	--	3	–	–	3
2053113	Sensors & Actuators	3	--	--	3	–	–	3
2053114	Basic Human Anatomy & Physiology	3	--	--	3	–	–	3
	Open Elective (form other boards like Science/ Commerce/ Management stream)	2#	--	--	2	–	–	2
2053115	Applied Electronics lab for Biomedical Engineers	--	2	–	–	–	1	1
2053116	Sensors & Actuators lab	--	2	–	–	–	1	1
2053611	Mini Project (group project)	--	2*+2	–	–	–	2	2
2993511	Entrepreneurship Development	--	2*+2	---	–	–	2	2
2993512	Environmental Science for Engineers	--	2*+2	--	–	–	2	2
Total		**13**	**16**	**01**	**13**	**01**	**08**	**22**

* Two hours of practical class to be conducted for full class as demo/discussion.

Theory / Tutorial 1 credit for 1 hour and Practical 1 credit for 2 hours

Institute shall offer a course for Open Elective from Science/Commerce/Management stream bucket provided by the University of Mumbai.

Institute shall offer a course for MDM from other Engineering Boards.

Course Code	Course Description	Examination scheme							
		Internal Assessment Test (IAT)			End Sem. Exam Marks	End Sem. Exam Duration (Hrs)	Term Work (Tw)	Oral & Pract.	Total
		IAT-I	IAT-II	Total (IAT-I) + IAT-II)					
2053111	Biomedical Signals & Systems	20	20	40	60	2	25	--	125
2053112	Applied Electronics for Biomedical Engineers	20	20	40	60	2	--	--	100
2053113	Sensors & Actuators	20	20	40	60	2	--	--	100
2053114	Basic Human Anatomy & Physiology	20	20	40	60	2	--	--	100
	Open Elective (form other boards like Science/ Commerce/ Management stream)	20	20	40	60	2	--	--	100
2053115	Applied Electronics lab for Biomedical Engineers	--	--	--	--	--	25	25	50
2053116	Sensors & Actuators lab	--	--	--	--	--	25	25	50
2053611	Mini Project (group project)	--	--	--	--	--	50	25	75
2993511	Entrepreneurship Development	--	--	--	--	--	50	--	50
2993512	Environmental Science for Engineers	--	--	--	--	--	50	--	50
Total		**100**	**100**	**200**	**300**	**10**	**225**	**75**	**800**

Program Structure for Second Year of Bio-Medical Engineering

UNIVERSITY OF MUMBAI (With Effect from 2025-2026)

SEMESTER IV

Course Code	Course Description	Teaching Scheme (Contact Hours)			Credit Assigned			
		Theory	Practical	Tutorial	Theory	Tutorial	Practical	Total Credits
2054111	Biomedical Signal Analysis & Processing	2	--	1	2	1	–	3
2054112	Microcontrollers & Applications	3	–	--	3	–	–	3
2054113	Diagnostic Instruments	3	--	--	3	–	–	3
	Multidisciplinary minor (form Other Engineering Branch/Science/Commerce/Management)	3	–	--	3	–	–	3
	Open Elective (From other boards Science/Commerce/Management stream)	2#	–	--	2	–	–	2
2054114	Microcontrollers & Applications Lab	–	2	–	–	–	1	1
2054115	Diagnostic Instruments Lab	–	2	–	–	–	1	1
	Multidisciplinary minor (form Other Engineering Branch/ Science/ Commerce/ Management)	–	2	–	–	–	1	1
2054411	Python Programming Practice (Mini Project)	–	2*+2	–	–	–	2	2
2994511	Business Model Development	–	2*+2	–	–	–	2	2
2994512	Design Thinking	–	2*+2	–	–	–	2	2
Total		**13**	**18**	**01**	**13**	**01**	**09**	**23**

* Two hours of practical class to be conducted for full class as demo/discussion.

Theory / Tutorial 1 credit for 1 hour and Practical 1 credit for 2 hours

Students must select course for Open Elective from Science/Commerce/Management stream bucket provided by the University of Mumbai.

Institute shall offer a course for MDM from other Engineering Boards.

Course Code	Course Description	Examination scheme							
		Internal Assessment Test (IAT)			End Sem. Exam Marks	End Sem. Exam Duration (Hrs)	Term Work (Tw)	Oral & Pract.	Total
		IAT-I	IAT-II	Total (IAT-I) + IAT-II)					
2054111	Biomedical Signal Analysis & Processing	20	20	40	60	2	25	--	125
2054112	Microcontrollers & Applications	20	20	40	60	2	--	--	100
2054113	Diagnostic Instruments	20	20	40	60	2	--	--	100
	Multidisciplinary minor (form Other Engineering Branch/Science/Commerce/Management)	20	20	40	60	2	--	--	100
	Open Elective (From other boards Science/Commerce/Management stream)	20	20	40	60	2	--	--	100
2054114	Microcontrollers & Applications Lab	--	--	--	--	--	25	25	50
2054115	Diagnostic Instruments Lab	--	--	--	--	--	25	25	50
	Multidisciplinary minor (form Other Engineering Branch/ Science/ Commerce/ Management)	--	--	--	--	--	25	--	25
2054411	Python Programming Practice (Mini Project)	--	--	--	--	--	50	25	75
2994511	Business Model Development	--	--	--	--	--	50	--	50
2994512	Design Thinking	--	--	--	--	--	50	--	50
Total		**100**	**100**	**200**	**300**	**10**	**250**	**75**	**825**

Vertical – 1
Major

Detailed Syllabus

Semester III

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Tut.	Pract/Oral	Theory	Tut.	Pract/Oral	Total
2053111	Biomedical Signals & Systems	2	1	--	2	1	---	3

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment Test (IAT)			End Sem Exam	Exam Duration (in Hrs)			
		IAT-I	IAT-II	IAT-I + IAT-II					
2053111	Biomedical Signals & Systems	20	20	40	60	2	25	---	125

Rationale

This introductory course „Biomedical Signals and Systems" in second year of Biomedical Engineering is to give overall view of biomedical signals and systems, Discrete time signals and systems, various transforms used in signal processing, Fourier transform, its implementation and analysis for biosignals including random signal.

Course Objectives

1. To understand the biomedical signals and systems
2. To understand the concept of discrete time signals and systems
3. To understand Transforms in continuous and discrete signals processing
4. To understand discrete time signal processing
5. To understand the discrete Fourier, transform and its computation
6. To understand the random signal and their analysis

Course Outcomes

On completion of the course the learners will be able to:

1. Explain the types of Biomedical signals and understand their nature

2 Implement different discrete time signals and systems and operations on them

3. Implement the z- transform and hightlight its applications

4. Describe DTFT, DFT, Inter-relations among Fourier conversions and implement them

5. Describe DFT, FFT, and implement them

6. Explain the nature of random signal and their analysis

Detailed Syllabus

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
0	Pre-requisites	Basic knowledge of integration, summation, differentiation, limit, complex Numbers, physiological systems and signals.	0	--
I	Biomedical signals and systems	**Biomedical signals:** Problem Statement, Operations on time signals, Concurrent, Coupled, and Correlated Processes, Physiological systems	6	CO1
II	Discrete time signals and systems	**Discretization of continuous time signals:** Discrete time signals, Discrete time systems, Ensemble average and time average	6	CO2
III	Transforms in continuous and discrete signals processing	**The Laplace transform:** Properties of Laplace transform, Frequency response of LTI system, Pole zero plots, Frequency filters Phase shifts and time delays, Systems representation of physiological processes **The Z-transform:** Properties of z-transform, convolution in discrete-time domain, time shift, pole zero plot in complex-z plane, The bilinear transform	6	CO3
IV	Discrete time signal processing	Decomposition of periodic signals, Fourier conversion, Aperiodic continuous signals-Fourier Transform, System transfer function, **Discrete Fourier conversions:** Periodic discrete time signals-discrete Fourier series, Aperiodic discrete -Time signals-DTFT, properties of DTFT, Numerical implementation of Fourier conversion: DFT, Inter-relations among Fourier conversions	6	CO4
V	Discrete Fourier transform	**Applying the discrete Fourier transform:** Properties of DFT, windowing, The Fast Fourier Transform, Convolution using FFT-circular convolution	6	CO5
VI	Random signal analysis	**Discrete Fourier transform of random signals:** Estimation the power spectrum: spectrum estimation by averaging periodograms Transfer function estimation or system identification	6	CO6

Text Books

1. Suresh R. Devasahayam, Signals and systems in Biomedical Engineering: Signal processing and Physiological systems modelling, Kluwer Academic/Plenum Publishers, New York, Boston, Dordrecht, London, Moscow, 2000

References

1. D C Reddy "Biomedical Signal Processing: Principles and Techniques", Tata McGraw-Hill Publishing Co. Ltd, 2005

2. R M Rangayyan "Biomedical Signal Analysis: A Case Based Approach", IEEE Press, John Wiley & Sons. Inc, 2002

3. Willis J. Tompkins, Biomedical Digital Signal Processing, Prentice Hall, Upper Saddle River, New Jersey 07458

Online References

Sr. No.	Website Name
1.	Principles of Signals and Systems, Prof. Aditya K. Jagannatham, IIT Kanpur *https://onlinecourses.nptel.ac.in/noc24_ee36/announcements?force=true*
2.	Signals and Systems, Prof. Hitesh Shrimali, Prof. Kushal K. Shah, IIT Mandi, IISER Bhopa https://onlinecourses.nptel.ac.in/noc25_ee78/unit?unit=19&lesson=26

Assessment:

Internal Assessment (IA) for 40 marks:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test.
- Internal Assessment Test can be **open book**, provided all the questions are of **level IV and above** as per **Bloom's Taxonomy**.

➢ Question paper format

- Question Paper will comprise of a total of six questions each carrying 15 marks. Q.1 will be compulsory and should cover maximum contents of the syllabus
- Remaining questions will be mixed in nature (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
- A total of four questions needs to be answered

Tutorials: minimum 10 tutorials from the following list

Sr. No.	Title	Hours
1	Numerical examples on Operations on discrete time signals	1
2	Numerical examples on types of discrete time signals	1
3	Numerical examples on properties of systems	1
4	Numerical examples on Ensemble average and time average	1
5	Numerical examples on Laplace transform: Pole zero plots	1
6	Numerical examples on The Z-transform	1
7	Numerical examples on convolution in discrete-time domain,	1
8	Numerical examples on Fourier Transform, System transfer function	1
9	Numerical examples on DFT	1
10	Numerical examples on Fast Fourier Transform,	1
11	Numerical examples on Convolution using FFT-circular convolution	1
12	Numerical examples on analysis of random signals	1

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Tut.	Pract/Oral	Theory	Tut.	Pract/Oral	Total
2053112	Applied Electronics for BME	3	-	--	3	-	--	3

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment Test (IAT)			End Sem Exam	Exam Duration (in Hrs)			
		IAT-I	IAT-II	IAT-I + IAT-II					
2053112	Applied Electronics for BME	20	20	40	60	2	--	--	100

Rationale:

Electronic circuits are the building blocks of Biomedical Instrumentation. Its study helps Biomedical engineers to understand signal conditioning in biomedical instruments. It enables the learners to analyse and design crucial medical applications.

Course Objectives:

1. To provide comprehensive understanding of regulated power supply.
2. To understand transistors and how it works as an amplifier
3. To gain knowledge of MOSFET and its applications.
4. To provide concepts of operational amplifier to use in various applications.
5. To design various oscillators and filter circuits.
6. To design and develop different circuits using various integrated circuits.

Course Outcomes: Learner will be able to

1. Explain the characteristics of various semiconductor devices.
2. Design small signal amplifiers.
3. Select MOSFETs for various applications.
4. Apply knowledge of operational amplifier to analyse different operational amplifier based circuits.
5. Apply knowledge of operational amplifier to design various electronic circuits such as oscillators, filters, waveform generators etc
6. Apply designing concepts in various projects/applications.

Prerequisite: Students should know basics of semiconductor physics, laws and theorems of electricity.

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
I	Semiconductor Devices	Characteristics and applications of: pn junction diode, Zener diode, LED, Photodiode, Solar cell, UJT, SCR, Optocoupler	7	CO1

II	Bipolar Junction Transistor	Construction, Working and Characteristics of three different configurations of BJT, Concept of Quiescent point and load line, Concept of biasing, A.C. Equivalent Model: r_e model, use of BJT as small signal amplifier, Frequency response of BJT, Amplifier analysis	9	CO2
III	MOSFETs	Classification, Construction, Characteristics of MOSFETs, Biasing of MOSFET, MOSFET as an amplifier & MOSFET as a switch.	8	CO3
IV	Basics and linear circuits of Operational amplifiers	Introduction: Block Diagram of Op-amp, Characteristics of op-amp, Equivalent circuit, Concept of virtual ground, Voltage comparators, Concept of feedback in op-amp, Inverting, Noninverting and differential configuration, Voltage follower, Adder, Subtractor, Instrumentation amplifier, Monolithic instrumentation amplifier(eg AD620) Voltage to Current and Current to Voltage converters	7	CO4
V	Nonlinear Circuits of Operational amplifier	Integrator and Differentiator (Ideal and practical), Schmitt Trigger, Peak detector, Precision Rectifier, Concepts of Oscillations: Barkhausen‟s criteria for an oscillator, Types of oscillators: RC and LC. Working and design of RC Phase shift Oscillator and Wien Bridge oscillator; Crystal Oscillator	7	CO5
VI	Special Function ICs	IC 555 pin diagram and Functional Block diagram, IC 555 as Astable and Monostable multivibrator(functional diagram, circuit diagram and applications), Fundamentals of Phase Locked Loop and PLL applications. (IC 4046/ IC 565) Design of voltage regulator using IC 78XX, 79XX, LM 317 (High voltage regulator) Concept of large signal amplifier(power amplifier), classes of power amplifier, Power amplifier IC LM380	7	CO6

Text Books:

1. Electronic Devices and Circuit Theory, by Robert L. Boylestad and Louis Nashelsky, Pearson Education.
2. Op-Amps and linear integrated circuits by Ramakant Gayakwad, Prentice Hall

References:

1. Design with Operational Amplifiers and Analog Integrated Circuits, by Sergio Franco, McGraw Hill, 2002
2. Electronic design, by Martin S. Roden, Gordon L. carpenter, William R Wieseman, Shroff Publishers & Distributors Pvt. Limited

Online References:

Sr. No.	Website Name
1.	Fundamentals Of Electronic Materials And Devices - Course https://onlinecourses.nptel.ac.in/noc25_mm15/preview
2.	Integrated Circuits and Applications - Course https://onlinecourses.nptel.ac.in/noc24_ee73/preview

Assessment:

Internal Assessment (IA) for 40 marks:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test

- Internal Assessment Test can be **open book**, provided all the questions are of **level IV and above** as per **Bloom's Taxonomy**.

End Semester Question paper format

- Question Paper will comprise of a total of **six questions each carrying 15 marks. Q.1** will be **compulsory** and should **cover maximum contents of the syllabus**

- **Remaining questions** will be **mixed in nature.** Sub question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)

- A total of **four questions** need to be answered

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Tut.	Pract	Theory	Tut.	Pract	Total
2053113	Sensors and Actuators	2	--	--	2	--	--	3

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment Test (IAT)			End Sem Exam	Exam Duration (in Hrs)			
		IAT-I	IAT-II	IAT-I + IAT-II					
2053113	Sensors and Actuators	20	20	40	60	2	--	--	100

Rationale:
Measure the physiological parameters with high accuracy is one of the key area in Biomedical Engineering. This depends on the proper selection of transducer for application. This course introduces students to working principles, construction of basic transducers, biosensors and actuators. It also covers the applications of sensors and actuators in biomedical engineering.

Course Objectives:

1. To provide the knowledge of basic concepts such as generalized medical instrumentation system, transducer characteristics.
2. 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.
3. Enable learners to understand principle and working of biosensors.
4. To study the medical applications of the mentioned transducers and sensors.
5. Enable learners to understand principle and working of actuators and its medical applications
6. To perform experiments based on some of the mentioned transducers and sensors.

Course Outcomes: Learner will be able to

1. Explain different components of a generalized medical instrumentation system, and transducer characteristics.
2. Apply the knowledge of principles of various types of transducers and sensors including motion, displacement, force, pressure sensors to different medical applications.
3. Apply the knowledge of principles of various types of temperature sensors to different medical applications.
4. Apply the knowledge of the various biopotential electrodes for measuring different types of bio potentials, various chemical sensors for measuring concentration of biochemical analytes and biosensors with medical applications.
5. Discuss the principle and working of different types of actuators
6. Demonstrate the working of electric actuators such as relays, DC, servo and stepper motors

Prerequisite: Basic physics, chemistry, electronics, Measurements and Instruments

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
I	**Sensors Introduction**	Generalized medical instrumentation system; Sensors characteristics: Accuracy, precision, resolution, reproducibility, sensitivity, drift, hysteresis, linearity, input impedance and output impedance	**03**	**CO1**

II	**Displacement, Force and Pressure Sensors**	Strain gauges, L.V.D.T., capacitive sensors; Piezoelectric sensor, Diaphragms, Load cell, Bourdon tube, Medical Applications	**05**	**CO2**
III	**Temperature and Radiation Sensors**	Thermistor, thermocouple, resistive temperature detector; IC-based sensor, IR sensor, Photomultiplier tube, Photo-resistive sensor, Medical Applications.	**05**	**CO3**
IV	**Biopotential Electrodes**	Electrode circuit model, electrode-skin interface, Body surface electrodes; Internal electrodes: Needle and wire electrodes (different types); Microelectrodes: Metal and supported metal micropipette (metal filled glass and glass micropipette) electrodes.	**05**	**CO4**
V	**Chemical Sensors and Biosensors**	pH, PCO_2, PO_2 electrodes; ISFETs; Fiber optic sensor, Optical and piezoelectric Biosensor, Medical Applications	**06**	**CO5**
VI	**Actuators**	Definition, linear; rotary Actuators, Pneumatic actuator, Hydraulic actuator , Diaphragm pump, Control valves; Micro Actuator, Relays, Principle of operation and its application: D. C. motors, Servo motors, Stepper motors, Medical applications	**06**	**CO6**

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. Biosensors: Fundamentals and Applications, Bansi Dhar Malhotra and Chandra Mouli Pandey, Smithers Rapra Technology.
5. W. Bolton-Mechatronics, Pearson Education Limited.
6. Control system components, B. Chatterjee, Khanna Publisher.

References:

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. Robert H. Bishop-The Mechatronics Handbook, 2nd Ed., Mechatronic Systems, Sensors and Actuators, fundamentals and modeling.
6. Control system components, MD desai, PHI learning

Online References:

Sr. No.	Website Name
1.	*Course*: Industrial Instrumentation by Prof. Alok Barua - IIT Kharagpur *https://nptel.ac.in/courses/108/105/108105064/*
2.	Transducers For Instrumentation https://onlinecourses.nptel.ac.in/noc23_ee105/preview

Assessment:

Internal Assessment (IA) for 40 marks:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test
- Internal Assessment Test can be **open book**, provided all the questions are of **level IV and above** as per **Bloom's Taxonomy**.

End Semester Question paper format

- Question Paper will comprise of a total of **six questions each carrying 15 marks. Q.1** will be **compulsory** and should **cover maximum contents of the syllabus**
- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
- A total of **four questions** need to be answered

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Tut.	Pract/Oral	Theory	Tut.	Pract/Oral	Total
2053114	Basics of Human Anatomy and Physiology	3	-	--	3	--	--	3

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment Test (IAT)			End Sem Exam	Exam Duration (in Hrs)			
		IAT-I	IAT-II	IAT-I + IAT-II					
2053114	Basics of Human Anatomy and Physiology	20	20	40	60	2	--	--	100

Rationale:
Biomedical Engineering course remains incomplete if the learner is not aware about the human body, generation of bio potential and the correct usage of devices before placing them on human body. This can be achieved only by having the basic understanding about the anatomy of each organs and its functioning. Thus this course provides an insight to students about the overall anatomy and physiological functioning of the human body.

Course Objectives:

1. To understand the anatomical structures of the human body
2. The study how these organs are interrelated.
3. To be cognizant of the bio potential concepts.
4. To understand the different physiological processes taking place inside the human body
5. To realize some of the basic gadgets that will help us to observe these physiological signals.
6. To perform experiments based on physiological signal measurements from human body.

Course Outcomes: Learner will be able to

1. Illustrate the organization of the human body, homeostasis and its maintenance,structure and functions of a cell and basic tissues.
2. Demonstrate the components of blood and their functions.
3. Interpret the anatomical parts and physiological processes of the cardiovascularsystem and respiratory system.
4. Explain the anatomical parts and physiological processes of the alimentarysystem and renal system.
5. Define the structure and functions of nervous system
6. Define the structure and function of endocrine system

Prerequisite: Basic concepts of Biology.

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
1	**Introduction to Human Body, Cells ,Tissues and Types**	Homeostasis and its maintenance. Structure and functions of a cell; Tissues: epithelial, connective, muscle and nervous Transport across the plasma membrane: Passive	**05**	**CO1**

		and Active		
2	**Cardiovascular and Respiratory system**	Generation of Action Potential, 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. Anatomy of respiratory system; Internal and External respiration, Gas laws – Boyle‟s Law, Dalton‟s law and Henry‟s law, Spirometery	**11**	**CO2**
3	**Blood**	Composition of Blood, blood cells and their functions, Clotting and factors,BloodGrouping and various blood disorders	**05**	**CO3**
4	**Digestive System and Renal System**	Anatomy of the alimentary system; Secretions of different organs of the alimentary system and their main function. Anatomy of the renal system; Functions of kidney and Micturition. BP regulation by renal system.	**11**	**CO4**
5	**Nervous System**	Classification of the nervous system, Brain, its parts and functions, spinal cord, Ventricles, Formation and circulation of Cerebrospinal fluid, Reflex action and reflex arc; Monosynapse and Polysynapse, Nerve action potential, Nerve conduction in Myelinated and Non Myelionated neurons.	**08**	**CO5**
6	**Endocrine System**	All Glands of the endocrine system, their secretions and functions.	**05**	**CO6**

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/102/104/10210405/
https://swayam.gov.in/nd1_noc20_bt42/previw

Assessment:

Internal Assessment (IA) for 40 marks:

- IA will consist of Two Compulsory Internal Assessment Tests of 20 marks each. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test.
- Internal Assessment Test can be **open book**, provided all the questions are of **level IV and above** as per **Bloom's Taxonomy**.

End Semester Question paper format

- Question Paper will comprise of a total of **six questions each carrying 15 marks. Q.1** will be **compulsory** and should **cover maximum contents of the syllabus**
- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
- A total of **four questions** need to be answered

OEC 301 to be picked up from the bucket provided by other boards like Science/ Commerce/ Management streams

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Tut.	Pract/Oral	Theory	Tut.	Pract/Oral	Total
2053115	Applied Electronics for BME Lab	--	-	2	--	--	1	1

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment Test (IAT)			End Sem Exam	Exam Duration (in Hrs)			
		IAT-I	IAT-II	IAT-I + IAT-II					
2053115	Applied Electronics for BME Lab	--	--	--	--	--	25	25	50

Lab Objectives:

1. Learn to operate electronic lab instruments.
2. To practically verify characteristics of different semiconductor devices like diodes, BJT, MOSFET etc
3. To practically implement and verify operational amplifier based circuits.
4. To practically verify outputs/ frequency response of various circuits such as amplifiers, filters, oscillators.
5. To design and implement regulated power supply, waveform generators etc.
6. To design and implement a power supply circuit on a PCB.

Lab Outcomes (LO):

The learner will be able to:

1. Use electronic lab instruments for testing and troubleshooting electronic circuits.
2. Understand the transfer characteristics of basic semiconductor devices.
3. Verify frequency response of amplifier circuits.
4. Read the data sheet of different ICs, compare the parameters to select appropriate IC.
5. To learn soldering
6. To design and implement various building blocks of different biomedical instruments.

Prerequisite: Basic electronics, sensors characteristics

List of Experiments:

Sr No	List of Experiments	Hrs	LO Mapping
01	To verify transfer characteristics of various semiconductor devices.	2	LO2
02	To verify input and output characteristics of BJT.	2	LO2
03	To implement CE amplifier and study its frequency response.	2	LO3
04	To verify input and output characteristics of MOSFET.	2	LO2
05	To study MOSFET as a switch	2	LO3

06	To verify outputs of various linear circuits using op-amps.	2	LO3

07	To verify outputs of various nonlinear circuits using op-amps.	2	LO3
08	To generate sine wave using RC phase shift oscillator using 2 different op amp ICs	2	LO4
09	To generate sine wave using Wein bridge oscillator	2	LO5
10	Design and implement monostable multivibrator using IC 555	2	LO5
11	Design and implement astable multivibrator using IC 555	2	LO5
12	Verify various outputs of IC 4047	2	LO5
13	To verify output of PLL	2	LO5
14	Implement any one Biomedical application	2	LO5
15	To design regulated power supply.	2	LO6

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

Assessment:

Term Work: Term Work shall consist of at least 10 practicals based on the above list. Also, Term work Journal must include at least 5 assignments.

Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiment) + 5 Marks (Assignments) + 5 Marks (Attendance)

Practical & Oral Exam: An Oral & Practical exam will be held based on the above syllabus

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Tut.	Pract/Oral	Theory	Tut.	Pract/Oral	Total
2053116	Sensors and Actuators Lab	--	--	2	--	--	1	1

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment Test (IAT)			End Sem Exam	Exam Duration (in Hrs)			
		IAT-I	IAT-II	IAT-I + IAT-II					
2053116	Sensors and Actuators Lab	--	--	--	--	--	25	25	50

Lab Objectives:

1. To measure pressure using a pressure sensor.
2. To measure displacement using various displacement sensors.
3. To measure temperature using various temperature sensors.
4. To study different types of Biopotential electrodes
5. To measure pH of a solution using a pH electrode.
6. To study the principle and working of Actuator

Lab Outcomes (LO):

The learner will be able to:

1. Demonstrate the measurement of pressure using a pressure sensor.
2. Demonstrate the measurement of displacement using displacement sensor.
3. Demonstrate the measurement of temperature using various temperature sensors.
4. Distinguish various types of biopotential electrodes.
5. Demonstrate the measurement of pH of a solution using a pH electrode.
6. Demonstrate the principle and working of Actuator

Prerequisite: Basic electronics, sensors characteristics

List of Experiments:

Sr No	List of Experiments	Hrs	LO Mapping
01	To study principle and working of a strain gage sensor	2	LO1
02	To study principle and working of LVDT	2	LO2
03	To study principle and working of a pressure transducer	2	LO1
04	To study measurement of angular displacement using of a capacitive transducer	2	LO2
05	To study the resistance vs temperature characteristics of a thermistor	2	LO3
06	To study the temperature measurement using thermocouple	2	LO3

07	To study the temperature measurement using IC based sensor	2	LO3
08	To study various Biopotential electrodes	2	LO4
09	To study principle and working of a pH electrode	2	LO5
10	To study principle and working of any one type of Actuator	2	LO6
11	To study principle and working of a DC motor	2	LO6
12	To study principle and working of stepper motor	2	LO6

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

Assessment:

Term Work: Term Work shall consist of at least 10 practicals based on the above list. Also, Term work Journal must include at least 5 assignments.

Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiment) + 5 Marks (Assignments) + 5 Marks (Attendance)

Practical & Oral Exam: An Oral & Practical exam will be held based on the above syllabus

Detailed Syllabus

Semester IV

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2054111	Biomedical Signal Analysis & Processing	2	--	1	2	--	1	3

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment Test (IAT)			End Sem Exam	Exam Duration (in Hrs)			
		IAT-I	IAT-II	IAT-I + IAT-II					
2054111	Biomedical Signal Analysis & Processing	20	20	40	60	2	25	---	125

Rationale

This introductory course Biomedical Signals and Systems in second year of Biomedical Engineering is to gives overall view of digital filters used for Removal of Artifacts in signal recording, Detection of specific event, wave-shapes and waveform complexities.

Course Objectives

1. To understand the concept of analog filters, frequency transformation and working of infinite impulse response filter.
2. To understand the concept and working of finite impulse response
3. To understand artifacts in biomedical recording and filtering for Removal of Artifacts
4. To understand the detection of physiological events recorded in biomedical signal
5. To understand the biomedical signal waveforms and its complexity
6. To understand the frequency components in biomedical signal

Course Outcomes

On completion of the course the learners will be able to:

1. Design and implement infinite impulse response filters along with frequency transformation.
2. Design and implement finite impulse response filters
3. Identify the nature of artifacts recorded along with biomedical signal and use of appropriate filter for removal of artifacts.
4. Identify the different physiological events recorded in biomedical signal and implementation of algorithm for automatic detection of events.
5. Correlate the shapes of recorded waveform and complexity in it with the associated physiological

events.

6. Determine the frequencies of different biomedical signals using signal processing tools.

Detailed Syllabus

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
0	Prerequisite	Knowledge of biomedical signals and systems, types of signals and systems, system characterization, sampling of signal, different transforms, characteristics of signals, operations on signals.	0	----
I	Infinite impulse response filter	Butterworth and Chebyshev filters and design, frequency transformation, design of IIR digital filters using impulse invariance method, Bilinear transformation method, design of digital filters using bilinear transformation.	5	CO1
II	Finite impulse response	FIR filters, structure, linear phase filters, FIR filter design using window technique, direct, cascade and parallel forms	5	CO2
III	Filtering for removal of artifacts	Problem statement, noise in biomedical signal recording, illustration of the problem in case studies, time-domain filters, frequency-domain filters, optimal filtering, adaptive filters for removal of interference: Removal of artifacts in the ECG, maternal-fetal ECG, Muscle-contraction Interference	5	CO3
IV	Event detection	Problem statement, illustration of the problem with case-studies, Detection of events and waves, correlation analysis of EEG channels, cross-spectral techniques matched filter, detection of the P-wave, homomorphic filtering, applications: ECG rhythm analysis, identification of heart sounds, detection of the aortic component of S2	5	CO4
V	Wave-shape and waveform complexity	Problem statement, illustration of the problem with case-studies: Analysis of event-related potentials, morphological analysis of ECG waves. envelope extraction and analysis, analysis of activity	5	CO5
VI	Frequency-domain characterization	Problem statement, illustration of the problem with case-studies, Fourier spectrum, estimation of the power spectral density function, measures derived from PSD.	5	CO6

Text Books

1. R M Rangayyan “Biomedical Signal Analysis: A case Based Approach”, IEEE Press, John Wiley & Sons. Inc, 2002

References

1. D C Reddy “Biomedical Signal Processing: Principles and Techniques”, Tata McGraw-Hill Publishing Co. Ltd, 2005
2. Willis J. Tompkins “Biomedical Digital Signal Processing”, EEE, PHI, 2004
3. J G Webster “Medical Instrumentation: Application & Design”, John Wiley & Sons Inc., 2001
4. C Raja Rao, S K Guha “Principles of Medical Electronics and Biomedical Instrumentation”, Universities Press, 2001
5. AV Oppenheim and RW Shafer "Discrete-time Signal Processing", Prentice Hall, Englewood Cliffs, NJ, 1989.
6. Steven M. Kay, "Modern spectral estimation theory and application ", Prentice Hall, Englewood Cliffs, NJ, 1987.

Sr. No.	Website Name
1.	Biomedical Signal Processing Prof. Sudipta Mukhopadhyay, IIT Kanpur. *https://onlinecourses.nptel.ac.in/noc25_ee09/preview*
2.	Discrete Time Signal Processing Prof. Mrityunjoy Chakraborty, IIT Kharagpur *https://onlinecourses.nptel.ac.in/noc25_ee26/preview*
3.	Signal Processing Techniques and Its Applications, Prof. Shyamal Kumar Das Mandal IIT Kharagpur *https://onlinecourses.nptel.ac.in/noc25_ee77/preview*

Assessment

Internal Assessment (IA) for 20 marks each:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of the syllabus content must be covered in the IAT-I and the remaining 40% to 50% of the syllabus content must be covered in the IAT-II.
- Internal Assessment Test can be **open book**, provided all the questions are of **level IV and above** as per **Bloom's Taxonomy**.

End Semester Theory Examination:

➢ Question paper format

- Question Paper will comprise a total of six questions each carrying 15 marks. Q.1 will be compulsory and should cover the maximum contents of the syllabus
- Remaining questions will be mixed in nature (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
- A total of four questions need to be answered

Tutorials: Minimum 10 tutorials from the following list**.**

Sr No	List of Tutorials	Hrs
01	Implement the program for power spectral density of a signal	1
02	Implement a program for frequency spectrum and impulse response of a digital linear process with the digital transfer function	1
03	Design and implementation of window-based FIR low pass, high pass and band pass filter	1
04	Design and implementation of IIR low pass, high pass and band pass filter	1
05	Synthesis of ECG using sinusoidal signals	1
06	Implement convolution, cross correlation and cross correlation	1
07	Implementation of DFT and FFT	1
08	Introduction of biomedical signals such as ECG, EEG, EMG	1
09	Design a notch filter to remove the artifact in ECG recording.	1
10	Implement synchronized averaging filter for biomedical signal	1
11	Implement moving average filter for biomedical signal	1
12	Implement derivative based filter for biomedical signal	1
13	Implement a low pass filters for noisy ECG signal using different order and cutoff frequency	1
14	Implement the Pan-Tompkins method for QRS detection	1

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Tut.	Pract/Oral	Theory	Tut.	Pract/Oral	Total
2054112	Microcontrollers and Applications	3	-	--	3	-	--	3

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment Test (IAT)			End Sem Exam	Exam Duration (in Hrs)			
		IAT-I	IAT-II	IAT-I + IAT-II					
2054112	Microcontrollers and Applications	20	20	40	60	2	--	--	100

Rationale:

Microcontrollers play an essential role in design of embedded systems. The current era is migrating towards automation rapidly and hence the knowledge of 8051 microcontroller and Arduino controller is needed for a UG student of Biomedical Engineering. Students will be taught the basic use of an assembly as well as embedded C programming environment to control peripheral devices. UG Students will also understand the interfacing of various peripheral elements with microcontroller to design an automated system.

Course Objectives:

1. Explain the fundamental concepts of 8051 microcontroller.
2. Describe the instruction set of microcontroller
3. Illustrate the concepts of interfacing devices.
4. Implement simple application based on 8051 microcontroller.
5. Explain the fundamental concepts of Arduino microcontroller.
6. Implement small applications using Arduino microcontroller.

Course Outcomes: Learner will be able to

1. Explain the fundamental concepts of 8051 microcontroller.
2. Implement the concept of 8051 microcontroller.
3. Analyze the features of interfacing devices.
4. Apply the concept of programming and implement simple applications using 8051
5. Implement the concept of 8051 microcontroller.
6. Apply the concept of programming and implement simple applications using Arduino

Prerequisite: Students should know basics of digital electronics.

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
I	8051 Microcontroller Architecture	Introduction: Von Neumann and Harvard architecture, CISC and RISC architecture, comparison of microprocessor and microcontrollers.	7	CO1

		8051 variants, Hardware block diagram, Pin diagram, CPU timing and machine cycle, Programmer‟s model, Memory organization, Parallel I/O ports		
II	8051 Programming	Assembly language programming process, programming tools, addressing modes, instruction set Programming practice using assembly and embedded C programming.	8	CO2
III	8051 Integrated Peripherals	Integrated prepherials such as timers/ counters, serial ports, parallel I/O ports, interrupt structure, Memory interfacing	8	CO3
IV	8051 Microcontroller Interfacing	8051 interfacing with LED, LCD, Keypad, ADC and sensors, DAC, relays and D.C. motors, stepper motors, interfacing of 8051 with RS232	8	CO4
V	Introduction to Arduino	Learn the terminology, use, and potential of Arduino, Learn about the open-source electronics platform and its easy-to-use hardware and software, Data types, Operators, Loops,	7	C05
VI	Arduino Programming	Simple programs, interfacing with LED, LCD, Stepper motor.	7	CO6

Text Books:

1. The 8051 Microcontroller and Embedded Systems Muhammad A Mazidi, , Pearson Education

2. Dr. Yogesh Misra, “Programming and Interfacing with Arduino”, Taylor and Francis

References:

1. The 8051 microcontrollers-Kenneth J Ayala
2. Barry B. Brey, “The Intel Microprocessors” 8th Edition
3. Embedded System Design: A unified Hardware/Software Introduction Frank Vahid,Toney - Givargis- John Wiley publication.

Online References:

Sr. No.	Website Name
1.	https://archive.nptel.ac.in/courses/117/104/117104072/

Assessment:

Internal Assessment (IA) for 40 marks:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test
- Internal Assessment Test can be **open book**, provided all the questions are of **level IV and above** as per **Bloom’s Taxonomy**.

End Semester Question paper format

- Question Paper will comprise of a total of **six questions each carrying 15 marks. Q.1** will be **compulsory** and should **cover maximum contents of the syllabus**
- **Remaining questions** will be **mixed in nature.** Sub question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
- A total of **four questions** need to be answered

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Tut.	Pract/Oral	Theory	Tut.	Pract/Oral	Total
2054113	Diagnostic Instruments	3	--	--	3	--	--	3

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment Test (IAT)			End Sem Exam	Exam Duration (in Hrs)			
		IAT-I	IAT-II	IAT-I + IAT-II					
2054113	Diagnostic Instruments	20	20	40	60	2	--	--	100

Rationale:
Biomedical Instruments are used to measure, monitor, record, evaluate and treat biological systems and are essential for medical treatments. Hence, to learn and study the various diagnostic, analytical equipments, monitoring and point care devices are very important, Students will learn the fundamentals of instrumentation, principles of operation, calibration and maintenance. They also develop skills in circuit design and

Course Objectives:

1. To understand the basic principles and working of Diagnostic Instruments
2. To develop skills enabling Biomedical Engineers to serve the health care industry
3. To develops core competency and skill in the field of Biomedical Engineering, to design and develop new health care systems.

Course Outcomes: Learner will be able to

1. Demonstrate the building blocks of Instrumentation
2. Understand the Origin of bio potentials and their measurement techniques.
3. Describe the principles of various analytical instruments used in hospital and laboratories
4. and explain the working principle of different types of Blood cell counters.
5. Demonstrate the basic principle and working of Pulmonary Function Analyzer, various
6. respiration measurement techniques
7. Demonstrate the Basic principle and working of Patient Monitoring Systems
8. Describe the Point of care devices and their design considerations for homecare devices

Prerequisite: Basic concepts of Diagnostic and Analytical Instruments

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
1	Building blocks of Instrumentation	Amplifiers, Differential Amplifier, Instrumentation Amplifier, Isolation Amplifier, Rectifiers, Differentiator, Integrator Low pass, High pass and Band Pass Filters, Peak detector	08	CO1
2	Origin of bio potentials and their	Basic principle, working and technical specifications of ECG, EMG and EEG	10	CO2

	measurement techniques	machines, LEAD configurations, 10-20 electrode system, measuring techniques for EOG, ERG and Phonocardiography		
3	Blood Cell Counters	Basic principle, working and technical specifications of Blood cell counter (Coulter and Pico-scale)	06	CO3
4	Analytical Instruments and	Basic principle, working and technical specifications of Analytical Instruments 1. Colorimeter 2. Spectrophotometer 3. Principles of Chromatography 4. Principles of Electrophoresis apparatus 5. ELISA concepts (direct and indirect), Reader & Washer.	09	CO4
5	Pulmonary Function Analyzer &Respiration measurement technique	Basic principle and working of Pulmonary Function Analyzer, Respiration measurement technique: Lung volume and capacities, Spirometry, Nitrogen washout, Helium dilution.	07	CO5
6	Point of care devices	Point of care devices and their design considerations for homecare devices: Blood Glucose Monitors (Glucometer), Urine dipsticks.	05	CO6

Text books:

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

Reference Books:

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

NPTEL/Swayam Course:

Course: Biomedical Instrumentation and sensors

By-Dr.Piyush Lotia and Mr.Thaneshwar Kumar Sahu,Chhattisgarh Swami Vivekanand Technical University,Bhilai

https://onlinecourses.swayam2.ac.in

Assessment:

Internal Assessment (IA) for 40 marks:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test
- Internal Assessment Test can be **open book**, provided all the questions are of **level IV and above** as per **Bloom's Taxonomy**.

End Semester Question paper format

- Question Paper will comprise of a total of **six questions each carrying 15 marks. Q.1** will be **compulsory** and should **cover maximum contents of the syllabus**

- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)

- A total of **four questions** need to be answered

MDM401 will be picked from form Other Engineering Branch/ Science/ Commerce/ Management

OEC 401 will be picked up from other boards Science/ Commerce/ Management stream

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Tut.	Pract/Oral	Theory	Tut.	Pract/Oral	Total
2054114	Microcontrollers and Applications Lab	--	-	2	--	--	1	1

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment Test (IAT)			End Sem Exam	Exam Duration (in Hrs)			
		IAT-I	IAT-II	IAT-I + IAT-II					
2054114	Microcontrollers and Applications Lab	--	--	--	--	--	25	25	50

Lab Objectives:

1. Teach to simulate assembly codes and C codes using Keil software.
2. Teach to simulate hardware circuits using Proteus software.
3. To make the students familiar with timer, counter, serial communication etc
4. To make the students familiar to use Arduino kit
5. To acquire a signal to transfer to a personal computer.
6. To work on a live problem.

Lab Outcomes (LO):

The learner will be able to:

1. Write various assembly language and C programs for 8051 microcontroller and simulate using Keil software.
2. Use of Proteus software effectively.
3. Successfully simulate programs for timer, counters and serial port.
4. Simulate various programs and test using Arduino kits.
5. Acquire live signal and send it to a computer.
6. To use all the concepts of microcontroller in a practical circuit.

Prerequisite: Knowledge of basic electronics components, sensors, basic computer

List of Experiments:

Sr No	List of Experiments	Hrs	LO Mapping
01	Simulating various assembly language programs using Keil.	2	LO1
02	Simulate various Port programming for 8051 using Keil and Proteus software	2	LO2
03	Simulating 8051 timer programs	2	LO3
04	Simulating counter programs	2	LO3
05	Simulating Serial communication programming for 8051	2	LO2
06	Design and simulate a 8051 based system to interface the temperature sensor and to display the temperature in the LCD display.	2	LO3

7	Design and simulate 8051 based system to generate various waveforms.	2	LO3
08	Design and simulate 8051 based system to run a stepper motor	2	LO3
09	Simulate different Basic programming using Arduino kit	2	LO4
10	Simulate specific time delays using Arduino kit	2	LO4
11	Design a system to read a sensor value and communicate to a personal computer.	2	LO5
12	To implement any one application using microcontroller.	2	LO6

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

Assessment:

Term Work: Term Work shall consist of at least 10 practicals based on the above list. Also, Term work Journal must include at least 5 assignments.

Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiment) + 5 Marks (Assignments) + 5 Marks (Attendance)

Practical & Oral Exam: An Oral & Practical exam will be held based on the above syllabus

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Tut.	Pract/Oral	Theory	Tut.	Pract/Oral	Total
2054115	Diagnostic Instruments Lab	--	--	2	--	--	1	1

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment Test (IAT)			End Sem Exam	Exam Duration (in Hrs)			
		IAT-I	IAT-II	IAT-I + IAT-II					
2054115	Diagnostic Instruments Lab	--	--	--	--	--	25	25	50

Lab Objectives:

1. To demonstrate the application technique of diagnostic and equipment.
2. To measure the physiological signals from Human Heart
3. To measure the Blood Pressure
4. To study the Lead system in ECG,EEG and EMG
5 .To gain the knowledge of measurement of various physiological parameters of human body.
6. To understand the basic principles and working of patient monitoring system.

Lab Outcomes (LO):

The learner will be able to:

1. Understand the working of ECG machine by recording ECG.
2. Design and Implement Instrumentation amplifier to amplify low amplitude signals.
3. Demonstrate the measurement of Blood Pressure.
4. Demonstrate the measurement of lung volumes and capacities using Spirometer
5. Demonstrate the measurement of Blood glucose, Blood cells.
6. explain the basic principles and working of patient monitoring system.

Prerequisite: Basic knowledge in Diagnostic,Analytical,Point Care devices

List of Experiments:

Sr No	List of Experiments	Hrs	LO Mapping
01	Design and Implementation of 5V,1Amp Regulated Power Supply	2	LO1
02	Design and Implementation of Low Pass Filter	2	LO1

03	Design and Implementation of High Pass Filter	2	LO1
04	Design and Implementation of Band Pass Filter	2	LO1
05	To study and demonstration of the ECG machine	2	LO2
06	To study and measurement of ECG using Tele-ECG	2	LO2
07	Selection of wavelength for colorimeter and Spectrophotometer	2	LO4
08	Find out the concentration of unknown sample using Colorimeter and Spectrophotometer	2	LO4
09	Calculations of lung volumes and capacities using Spirometer	2	LO5
10	To study the Digital Blood Pressure measurement technique	2	LO2
11	To study and demonstration of Blood cell counters	2	LO4
12	Design of Instrumentation amplifier	2	LO1
13	To study and measurement of Blood glucose using Glucometer	2	LO6
14	To study and demonstration of the EEG machine	2	LO2
15	Industry / hospital visit to be conducted.	2	LO6

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

Assessment:

Term Work: Term Work shall consist of at least 10 practicals based on the above list. Also, Term work Journal must include at least 5 assignments.

Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiment) + 5 Marks (Assignments) + 5 Marks (Attendance)

Practical & Oral Exam: An Oral exam will be held based on the above syllabus

MDL 401 will be picked from form Other Engineering Branch/ Science/ Commerce/ Management

Vertical - 4

Detailed Syllabus

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Tut.	Pract/Oral	Theory	Tut.	Pract/Oral	Total
2054411	Python Programming Practice	-	--	4	-	--	2	2

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment Test (IAT)			End Sem Exam				
		IAT-I	IAT-II	IAT-I + IAT-II					
2054411	Python Programming Practice	--	--	--	--		25	25	50

Lab Objectives:

1. To effectively apply mathematical operations on array and matrix
2. To enable learners to proficiently handle file operations
3. To design a graphical user interface (GUI) application
4. To understand features extraction from medical data
5. To study different types filters for biomedical signal processing
6. To explore peak detection of Biomedical signal and heart rate measurement

Lab Outcomes:

The learner will be able to:

1. Demonstrate the different types of operations on array and matrix.
2. Demonstrate the operations on text or binary data type file and plotting of biosignal.
3. Extracts features from the medical data
4. Develop the graphical user interface (GUI) application.
5. Demonstrate the various types of filters operation on biomedical signal.
6. Demonstrate the peak detection of biomedical signal and heart rate measurements

Prerequisite: C-programming, Python programming basics

List of Experiments:

Sr No	List of Experiments	Hrs	LO Mapping
01	Create an array and perform operations on array	2	LO1
02	Create a matrix and perform operations on matrix	2	LO1
03	Develop the algorithm to read different type of files and perform operations on file	2	LO2
04	Upload the biomedical signal and study of signal plotting	2	LO2
05	Upload the medical data (any one disease) from available database and extract time domain features from data	2	LO3

06	Upload the medical data (any one disease) from available database and extract frequency domain features from data	2	LO3
07	Develop the GUI to display biomedical signal and its statistical features	2	LO4
08	Apply low pass , high pass & band pass filters on Biomedical signal	2	LO5
09	Filtering of biomedical signal using convolution	2	LO5
10	Develop the GUI to display original biomedical signal and filtered signal	2	LO4
11	Design and develop the algorithm for peak detection of Biomedical signal	2	LO6
12	Design and develop the algorithm for measurement of heart rate	2	LO6

* Two hours of practical class to be conducted for discussion of theory required to perform experiment.

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

Assessment:

Term Work: Term Work shall consist of at least 10 practicals based on the above list. Also, Term work Journal must include at least 5 assignments or case studies.

Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiment) + 5 Marks (Assignments or case studies) + 5 Marks (Attendance)

Practical & Oral Exam: An Oral & Practical exam will be held based on the above syllabus

SEC

Vertical – 5

Detailed Syllabus

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2993511	Entrepreneurship Development	--	2*+2	-	-	2*+2	-	2

Course Code	Course Name	Examination Scheme						
		Theory Marks				Term Work	Practical/ Oral	Total
		Internal assessment			End Sem. Exam			
		IAT-I	IAT-II	IAT-I + IAT-II				
2993511	Entrepreneurship Development	--	--	--	--	50	--	50

Note: * Two hours of practical class to be conducted for full class as demo/discussion/theory.

Lab Objectives:

1. To introduce students to entrepreneurship concepts and startup development.
2. To develop business idea generation, validation, and business model preparation.
3. To provide hands-on experience in market research, financial planning, and business pitching.
4. To enhance problem-solving and decision-making skills in entrepreneurial ventures.
5. To familiarize students with government schemes and support systems for entrepreneurs.
6. To develop communication and presentation skills required for business pitching.

Lab Outcomes:

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

1. Understand the fundamental concepts of entrepreneurship and business models.
2. Conduct market research and develop business plans.
3. Utilize financial planning and cost analysis for startups.
4. Apply entrepreneurial skills to identify and solve business challenges.
5. Develop prototypes using open-source software for business operations.
6. Pitch business ideas effectively with structured presentations.

DETAILED SYLLABUS

Sr. No.	Module	Detailed Content	Hours	LO Mapping
0	**Prerequisite**	Fundamentals of communication and leadership skills.	01	--
I	**Introduction to Entrepreneurship**	Definition, Characteristics, and Types of Entrepreneurs. Entrepreneurial Motivation and Traits. Start-up Ecosystem in India. Challenges in Entrepreneurship	**02**	**LO1**

II	**Business Idea Generation & Validation**	Ideation Techniques: Design Thinking, Brainstorming, Mind Mapping. Business Model Canvas (BMC). Market Research & Customer Validation. Minimum Viable Product (MVP) Concept.	**04**	**LO2**
III	**Business Planning & Strategy**	Writing a Business Plan. SWOT Analysis and Competitive Analysis. Financial Planning and Budgeting. Risk Assessment and Management	**04**	**LO3**
IV	**Funding and Legal Framework**	Sources of Funding: Bootstrapping, Angel Investors, Venture Capital Government Schemes & Start-up India Initiatives. Business Registration & Legal Formalities. Intellectual Property Rights (IPR) & Patents	**05**	**LO4**
V	**Marketing & Digital Presence**	Branding and Digital Marketing. Social Media Marketing & SEO. Customer Relationship Management (CRM). E-commerce & Online Business Models	**05**	**LO5**
VI	**Business Pitching & Prototype Development**	Pitch Deck Preparation & Presentation Techniques. Prototyping with Open-source Tools. Elevator Pitch & Investor Pitch. Case Studies of Successful Start-ups	**05**	**LO6**

Text Books:

1. "Entrepreneurship Development and Small Business Enterprises" – Poornima M. Charantimath, Pearson, 3rd Edition, 2021.
2. "Innovation and Entrepreneurship" – Peter F. Drucker, Harper Business, Reprint Edition, 2019.
3. "Startup and Entrepreneurship: A Practical Guide" – Rajeev Roy, Oxford University Press, 2022.
4. "Essentials of Entrepreneurship and Small Business Management" – Norman Scarborough, Pearson, 9th Edition, 2021.
5. "The Lean Startup" – Eric Ries, Crown Publishing, 2018.

References:

1. "Disciplined Entrepreneurship: 24 Steps to a Successful Startup" – Bill Aulet, MIT Press, 2017.
2. "Zero to One: Notes on Startups, or How to Build the Future" – Peter Thiel, 2014.
3. "The $100 Startup" – Chris Guillebeau, Crown Business, 2019.
4. "Business Model Generation" – Alexander Osterwalder & Yves Pigneur, Wiley, 2020.
5. "Blue Ocean Strategy" – W. Chan Kim & Renée Mauborgne, Harvard Business Review Press, 2019.

Online Resources:

Website Name
1. Startup India Portal – https://www.startupindia.gov.in 2. MIT OpenCourseWare – Entrepreneurship – https://ocw.mit.edu/courses/sloan-school-of-management/ 3. Coursera – Entrepreneurship Specialization – https://www.coursera.org/specializations/entrepreneurship 4. Harvard Business Review – Entrepreneurship Articles – https://hbr.org/topic/entrepreneurship 5. Udemy – Startup & Business Courses – https://www.udemy.com/courses/business/entrepreneurship/

List of Experiments.

Sr No	List of Experiments	Hrs
01	Business Idea Generation using Mind Mapping.	02
02	Conducting Market Research & Customer Validation.	02
03	Preparing a Business Model Canvas for a Startup Idea.	02
04	Developing a Financial Plan & Break-even Analysis.	02
05	Creating a Website using WordPress/Wix.	02
06	Social Media Marketing Campaign using Open-source Tools.	02
07	Digital Prototyping using Figma/Inkscape.	02
08	Business Pitch Deck Preparation & Presentation.	02
09	Exploring Government Schemes for Startups.	02
10	Legal Compliance & IPR Basics (Case Study).	02

Sr No	List of Assignments / Tutorials	Hrs
01	a. Write a report on any successful entrepreneur and their startup journey. b. Conduct SWOT analysis for a real-life startup.	02
02	Develop a business idea and create a one-page business plan.	02
03	Conduct market research using surveys & present findings.	02
04	Design a simple logo and branding strategy for a startup.	02
05	Create a financial model and cost estimation for a startup.	02
06	Make a case study report on startup failure analysis.	02

List of Open-Source Software
1. Canva – Designing pitch decks, social media posts, and branding materials. 2. Trello / Asana – Project management for startups. 3. GIMP / Inkscape – Graphic design and logo creation. 4. WordPress / Wix – Website development for startups. 5. OpenCart / PrestaShop – E-commerce website setup. 6. Figma – UI/UX design and prototyping. 7. LibreOffice Calc – Financial planning and budgeting. 8. Google Suite (Docs, Sheets, Slides) – Documentation and presentations. 9. Python (Pandas, Flask, Django) – Data analytics and web application development. 10. MailChimp – Email marketing and customer engagement.

Assessment :

Term Work: Term Work shall consist of at least 08 to 10 practicals‟ based on the above list. Also, Term work Journal must include at least 6 assignments.

Term Work Marks: 50 Marks (Total marks) = 20 Marks (Experiment) + 15 Marks (Assignments) + 5 Marks (Attendance)+ 10 Marks (Report)

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2993512	Environmental Science	--	2*+2	-	--	2*+2	-	2

Course Code	Course Name	Examination Scheme						
		Theory Marks				Term Work	Practical/ Oral	Total
		Internal assessment			End Sem. Exam			
		IAT-I	IAT-II	IAT-I + IAT-II				
2993512	Environmental Science	--	--	--	--	50	--	50

Note: * Two hours of practical class to be conducted for full class as demo/discussion/theory.

Rationale:

Most of the engineering branches are offspring of applied sciences, and their practices have a significant impact on the environment. Understanding environmental studies is essential for engineers to develop sustainable solutions, minimize ecological footprints, and promote responsible resource management. This course equips students with the knowledge of ecosystems, biodiversity, pollution control, and environmental laws, enabling them to integrate sustainability into engineering practices.

Lab Objectives:

1. To understand the scope, importance, and role of environmental studies in public awareness and health.
2. To study different natural resources, their issues, and sustainable conservation.
3. To understand ecosystem types, structures, and functions.
4. To explore biodiversity, its importance, threats, and conservation.
5. To learn about pollution types, causes, effects, and control measures.
6. To understand environmental challenges, sustainability, and ethics.

Lab Outcomes:

1. Explain the significance of environmental studies and the role of IT in environment and health.
2. Describe resource types, associated problems, and conservation methods.
3. Classify ecosystems and explain their role in ecological balance
4. Analyze biodiversity levels and conservation strategies, especially in India.
5. Explain pollution impacts and suggest preventive measures.
6. Discuss environmental issues and propose sustainable solutions.

DETAILED SYLLABUS:

Unit Name	Topic Name	Topic Description	Hours	LO Mapping

I	**The Multidisciplinary Nature of Environmental Studies**	Definition, scope and importance. Need for public awareness, Role of information technology in environment and human health. Human population and the environment: Population growth, variation among nations. Population Explosion- family welfare program. Environment and human health Women and child welfare	**03**	LO1
II	**Natural Resources**	Renewable and non-renewable resources. Natural resources & associated problems: a) Forest resources: b) Water resources: Natural resources & associated problems c) Mineral resources: d) Food resources: e) Energy resources: Role of an individual in conservation of natural resources: f) Equitable use of resources for sustainable lifestyles.	**04**	LO2
III	**Ecosystems**	Concepts of an ecosystem. Introduction, types, characteristic features, structure and function of the following ecosystem: a. Forest ecosystem b. Grassland ecosystem c. Desert ecosystem d. Aquatic ecosystem (ponds, streams, lakes, rivers, oceans, estuaries). Case study on various ecosystems in India.	**05**	LO3
IV	**Biodiversity and its Conservation**	Introduction-Definition: genetic species and ecosystem diversity. Bio-geographical classification of India Value of biodiversity : Consumptive use, productive use, social, ethical, aesthetic and option values, Bio-diversity at global, national, local levels India as a mega diversity nation Case study on Bio diversity in India.	**05**	LO4
V	**Environmental Pollution Definition**	Causes, effects and control measures of: a) Air pollution b) Water pollution c) Soil pollution. Solid waste management: Causes, effect and control measures of urban and industrial wastes. Role of an individual in prevention of pollution, Case study on Pollution Disaster management: floods, earthquake, cyclone and landslides. Carbon Credits for pollution prevention	**05**	LO5
VI	**Social Issues and Environment**	From unsustainable to sustainable development Urban problems related to energy, Water conservation, rain water harvesting, watershed management. Environmental ethics: issues and possible solution. Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust. Case studies. Consumerism and waste products. Environment protection act. Public awareness Case study on Environmental Ethics	**04**	LO6

Textbooks

1. Environmental Science: Towards a Sustainable Future, G. Tyler Miller and Scott

Spoolman, 13th Edition, Cengage Learning 2021
2. Environmental Management: Text and Cases, Bala Krishnamoorthy, 3rd Edition, PHI Learning, Publication Year: 2016
3. Green IT: Concepts, Technologies, and Best Practices, Markus Allemann, Springer 2008
4. Sustainable IT: Slimming Down and Greening Up Your IT Infrastructure, David F. Linthicum, IBM Press 2009
5. Environmental Modelling: Finding Solutions to Environmental Problems, David L. Murray, Cambridge University Press 2016
6. Remote Sensing and Image Interpretation, Thomas M. Lillesand, Ralph W. Kiefer, and Jonathan W. Chipman, 9th Edition, John Wiley & Sons 2020
7. Business Ethics: Concepts and Cases, Manuel Velasquez, Pearson 2012

Reference Books

1. Environmental Law and Policy in India, Shyam Divan and Armin Rosencranz, 2nd Edition, Oxford University Press 2018
2. The International Handbook of Environmental Laws, David Freestone and Jonathon L. Rubin, Edward Elgar Publishing 2000
3. E-Waste Management: Challenges and Opportunities in Developing Countries, Ruediger Kuehr and Ram K. Jain, Springer 2008
4. The E-Waste Handbook: Managing Electronic Waste, Klaus Hieronymi, Ruediger Kuehr, and Ram K. Jain, Earthscan 2009
5. Environmental Ethics: An Introduction, J. Baird Callicott, University of Georgia Press1999

Online References:

Sr. No.	Website Name
1.	Centre for Science and Environment (CSE), Website: cseindia.org
2.	Ministry of Environment, Forest and Climate Change (MoEFCC), Government of India
3.	CSIR-National Environmental Engineering Research Institute (NEERI)

List of Experiments.

Sr No	List of Experiments	Hrs
01	Study of Environmental Components and Ecosystems.	2
02	Visit and Report on Solid Waste Management Plant.	2
03	Study of Renewable Energy Sources (Solar, Wind, Biogas).	2
04	Analysis of Air and Water Quality Parameters.	2
05	Study of Local Biodiversity and Conservation Methods.	2
06	Awareness Activity on Environmental Issues.	2
07	Rainwater Harvesting System Design	2
08	Case Study on Environmental Pollution & Control Measures.	2
09	Report on Climate Change Impact and Adaptation.	2
10	Study of Environmental Laws and Acts.	2
11	Study of Disaster Management Techniques.	2
12	Report on Role of IT in Environmental Protection.	2

Sr No	List of Assignments / Tutorials	Hrs
01	Prepare a report on Renewable and Non-Renewable Resources.	2
02	Write a case study on Ecosystem Types in India	2
03	Write a report on Biodiversity in India.	2
04	Prepare a report on Pollution Types and Control Measures.	2
05	Prepare a report on Environmental Ethics and Sustainability.	2
06	Prepare a case study report on Global Warming and Climate Change.	2
07	Report on Role of an Individual in Environmental Protection.	2
08	Write a report on Disaster Management Techniques.	2
09	Prepare a report on Environmental Laws and Acts in India.	2
10	Case Study on E-waste Management and Recycling Techniques.	2

Assessment :

Term Work: Term Work shall consist of at least 10 to 12 practical‟s based on the above list. Also, Term work Journal must include at least 8 to 10 assignments.

Term Work Marks: 50 Marks (Total marks) = 20 Marks (Experiment) + 15 Marks (Assignments) + 5 Marks (Attendance)+ 10 Marks (Report)

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2994511	Business Model Development	--	2*+2	-	--	2*+2	-	2

Course Code	Course Name	Examination Scheme						
		Theory Marks				Term Work	Practical/ Oral	Total
		Internal assessment			End Sem. Exam			
		IAT-I	IAT-II	IAT-I + IAT-II				
2994511	Business Model Development	--	--	--	--	50	--	50

Note: * Two hours of practical class to be conducted for full class as demo/discussion/theory.

Lab Objectives:

1. To introduce a learner to entrepreneurship and its role in economic development.
2. To familiarize a learner with the start-up ecosystem and government initiatives in India.
3. To explain the process of starting a business.
4. To familiarize a learner with the building blocks of a business.
5. To teach a learner to plan their own business with the help of Business Model Canvas.
6. To teach a learner to have financial plan for a business model.

Lab Outcomes:

The learner will be able to:

1. Discuss the role of entrepreneurship in the economic development of a nation and describe the process of starting a business.
2. Describe start-up ecosystems in Indian and global context.
3. Identify different types of business models.
4. Identify customer segments, channels and customer relationship components for a particular business.
5. Identify key activities, key partners and key resources for a particular business.
6. Develop a financial plan for a business with the help of cost structure and revenue model.

DETAILED SYLLABUS:

Sr. No.	Module	Detailed Content	Hours	LO Mapping
0	**Prerequisite**	Basic Design Thinking principles	**01**	**--**
I	**Introduction to Entrepreneurship**	**Introduction to Entrepreneurship**: Definition, the role of entrepreneurship in the economic development, the entrepreneurial process, Women entrepreneurs, Corporate entrepreneurship, Entrepreneurial mindset **Self-learning Topics:** Case studies: Henry Ford https://www.thehenryford.org/docs/default-source/default-document-library/default-document-	**04**	**L1, L2**

		library/henryfordandinnovation.pdf?sfvrsn=0 The Tatas: How a Family Built a Business and a Nation by Girish Kuber, April 2019, Harper Business		
II	**Entrepreneurship Development**	**Entrepreneurship Development**: Types of business ownerships: Proprietorship, Public and Private Companies, Co-operative businesses, Micro, Small and Medium Enterprises (MSME): Definition and role of MSMEs in economic development	**05**	**L2, L3, L4**
III	**Start-up financing**	**Start-up financing:** Cost and revenue models, Sources of start-up fundings: Angel investors, Venture capitalists, Crowd funding, Government schemes for start-up funding **Self-learning Topics:** Successful business pitching	**04**	**L2, L3, L4, L5**
IV	**Intellectual Property Rights (IPR)**	**Intellectual Property Rights (IPR):** Types of IPR: Patents, trademarks and copyrights, Patent search and analysis, Strategies for IPR protection, Ethics in technology and innovation	**04**	**L2, L3, L4**
V	**Business Model Development**	**Business Model Development:** Types of business models, Value proposition, Customer segments, Customer relationships, Channels, Key partners, Key activities, Key resources, Prototyping and MVP **Self-learning Topics:** The Art of the Start 2.0: The Time-Tested, Battle-Hardened Guide for Anyone Starting Anything by Guy Kawasaki	**04**	**L3, L4, L5, L6**
VI	**Digital Business Management**	**Digital Business Management:** Digital Business models (Subscription, Freemium *etc*), Digital marketing: Search Engine Optimization (SEO), Search Engine Marketing (SEM), Social media and influencer marketing, Disruption and innovation in digital business **Self-learning Topics:** Case study: Airbnb https://www.prismetric.com/airbnb-business-m	**04**	**L2, L3**

Textbooks:

1. Entrepreneurship: David A. Kirby, McGraw Hill, 2002
2. Harvard Business Review: Entrepreneurs Handbook, HBR Press, 2018
3. Business Model Generation; Alexander Ostlewalder and Yves Pigneur, Strategyzer, 2010
4. E- Business & E– Commerce Management: Strategy, Implementation, Practice – Dave Chaffey, Pearson Education

Reference books:

1. Entrepreneurship: New venture creation by David Holt, Prentice Hall of India Pvt. Ltd.
2. E- Business & E– Commerce Management: Strategy, Implementation, Practice – Dave Chaffey, Pearson Education

Online Resources:

Sr. No.	Website Name
1.	Entrepreneurship by Prof. C Bhaktavatsala Rao https://onlinecourses.nptel.ac.in/noc20_mg35/preview
2.	Innovation, Business Models and Entrepreneurship by Prof. Rajat Agrawal, Prof.

	Vinay Sharma https://onlinecourses.nptel.ac.in/noc21_mg63/preview
3.	Sarasvathy‟s principles for effectuation https://innovationenglish.sites.ku.dk/model/sarasvathy-effectuation/

List of Experiments.

The lab activities are to be conducted in a group. One group can be formed with 4-5 students. A group has to develop a Business Model Canvas and a digital prototype (Web App/ mobile app). Weekly activities are to be conducted as follows:

Sr No	Lab activities	Hrs
01	Problem identification (Pain points, Market survey)	2
02	Design a digital solution for the problem (Ideation techniques)	2
03	Preparing a business model canvas: Value proposition, Key partners, Key resources, Key activities	2
04	Preparing a business model canvas: Customer segment, Customer relationships and channels	2
05	Preparing a business model canvas: Cost and Revenue structure	2
06	Prototype development: Low fidelity	2
07	Prototype development: Customer feedback	2
08	Prototype development: High fidelity	2
09	Presentation of high-fidelity prototype	2

Sr No	List of Assignments / Tutorials	Hrs
01	Presentation on case study of a failed business model	2
02	Presentation on case study of a woman entrepreneur	2

Assessment:

Term Work: Term Work shall consist of 09 lab activities based on the above list. Also, Term work journal must include any 2 assignments from the above list.

Term Work Marks: 50 Marks (Total marks) = 25 Marks (Experiment) + 10 Marks (Assignments) + 5 Marks (Attendance)+10 Marks (Report).

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2994512	Design Thinking	--	2*+2	-	--	2*+2	-	2

Course Code	Course Name	Examination Scheme						
		Theory Marks				Term Work	Practical/ Oral	Total
		Internal assessment			End Sem. Exam			
		IAT-I	IAT-II	IAT-I + IAT-II				
2994512	Design Thinking	--	--	--	--	50	--	50

Note: * Two hours of practical class to be conducted for full class as demo/discussion/theory.

Lab Objectives:

1. To introduce a learner to the principles of Design Thinking.
2. To familiarize a learner with the process (stages) of Design Thinking.
3. To introduce various design thinking tools.
4. Study of the techniques for generation of solutions for a problem.
5. To expose a learner to various case studies of Design Thinking.
6. Create and test a prototype.

Lab Outcomes:

Students will be able to …

1. Compare traditional approach to problem solving with the Design Thinking approach and discuss the principles of Design Thinking
2. Define a user persona using empathy techniques
3. Frame a problem statement using various Design Thinking tools
4. Use ideation techniques to generate a pool of solutions for a problem
5. Create prototypes using different techniques
6. Test the prototypes and gather feedback for refining the prototype

DETAILED SYLLABUS:

Sr. No.	Module	Detailed Content	Hours	LO Mapping
0	Prerequisite	No perquisites	-	-
I	**Introduction to Design Thinking**	**Introduction to Design Thinking:** Definition, Comparison of Design Thinking and traditional problem-solving approach, Need for Design Thinking approach, Key tenets of Design Thinking, 5 stages of Design Thinking (Empathize, Define, Ideate, Prototype, Test)	**05**	**L1, L2**

Self-learning Topics:

		Design thinking case studies from various domains https://www.design-thinking-association.org/explore-design-thinking-topics/external-links/design-thinking-case-study-index		
II	**Empathy**	**Empathy:** Foundation of empathy, Purpose of empathy, Observation for empathy, User observation technique, Creation of empathy map **Self-learning Topics:** Creation of empathy maps https://www.interaction-design.org/literature/topics/empathy-mapping	**05**	**L2, L3**
III	**Define**	**Define:** Significance of defining a problem, Rules of prioritizing problem solving, Conditions for robust problem framing, Problem statement and POV **Self-learning Topics:** Creating a Persona – A step-by-step guide with tips and examples https://uxpressia.com/blog/how-to-create-persona-guide-examples	**05**	**L2, L3**
IV	**Ideate**	**Ideate:** What is ideation? Need for ideation, Ideation techniques, Guidelines for ideation: Multi-disciplinary approach, Imitating with grace, Breaking patterns, Challenging assumptions, Looking across value chain, Looking beyond recommendation, Techniques for ideation: Brainstorming, Mind mapping **Self-learning Topics:** How To Run an Effective Ideation Workshop: A Step-By-Step Guide https://uxplanet.org/how-to-run-an-effective-ideation-workshop-a-step-by-step-guide-d520e41b1b96	**05**	**L3**
V	**Prototype**	**Prototype:** Low and high-fidelity prototypes, Paper prototype, Story board prototype, Scenario prototype	**03**	**L6**
VI	**Test**	**Test:** 5 guidelines of conducting test, The end goals of test: Desirability, Feasibility and Viability, Usability testing	**03**	**L4, L5**

Textbooks:

1. Design Your Thinking: The Mindsets, Toolsets, and Skill Sets for Creative Problem-solving, Pavan Soni, Penguin Random House India Private Limited
2. Design Thinking: Methodology Book, Emrah Yayichi, 2016
3. Handbook of Design Thinking: Christian Mueller-Roterberg, 2018

Reference books:

1. Design Thinking for Strategic Innovation: What They Can't Teach You at Business or Design School, Idris Mootee, Wiley, 2013
2. Change by Design, Tim Brown, Harper Business, 2009

Online Resources:

Sr. No.	Website Name
1.	Design Thinking and Innovation by Ravi Poovaiah https://onlinecourses.swayam2.ac.in/aic23_ge17/preview
2.	Introduction to Design Thinking by Dr. Rajeshwari Patil, Dr. Manisha Shukla, Dr. Deepali Raheja, Dr. Mansi Kapoor https://onlinecourses.swayam2.ac.in/imb24_mg37/preview
3.	Usability Testing https://www.interaction-design.org/literature/topics/usability-testing

List of Experiments.

The experiments are to be performed in groups. A practical batch may be divided into groups of 4-5 students.

Sr No	List of Experiments	Hrs
01	Customer Journey Mapping: Visualize the steps users take to interact with a product or service. Map out the customer journey from discovering a product to making a purchase and using the product. Identify pain points and opportunities for improvement.	2
02	Stakeholder mapping: Identify all relevant stakeholders in a project. Create a stakeholder map, categorizing stakeholders based on their influence and interest. Include management of relationships with key stakeholders.	2
03	"How Might We" Problem Framing: Transform user insights into actionable problem statements. After empathizing with users, turn challenges into "How Might We" statements that define the problem without prescribing a solution.	2
04	Brainstorming Session: Generate a pool of ideas in a creative, non-judgmental environment. Using ideation techniques like mind mapping and brainwriting, students brainstorm as many solutions as possible to their "How Might We" problem statements.	2
05	Affinity Diagramming: Organize group ideas to find patterns and insights. After brainstorming, students will categorize their ideas into themes by placing sticky notes on a wall and moving them into groups based on similarities.	2
06	Rapid Prototyping: Create quick, low-fidelity versions of solutions. Use materials like paper, cardboard, and markers to build a prototype of their solution within 30 minutes. The focus is on speed and functionality, not aesthetics.	2
07	Wireframing: Create a visual guide for digital interfaces for mobile app / web app for the problems identified in earlier lab sessions. Students will sketch wireframes of the user interface for their product or service. Use tools like Balsamiq or paper and pen for low-fidelity wireframes.	2
08	Role-Playing: Walk through a prototype from the user‟s perspective. Students act as both users and designers, role-playing scenarios where they interact with their prototype (Developed in earlier lab sessions). Gather feedback from participants on how to improve the experience.	2
09	Usability Testing: Evaluation of the effectiveness and user-friendliness of a prototype (developed in earlier lab sessions). Students will have peers or target users test their prototypes, observe how they interact with it, and collect feedback on any issues or improvements needed.	2
10	Feedback Loop and Iteration: Refine solutions based on user feedback. After usability testing, students will refine their prototypes. Document changes made based on feedback and discuss how continuous iteration improves the design.	2

Sr No	List of Assignments (Any two)	Hrs
01	Create an empathy map for a target user group. Break them into four sections: *Says, Thinks, Feels, and Does*. Interview users or research their experiences to fill in the map.	3
02	Based on research, students will create user personas including demographic details, motivations, pain points, and goals. Each group will present their persona to the class.	3
03	Consider 3 examples of real-life products which have good design and bad design. Write down reasons why do you think they are good or bad designs. May take user survey to support your work.	3
04	Study any open-source design thinking tool and write a brief report about it.	3

Assessment:

Term Work: Term Work shall consist of 10 to 12 lab activities based on the above list. Also, Term work journal must include any 2 to 4 assignments from the above list.

Term Work Marks: 50 Marks (Total marks) = 25 Marks (Experiment) + 10 Marks (Assignments) + 5 Marks (Attendance)+ 10 Marks (Report).

Vertical – 6

Detailed Syllabus

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Tut.	Pract/Oral	Theory	Tut.	Pract/Oral	Total
2053611	Mini Project (group activity)	--	--	4	--	--	2	2

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment Test (IAT)			End Sem Exam	Exam Duration (in Hrs)			
		IAT-I	IAT-II	IAT-I + IAT-II					
2053611	Mini Project (group activity)	--	--	--	--	--	50	25	75

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.

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 shall be as below;
  - Marks awarded by guide/supervisor based on log book : 20
  - Marks awarded by review committee 20
  - Quality of Project report 10

Oral will be conducted by supervisor and external examiner.

Letter Grades and Grade Points:

Semester GPA/ Programme CGPA Semester/ Programme	% of Marks	Alpha-Sign/ Letter Grade Result	Grading Point
9.00 - 10.00	90.0 – 100	O (Outstanding)	10
8.00 - < 9.00	80.0 - < 90.0	A+ (Excellent)	9
7.00 - < 8.00	70.0 - < 80.0	A (Very Good)	8
6.00 - < 7.00	60.0 - < 70.0	B+ (Good)	7
5.50 - < 6.00	55.0 - < 60.0	B (Above Average)	6
5.00 - < 5.50	50.0 - < 55.0	C (Average)	5
4.00 - < 5.00	40.0 - < 50.0	P (Pass)	4
Below 4.00	Below 40.0	F (Fail)	0
Ab (Absent)	-	Ab (Absent)	0

Sd/-

Dr. Ghanshyam D Jindal
BoS-Chairman, Biomedical Engineering
Faculty of Technology

Sd/-

Dr. Deven Shah
Associate Dean
Faculty of Science & Technology

Sd/-

Prof. Shivram S. Garje
Dean
Faculty of Science & Technology