

University of Mumbai

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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 अमलबजावणीच्या 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.

मुंबई - ४०० ०३२
२७ मे, २०२५


(डॉ. प्रसाद कारंडे)
कुलसचिव

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4	P.A to all Deans of all Faculties
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1	The Chairman, Board of Deans pvc@fort.mu.ac.in
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As Per NEP 2020

University of Mumbai



Syllabus for Major Vertical – 1, 4, 5 & 6

Name of the Programme – B.E. (<u>Biomedical Engineering</u>)		
Faculty of <u>Engineering</u>		
Board of Studies in <u>Biomedical Engineering</u>		
U.G. Second Year Programme	Exit Degree	U.G. Diploma in <u>Biomedical Engineering.</u>
Semester		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. IV
7	Program Academic Level	5.00
8	Pattern	Semester
9	Status	New
10	To be implemented from Academic Year	2025-26

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

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/-

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

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Associate Dean
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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. – IV

S.E.BME Scheme

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 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. Mrityunjay 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 peripherals 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	CO5
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 develop 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

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: <i>Says, Thinks, Feels, and Does</i> . 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).

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