

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 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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3	The Deputy Registrar, Marks and Certificate Unit,. Vidyanagari dr.verification@mu.ac.in
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
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11	The Deputy Registrar, College Teachers Approval Unit (CTA), concolsection@gmail.com
12	The Deputy Registrars, Finance & Accounts Section, fort draccounts@fort.mu.ac.in
13	The Deputy Registrar, Election Section, Fort drelection@election.mu.ac.in
14	The Assistant Registrar, Administrative Sub-Campus Thane, thanesubcampus@mu.ac.in
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
17	The Director, Centre for Distance and Online Education (CDOE), Vidyanagari, director@idol.mu.ac.in
18	Director, Innovation, Incubation and Linkages, Dr. Sachin Laddha pinkumanno@gmail.com
19	Director, Department of Lifelong Learning and Extension (DLLE), dlleuniversityofmumbai@gmail.com

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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
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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 directr@dsd.mu.ac.in
6	The Director, Department of Information & Communication Technology, director.dict@mu.ac.in

As per NEP 2020

University of Mumbai



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

Name of the Programme – B.E. (Instrumentation Engineering) _____		
Faculty of <u>Engineering</u> _____		
Board of Studies in <u>Instrumentation Engineering</u> _____		
U.G. Second Year Programme	Exit Degree	U.G. Diploma in Instrumentation 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. (Instrumentation Engineering)
2	Exit Degree	U.G. Diploma in Instrumentation 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 - 650C R. TEU- 650 D	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/-

Dr. B. N. Chaudhari
BoS-Chairman-
Instrumentation 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, the 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 Electronics and Telecommunication Engineering Branch of 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 Electronics and Telecommunication Engineering for open electives and multidisciplinary minor 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.

The Program Core Course Covers Electronics and Telecommunication engineering core courses. Also, OE and MDM where a pool of subjects are given for selection. 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 the purpose Design Thinking is introduced in the First Semester to orient a journey learner to become 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 practices.

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 12-13 weeks, and the remaining 2-3 weeks are 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 Year and Final Year Engineering in the academic years 2026-27, and 2027-28, respectively.

Sd/-

Dr. B. N. Chaudhari

**BoS-Chairman- Instrumentation
Engineering**

Faculty of Technology

Sd/-

**Dr. Deven Shah
Associate Dean**

Faculty of Science & Technology

Sd/-

**Prof. Shivram S. Garje
Dean**

Faculty of Science & Technology

Under Graduate Diploma in Instrumentation Engineering

Credit Structure (Sem. III & IV)

	R: <u>650</u> C									
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	PCC301:3 PCC302:3 PCC303:3 PCC304:2 PCL302: 1 PCL303:1 PCL304:1	--	--	OE: 2	--	VEC: 2 HSL: 2	CEP: 2	22	UG Diploma 45
	R: <u>650</u> D									
	IV	PCC401:3 PCC402:3 PCC403:3 PCL402:1 PCL403:1	--	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.

[Abbreviation - 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]

S.E. Instrumentation Engineering Scheme Semesters III and IV

Program Structure for Second Year of Instrumentation 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
PC401	Engineering Mathematics-IV	2	--	1	2	1	—	3
PC402	Components of Instrumentation Systems	3	—	--	3	—	—	3
PC403	Electrical Network & Measurements	3	--	--	3	—	—	3
MDC401	Feedback Control System	3	—	--	3	—	—	3
OE401	Advanced and Smart Sensors	2	—	--	2	—	—	2
PCL402	Components of Instrumentation Systems Laboratory	—	2	—	—	—	1	1
PCL403	Electrical Network & Measurements	—	--	2	—	1	--	1
MDL401	Feedback Control System Laboratory	—	2	—	—	—	1	1
VSE401	Virtual Instrumentation	—	2*+2	—	—	—	2	2
EEM402	Business Model Development	—	2*+2	—	—	—	2	2
VE403	Design Thinking	—	2*+2	—	—	—	2	2
Total		13	16	03	13	02	08	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

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)					
PC401	Mathematics-IV	20	20	40	60	2	25	--	125
PC402	Components of Instrumentation Systems	20	20	40	60	2	--	--	100
PC403	Electrical Network & Measurements	20	20	40	60	2	--	--	100
MDC401	Feedback Control System	20	20	40	60	2	--	--	100
OE401	Advanced and Smart Sensors	20	20	40	60	2	--	--	100
PCL402	Components of Instrumentation Systems Laboratory	--	--	--	--	--	25	25	50
PCL403	Electrical Network & Measurements Laboratory	--	--	--	--	--	25	--	25
MDL401	Feedback Control System Laboratory	--	--	--	--	--	25	25	50
VSE401	Virtual Instrumentation	--	--	--	--	--	50	25	75
EEM402	Business Model Development	--	--	--	--	--	50	--	50
VE403	Design Thinking	--	--	--	--	--	50	--	50
Total		100	100	200	300	10	250	75	825

Vertical – 1

Major

Sem. IV

Detail Syllabus

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theor y	Pract.	Tut.	Theor y	Pract.	Tut.	Total
	Applied Mathematics-IV	2	-	1	2	-	1	3

		Theory					Term work	Pract t /Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Total					
	Applied Mathematics- IV	20	20	40	60	2	25	--	125

Rationale:

The goal of this course is to make the learner conversant with the basic tools of mathematics for application in Instrumentation engineering. The syllabus designed will help the learner build a foundation to model Instrumentation engineering problems mathematically, analyze and solve the same.

Prerequisite:

Applied Mathematics-I
Applied Mathematics-II

Course Objectives:

1. To introduce the concept of Vectors in n-dimensional vector space.
2. To familiarize with the concept of Complex Integration.
3. To introduce the concept of Correlation & Regression.
4. To familiarize with the concept of random variable and probability distributions with its applications in engineering and science.
5. To familiarize with the concept of Vector Differentiation and integration.
6. To introduce concepts and fundamentals of Calculus of Variations.

Course Outcomes:**On successful completion of the course learner will be able to:**

1. Understand the concept of Vectors in n -dimensional vector space.
2. Understand the concept of Complex Integration.
3. Apply the concept of Correlation & Regression in various problems.
4. Understand and apply the concept of random variable and standard probability distributions.
5. Understand and apply the concept of Vector Differentiation and integration.
6. Apply the concepts of the fundamentals of Calculus of Variations.

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
1	Linear Algebra: Vector spaces.	Vectors in n-dimensional vector space: properties, dot product, cross product, norm and distance properties in n-dimensional vector space, definition only of Vector spaces and sub spaces over real field. The Cauchy-Schwarz inequality, Orthogonal Subspaces, Gram-Schmidt process. Self-learning Topics: Vector spaces over real field, properties of vector spaces over real field, subspaces problems.	4	CO1
2	Complex Variables – Integration	Complex Integration: Line Integral, Cauchy's Integral theorem for simply connected regions, Cauchy's Integral formula. (without proof) Self-learning Topics: Taylor's and Laurent's Series Zeros, singularities, poles of $f(z)$, residues, Cauchy's Residue theorem. Applications of Residue theorem to evaluate real Integrals of different types.	5	CO2
3	Statistics	Correlation & Regression Karl Pearson's coefficient of correlation, covariance, Spearman's Rank correlation. Lines of Regression. Self-learning Topics: Angle between the lines of regressions, Curve fitting – First degree and second curves.	5	CO3
4	Random Variable & Probability Distribution	Discrete and Continuous random variables, Probability mass and density function, Probability distribution for random variables, Expectation, Variance, Poisson and Normal distribution. (No questions on finding the mean and variance for Normal distributions)	4	CO4

		Self-Learning Topics: Binomial Distribution, Moment generating function		
5	Vector Differentiation and integration.	Vector Differentiation: Gradient of scalar point function, divergence and curl of vector point function, Solenoidal and irrotational vector fields, conservative vector field. Vector Integral: Line integral, work done. Self-learning Topics: Green's theorem in a plane, Gauss divergence theorem and Stokes theorem.	4	CO5
6	Calculus of Variations	Introduction, functional, Euler's differential equation, Geodesic, Isoperimetric problems- Lagrange Method , Euler's differential equation for second order derivative. Self-learning Topics: Several dependent variables, Functions involving higher order derivatives, Rayleigh-Ritz Method.	4	CO6

Note:

- a. Tutorial shall be conducted batch wise.
- b. No Questions to be asked from Self-Learning

Topics. Text / Reference Books:

1. Higher Engineering Mathematics, Dr. B. S. Grewal, Khanna Publication.
2. Advanced Engineering Mathematics, Erwin Kreyszig, WileyEastern Limited.
3. Advanced Engineering Mathematics, R. K. Jain and S.R.K. Iyengar, Narosa publication
4. Signals and Systems, A Nagor Kani, Tata McGraw Hill.
5. Probability, Statistics and Random Processes, T. Veerarajan, Mc.Graw Hill education.
6. Advanced Engineering Mathematics, H. K. Dass, S. Chand & Company Ltd.

Online References:

Sr.No.	WebsiteName
1.	https://nptel.ac.in/courses/111/106/111106139/
2.	https://www.youtube.com/watch?v=2CP3m3EgLIQ
3.	https://www.youtube.com/watch?v=Hw8KHNgRaOE

Term Work:**General Instructions:**

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

The distribution of Term Work marks will be as follows–

1.	Attendance (Theory and Tutorial)	05 marks
2.	Class Tutorials on entire syllabus	10 marks
3.	Mini project	10 marks

Assessment:**Internal Assessment (IA) Test:**

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

End Semester Examination:

1. Question paper will comprise of total 06 questions, each carrying 15 marks.

2. Total 04 questions need to be solved.
3. Question No:01 will be compulsory and should cover maximum content of the entire syllabus.
4. Remaining questions will be randomly selected from all the modules as per the weightage of each module (which is proportional to number of respective lecture hours mentioned in the syllabus).

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	TW/Pract.	Tut.	Total
PC402	Components of Instrumentation Systems	03	02	--	03	01	--	04

Course Code	Course Name	Examination Scheme						
		Theory				Term Work	Pract./ Oral	Total
		Internal Assessment Test (IAT)			End Sem. Exam			
		IAT-I	IAT-II	IAT-I + IAT-II (Total)				
PC402	Components of Instrumentation Systems	20	20	40	60	25	25 --	150

Course Objectives:

1. To impart knowledge of different control system components like Hydraulic, Pneumatic, Electrical & Electronics and their comparison.
2. To make the students to learn different types of Transmitters.
3. To give the students an overview of Industrial Control components & their Need in Instrumentation
4. To make the students to understand concept of control valve, different types, their working & selection criteria.
5. To give the students an overview of Analytical components & their Need in Instrumentation.
6. To give Knowledge related to the Analytical Instruments

Course Outcomes: Students will be able to...

1. Explain and select various pneumatic system components and circuits.
2. Apply knowledge to classify, select and use various transmitters.
3. Describe and select industrial components and study their usage.
4. Classify and select various control valves and their accessories.
5. Describe and select Analytical components and study their usage.
6. Demonstrate analytical Instrumentation components

DETAILED SYLLABUS

Module	Detailed Contents	Hrs.	CO Mapping
01	Pneumatic and Hydraulic System Pneumatic System Components: ISA symbols, Instrument Air and Plant Air. Air compressor system and its accessories. Directional control valves and special types of pneumatic valve such as Pilot-operated valves, Linear actuators- Single-acting, Double-acting, and special type of double- acting cylinder, Rotary actuators, Volume boosters Hydraulic pumps(centrifugal, gear , lobe), Pressure regulation method, Loading valves, Hydraulic valves, Electro Hydraulic actuators, Selection and comparison of pneumatic, hydraulic and electric systems.	7	CO1
02	Transmitters: Need, specifications and classification of transmitters, Need for Standardization of signals, concept of live zero and dead zero, 2-wire; 3- wire and 4-wire transmitters and its calibration, Electronic versus pneumatic transmitters, Electronic type transmitters - temperature; Pressure (gauge); differential pressure; level(capacitive type); flow transmitter (magnetic); SMART /Intelligent transmitter; Block schematic and Comparison withconventional transmitter; applications of transmitters,	7	CO2
03	Industrial and Auxiliary Components Panel Switches: Construction, symbolic representation, working, application of Toggle switches, Push buttons, Selector switches, DIP switches, Rotary switches, Thumbwheel switches, Drum switch, Limit switches, emergency push button, Tactile switch, Switch specifications Control Relays: Construction, working, specifications, and applications of Electro-mechanical relay, Solid state relays. Interposing relays and Overload relays. Contactors/starters: Construction, working, specifications and applications of starters and contactors. Comparison between relays and starters /contactors. Alarm annunciators and its sequences; Temperature regulator, Flowregulator, stepper motor (working principle)	6	CO3
04	Process Control Valves and Convertors Need and specifications of Control Valve; Control valve terminology;	11	CO4

	Control valve constructional details; Air to Open(AO), Air to Close (AC); MOC (Material of construction); classification of control valve; applications, advantages, disadvantage of - Globe, Ball, Needle, Butterfly, Diaphragm, Pinch, Gate, Solenoid; Flow characteristics (Inherent and Installed); Valve positioners: necessity, types-motion balance and force- balance, Effect on Performance of control valve; Control Valve Actuators - Electrical, Pneumatic, Hydraulic, Electro-mechanical, and piston actuators; selection guidelines for control valve. Converters: Need for Converters and types, working of Pneumatic to Electrical and Electrical to Pneumatic converters.			
05	Basic Analytical Instrumentation Introduction: Introduction to analytical Instrumentation. Fundamentals of Spectroscopy: Nature of Electromagnetic Radiation, Electromagnetic spectrum, Beer Lambert's Law statement and derivation. Interaction of radiation with matter Molecular Spectroscopy: Molecular Energy levels, correlation of energy levels with transitions. Introduction to UV-VIS molecular spectroscopy – basics of single beam, spectrophotometer and filter photometer, its instrumentation and applications. Basic principle, components and instrumentation of Fluorimeters, Phosphorimeters and Raman spectrometers	04	CO5	
06	Analytical Components Separation Science: Chromatography: Fundamentals of chromatographic Separations, Classification, Gas chromatographic system with components, factors affecting separation, applications. Mass Spectrometers: Basic principle, components and types of mass spectrometers, sample handling techniques for liquids and solids Industrial Gas Analyzers: Oxygen Analyzer, Combustion Gas Analyzers, Gas density analyzer	04	CO6	

References:

1. Andrew Parr, Hydraulic & pneumatics; A Technicians & Engineers Guide, Second Edition
2. Control Valve Handbook – Forth Edition, Fisher.
3. Pneumatics workbook Basic Level - FESTO
4. C.L.Albert and D.A. Coggan, -Fundamentals of Industrial Controlll, ISA, 1992.
5. Bela G. Liptak, -Instrument Engineer's Hand Book – Process Controlll, Chilton Company, 3rd Edition, 1995.
6. Andrew Williams, -Applied instrumentation in the process industriesll, 2nd Edition, Vol. 1 & 3, Gulf publishing company.
7. Guy Borden, Paul G Friedman , style Editor Control Valves- ISA
8. Process Instruments & Control Handbook, Douglas. M.Considine, McGraw-Hill
9. Analytical Instrumentation by R.S.Khandpur

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.

End Semester Theory Examination:

➤ Question paper format

- The 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.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	TW/Pract.	Tut.	Total
PC403	Electrical Network & Measurements	03	--	--	03	--	--	03

Course Code	Course Name	Examination Scheme						
		Theory				Term Work	Pract./ Oral	Total
		Internal Assessment Test (IAT)			End Sem. Exam			
		IAT-I	IAT-II	IAT-I + IAT-II (Total)				
PC403	Electrical Network & Measurements	20	20	40	60	--	--	100

Course Objectives:

1. To introduce the concept of circuit elements and analyze DC circuits with dependent sources and AC circuits using various theorems.
2. To analyze the transient response of circuits.
3. To analyze two port model of circuit and evaluate its parameters.
4. To analyze networks using graph theory.
5. To demonstrate basic analog and digital instruments.
6. To identify the various techniques for measurement of R-L-C.

Course Outcomes: Students will be able to-

1. Analyze DC and AC circuits using different theorems.
2. Evaluate transient and steady-state the parameters of passive electrical networks.
3. Analyze network using poles and zeros and determine their parameters like Z, Y, and ABCD.
4. Analyze the networks using graph theory.
5. Demonstrate construction and working principle and applications of analog and digital instruments.
6. Formulate electrical bridges and evaluate electrical parameter like R, L, C.

DETAILED SYLLABUS

Module	Detailed Contents	Hrs.	CO Mapping
01	Network Theorems Analysis of networks with dependent sources: mesh analysis, nodal analysis, super mesh and super node concept, source transformation technique, superposition theorem, Thevenin's theorem, Norton's theorem, Maximum power transfer theorem. Mesh analysis for AC networks.	10	CO1
02	Transient Analysis using time domain Initial Conditions in R, L, C elements, Transient analysis of R-L, R-C and R-L-C circuits. Solution of a First order and Second order differential equations.	06	CO2
03	Network Functions and Two-Port parameters Network functions for one port and two port networks, driving point and transfer functions, ladder network, poles and zeros of network functions, time domain behaviour from pole-zero plot. Stability using Hurwitz polynomials. Two-Port parameters, Open circuit, Short circuit, transmission and hybrid parameters,.	09	CO3
04	Graph Theory Introductory definition – Graph of a network, trees, co-trees, loops. Incidence matrix, loop matrix and cutset matrix. Network equilibrium equations, Duality.	06	CO4
05	Analog & Digital Meters Introduction and classification of analog meters (PMMC and PMMI instruments) D_Arsonaval galvanometers,. Shunts and multipliers, Construction and working principle of: ammeters, voltmeters, ohmmeters, power factor meter, Digital multimeter.	04	CO5
06	Measurement of Energy Concepts of Energy and power traditional method for energy and power measurement Electronic/ smart instruments for energy measurement	04	CO6

References:

1. Kuo Franklin F., "Network analysis and synthesis", Wiley International, 1962.
2. Van Valkenburg M.E., "Network analysis", Eastern Economy Edition, 1983.
3. A. K. Sawhney, Puneet Sawhney, "A course in Electrical and Electronic Measurement and Instrumentation", Dhanpat Rai and Co. Rai, 1996.
4. Hayt William, Kemmerly Jr. Jack E., "Engineering circuit Analysis", Tata McGraw Hill, 2002.
5. Edminister Joseph A., Nahvi Mohmood, "Electric Circuits", Tata McGraw Hill, 1999.
6. Shyammoan Sudhakar, "Circuits and Networks Analysis and Synthesis", Tata McGraw Hill, 2000.
7. Ravish Singh, — Electrical Networks Analysis and Synthesis, Mc-Graw Hill

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.

End Semester Theory Examination:

➤ Question paper format

- The 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.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	TW/Pract.	Tut.	Total
MD401	Feedback Control System	03	02	--	03	01	--	04

Course Code	Course Name	Examination Scheme						
		Theory				Term Work	Pract./ Oral	Total
		Internal Assessment Test (IAT)			End Sem. Exam			
		IAT-I	IAT-II	IAT-I + IAT-II (Total)				
MD401	Feedback Control System	20	20	40	60	25	25 --	150

Course Objectives:

1. The students should be able to learn the type of System, dynamics of physical systems, classification of control system, analysis and design objective.
2. The students should learn how to represent system by transfer function and block diagram reduction method and Mason's gain formula.
3. The students should able to learn time response analysis and demonstrate their knowledge to frequency response.
4. Students can be able to learn stability analysis of system using Root locus, bode plot, polar plot, and Nyquist plot

Course Outcomes: Students will be able to...

1. Identify open and closed loop control system
2. Formulate mathematical model for physical systems.
3. Simplify representation of complex systems using reduction techniques.
4. Use standard test signals to identify performance characteristics of first and second-order systems.
5. Apply root locus technique for stability analysis.
6. Analyze performance characteristics of system using Frequency response methods.

DETAILED SYLLABUS

Module	Detailed Contents	Hrs.	CO Mapping
01	Introduction: Definition of control system and related terms, open loop and closed loop system, examples. Development of automatic control systems, classification of control system, examples	02	CO1
02	Mathematical Models of Physical Systems: Definition of physical systems, principle of superposition and homogeneity, linear/non-linear, time variant/time invariant systems. Definition of transfer function, sinusoidal transfer function, transfer functions of physical systems, such as electrical and mechanical systems, Analogous systems.	05	CO2
03	Transfer Function and Feedback Characteristics: Block diagram algebra, reduction rules, signal flow graphs-definition, construction, properties, and Mason's gain formula, sensitivity of closed loop and open loop systems, effect of feedback, effect of disturbances signals, regenerative feedback with examples	08	CO3
04	Time Response Analysis: Standard test signals, pulse and impulse function, time response of first order system, time response of second order system, time response specifications, steady –state error, system types and error constants, Time response analysis of electrical RLC circuits	10	CO4
05	Stability Analysis and Root Locus Method: Concept of stability, definitions, relative stability, Routh's stability criterion, necessary and sufficient conditions for stability, relative stability analysis Root locus technique, applications, concept, construction of root loci, root loci of different systems, electrical RLC circuits, etc.	07	CO5
06	Frequency Response and Stability Analysis: Bode plots, polar plots, Nyquist stability criterion, Correlation between time and frequency response, stability analysis using-bode plots, polar plots, definition and significance of gain margin and phase margin, sensitivity analysis in frequency domain, Frequency response and analysis of electrical RLC circuits.	07	

References:

1. Gopal M. "Control Systems Principles and Design", Tata McGraw Hill Publishing Co. Ltd., New Delhi, 1998.
2. Nise Norman S., "Control Systems Engineering", 3rd.Edition, John Wiley and Sons, Inc.-2000.
3. Lewis Paul H., Chang Yang, "Basic Control Systems Engineering", Prentice Hall International, Inc. 1997.
4. Raymond T. Stefani, Bahram Shahian, late Clement J. Savant and, late Gene H. Hostetter, "Design of Feedback Control Systems", 4th Edition., Oxford, University Press, New Delhi, 2001.
5. Dhanesh N. Manik, "Control System", Cengage Learning India, 1st Edition, 2012.

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.

End Semester Theory Examination:**Question paper format**

- The 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.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	TW/Pract.	Tut.	Total
OE401	Advanced and Smart Sensors	02	--	--	02	--	--	02

Cou rse Cod e	Course Name	Examination Scheme							
		Theory				End Sem. Exam	Ter m Wo rk	Pract / Oral	Total
		Internal Assessment Test (IAT)							
		IA T-I	IA T-II	IAT -I + IAT -II (Tot al)					
OE401	Advanced and Smart Sensors	20	20	40	60	---	--	100	

Course Objectives:

- To expose the students to the concepts of smart and micro sensors.
- To provide sufficient knowledge about sensor fabrication.
- To create awareness about the various application fields of smart sensors.

Course Outcomes: Students will be able to...

1. Understand various principles employed in transducers
2. Examine the methods of fabricating a sensor.
3. Apply knowledge in designing smart sensors.
4. Understand techniques of fabrication and application of MEMS.
5. Understand various applications of smart sensors.
6. Understand advanced sensing technology.

DETAILED SYLLABUS

Module	Detailed Contents	Hrs.	CO Mapping
01	Review of Fundamentals of Sensors: Principle of physical and chemical transduction, sensor classification, characterization of mechanical, electrical, optical, thermal, magnetic, chemical and biological sensors, their calibration and determination of characteristics	03	CO1
02	Sensor Fabrication: Design considerations and selection criteria as per standards; Sensor fabrication techniques, process details, and latest trends in sensor fabrication; thick film sensing and system design.	04	CO2
03	Smart Sensors: Smart sensor basics, signal conditioning and A/D conversion for sensors, examples of available ICs (DHT, Smart analog IC 500, ADXL345) and their applications.	05	CO3
04	Micro Sensors: Introduction, Intrinsic characteristics of MEMS, common fabrication techniques, application of MEMS in sensing systems, including pressure sensors, accelerometers, gyroscopes, and strain gauges.	04	CO4
05	Advanced Sensor Applications: Temperature & Humidity measurement using DHT Sensor in environment monitoring, Acceleration measurement using ADXL345 for automotive industry, MEMS Temperature sensors for automotive applications, MEMS chemical sensors for survey meters, MEMS pressure sensors for medical applications	05	CO5
06	Advanced Sensing Technology: Sensors, instruments and measurement techniques for emerging application areas such as environmental measurement like DO (dissolved oxygen), BOD (biological oxygen demand), COD (chemical oxygen demand), TOC (total organic carbon), CO _x (carbon dioxides), NO _x (nitrogen oxide), for navigation and inertial measurements, for agricultural measurements such as soil moisture, wind speed, leaf wetness duration, sensors for food processing like smell or odour, taste	05	CO6

Text Books:

1. Chang Liu, Foundations of MEMS, Pearson Education Inc.,2012.
2. Stephen D Senturia, Microsystem Design, Springer Publication,2000.
3. Tai Ran Hsu, MEMS & Micro systems Design and Manufacture, Tata Mc Graw Hill, New Delhi,2002. 4. Jacob Fraden, Handbook of Modern Sensors
5 th Edition, Springer th 4. Jacob Fraden, Handbook of Modern Sensors, 5 5. S. M. Sze, Semiconductor Sensors, Wiley
6. M J Usher, Sensors and Transducers, MacMillan,1985. Edition, Springer .

References:

1. Nadim Maluf An Introduction to Microelectromechanical Systems Engineering Artech House, 2000
2. Mohamed Gad-el-Hak, editor, The MEMS Handbook, CRC press Baco Raton,2001.
3. Julian w. Gardner, Vijay K. Varadan, Osama O.Awadelkarim, Micro Sensors MEMS and Smart Devices, John Wiley & Son LTD,2002.
4. James J.Allen, Micro Electro Mechanical System Design, CRC Press Publisher,2005.
5. Thomas M. Adams and Richard A.Layton, Introduction to MEMS, Fabrication and Application, Springer,2010

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.

End Semester Theory Examination:**Question paper format**

The 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.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
PCL403	Electrical Network & Measurements Laboratory	--	--	2	--	--	1	1

	Course Name	Examination Scheme						
		Theory Marks				Term Work	Practical/ Oral	Total
		Internal assessment (IAT)			End Sem. Exam			
		IAT I	IAT-II	IAT-I + IAT-II (Total)				
PCL403	Electrical Network & Measurements Laboratory	--	--	--	--	25	--	25

Lab Objectives:

1. To introduce the concept of circuit elements and analyze DC circuits with dependent sources and AC circuits using various theorems.
2. To analyze the transient response of circuits.
3. To analyze two port model of circuit and evaluate its parameters.
4. To analyze the networks using graph theory
5. To demonstrate basic analog and digital instruments.
6. To identify the various techniques for measurement of R-L-C.

Lab Outcomes: Students will be able to-

1. Analyze DC and AC circuits using different theorems.
2. Evaluate transient and steady-state the parameters of passive electrical networks.
3. Analyze network using poles and zeros and determine their parameters like Z, Y, and ABCD.
4. Analyze the networks using graph theory.
5. Demonstrate construction and working principle and applications of analog and digital instruments.
6. Formulate electrical bridges and evaluate electrical parameter like R, L, C.

List of Tutorials. (Minimum Six tutorials required)

Sr. No	List of Tutorials	Hrs	LO
01	Tutorial on Analysis of DC network with Dependent Sources using mesh analysis.	02	01
02	Tutorial on Analysis of DC network with Dependent Sources using nodal analysis and superposition theorem,	02	01
03	Tutorial on Analysis of DC network with Dependent Sources using Thevenin's, Norton's, theorem, Maximum power transfer theorem.	02	01
04	Tutorial on Transient Analysis and initial conditions.	02	02
05	Tutorial on Steady state analysis.	02	02
06	Tutorial on Network Functions and Two-Port parameters.	02	03
07	Tutorial on Graph theory, different types of matrices.	02	03
08	Tutorial on graph theory equilibrium equations	02	04
09	Tutorial on Analog & Digital Meters.	02	05
10	Tutorial on energy measurement.	02	06

Term Work:

General Instructions:

Term work shall consist of minimum **six tutorials**. Two to four Simulation based analysis can be conducted on the modules.

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

Tutorials : 10 Marks

Journal : 10 Marks

Attendance (Practical) : 5 Marks

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

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Examination	Theory	Pract.	Tut.	Total
MDL401	Feedback Control System Lab Course	Theory Marks			--	1	--	1
Course Code	Name	Internal assessment (IAT)			End Sem. Exam	Term Work	Practical / Oral	Total
		IAT I	IAT-II	IAT-I + IAT-II (Total)				
MDL401	Feedback Control System Lab	--	--	--	--	25	25	50

Lab Objectives:

1. The students should be able to examine steady-state and frequency response of the Type 0, 1, and 2 systems.
2. The students should be able to examine steady-state and frequency response of first and second order electrical systems.
3. The students should be able to examine time response analysis of first and second order systems.
4. Students can be able to inspect stability analysis of system using Root locus, Bode plot, polar plot.

Lab Outcomes (LO):

Learners will be able to -

1. Plot frequency response of first-order electrical system.
2. Plot time response of second-order electrical system and calculate the steady-state error.
3. Demonstrate their knowledge to obtain the transfer function and transient and steady-state response to test signals such as step, ramp, and parabolic.
4. Understand the effect of damping factor on system response.
5. Inspect the time response specifications of systems by using root-locus.
6. Inspect the frequency response specifications of systems by using bode plot, Polar plot, Nyquist-plot techniques, and comment on the stability of system

List of Experiments. (Minimum Ten experiments required)

Sr. No	List of Experiments	Hrs.	LO
01	To plot the effect of time constant on first – order systems response.	02	LO1
02	To plot the frequency response of first-order system	02	LO2
03	To plot the time response of second – order systems.	02	LO4
04	To examine steady state errors for Type 0, 1, 2 systems	02	LO4
05	To study the block diagram reduction technique by using simulation software.	02	LO3
06	To interpret the effect of damping factor on the performance of second order system.	02	LO4
07	To inspect the relative stability of systems by Root-Locus using Simulation Software	02	LO5
08	To inspect the stability of systems by Bode plot using Simulation Software	02	LO5
09	To determine the frequency response specifications from Polar plot of system	02	LO6
10	To inspect the stability of systems by Nyquist plot using Simulation Software	02	LO6

Term Work:

Term work shall consist of minimum **Eight** experiments.

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

Laboratory work (Experiments) : 10 Marks

Laboratory work (programs / journal) : 10 Marks

Attendance (Practical) : 5 Marks

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

Vertical – 4

Vocational and Skill Enhancement Course (VSEC)

Detail Syllabus

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	TW/Pract.	Tut.	Total
VSE401	Virtual Instrumentation Laboratory	--	04	--	--	02	--	02

Course Code	Course Name	Examination Scheme						
		Theory Marks				Term Work	Practical / Oral	Total
		Internal assessment (IAT)			End Sem. Exam			
		IAT I	IAT-II	IAT-I + IAT-II (Total)				
VSE401	Virtual Instrumentation Laboratory	--	--	--	--	25	25	50

Lab Objectives:

To study graphical programming language for creating simulation and custom applications that interact with real-world data or signals in fields of science and engineering.

Lab Outcomes (LO):

Learners will be able to -

1. Design logical operations, using Graphical programming language
2. Develop customized virtual instruments and represent them in required format with user friendly graphical programming software for LOOPS like FOR LOOP, WHILE LOOP etc.
3. Plot the generated data and also able to export the data outside the programming environment
4. Select the data acquisition card or simulated software module and make user interface in the field of engineering.
5. Describe the concepts of different analysis tool.
6. Design and develop real world applications using graphical programming software.

DETAILED SYLLABUS

Module	Detailed Contents	Hrs.	CO Mapping
01	INTRODUCTION Virtual Instrumentation: Historical perspective, block diagram and Architecture of a virtual instrument, Conventional Instruments versus Virtual Instruments, data-flow techniques, graphical programming in data flow.		CO1
02	VI PROGRAMMING TECHNIQUES Data types, VIs and sub-VIs, Structures (For, While etc.) arrays, clusters, shift registers, case and sequence structures, formula nodes. Debugging techniques		CO2
03	PLOTTING AND EXPORT DATA Strings, File I/O, Plotting data: graphs and charts, report generation		CO3
04	DATA ACQUISITION Introduction to data acquisition on PC, Digital I/O, counters and timers, Software and Hardware installation, Calibration, Resolution, Data acquisition interface requirements, VISA programming.		CO4
05	MEASUREMENT ANALYSIS TOOLS Use of analysis tools for measurement of max, min, peak to peak voltage. Time period of signal, correlation methods. Design of oscilloscope, digital multimeter.		CO5
06	APPLICATIONS System development for a process. Development of Graphical User Interface (GUI). Implementation of various controllers (ON / OFF control, PID control) for a process. Simulation of a simple second order system.		CO6

List of Experiments. (Minimum Ten experiments required)

Sr. No	List of Experiments	Hrs	LO
01	To develop a VI to calculate speed, convert degree Celsius to Fahrenheit	02	LO1
02	To develop a Sub VI to implement Half adder and Full ADDER	02	LO2
03	To develop VI using FOR and WHILE loop to add 10 numbers, calculate Factorial of a given number	02	LO2
04	To create VI to find roots of quadratic equation, user defined unit conversions etc. using CASE structure	02	LO2
05	To develop a VI for storing all the points of simulated signal using File I/O s	02	LO3
06	Build a VI to plot circle in XY graph, generate and plot random numbers on chart, different colors in an intensity graph etc. with graph, chart properties	02	LO3
07	Measurement of AC/ DC voltage and current using DAQ cards.	02	LO4
08	Develop the VI, to ON /OFF the LED's using DAQ devices (Arduino, Raspberry Pi etc.)	02	LO4
09	Applications of Graphical Programming Software in process tank level / temperature control, alarm annunciator, batch process control etc	02	LO5
10	To create VI to simulate bottle filling plant using Sequence structure	02	LO5
11	Applications of Graphical Programming Software in control —simulate first and second order system response, effect of damping factor etc	02	LO6
12	To create VI to simulate traffic light control, stirred tank heater etc. using Sequence structure	02	LO6

References:

1. Jovitha Jerome, "Virtual Instrumentation", PHI, 2018.
2. Robert Bishop, "Learning with LabVIEW TM 7 express", Pearson Education, 2005.
3. Gupta S, "Virtual Instrumentation Using LabVIEW", Tata McGraw Hill Publishing Company Limited.
4. Lisa K. Wells & Jettrey Travis, "LabVIEW for everyone", Prentice Hall, New Jersey, 1997.
5. LabVIEW users manual – National Instruments.

Online References:

Sr. No.	Website Name
1.	https://www.ni.com/en.html?srsId=AfmBOoqA9YtGBXykbWCbIW84BumlfyBWllsghoAZhXM6DSfiJ4rTmS3L
2.	https://www.academia.edu/9455052/Virtual_Instruments_using_LabView_by_Jovitha_Jerome
3.	https://learn.ni.com/
4.	https://www.youtube.com/watch?v=hxPxuUhePdU
5.	https://www.slideshare.net/PrincyRandhawa/virtual-instrumentation-labview

Term Work:

General Instructions:

Term work shall consist of minimum **Eight** experiments.

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

Laboratory work (Experiments) : 10 Marks

Laboratory work (programs / journal) : 10 Marks

Attendance (Practical) : 5 Marks

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

AC –

Item No. –

As Per NEP 2020

University of Mumbai



Syllabus for HSSM Vertical 5

Faculty of Engineering

Board of Studies in Under Engineering

Second Year Programme in HSSM– Common to All Branches

Semester	III & IV	
Title of Paper (Lab)		Credits
I) Entrepreneurship Development	III	2
II) Environmental Science	III	2
III) Business Model Development	IV	2
IV) Design Thinking	IV	2
Total Credits		8
From the Academic Year		2025-26

Sem. – IV

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	Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		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	--
1	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-library/henryfordandinnovation.pdf?sfvrsn=0 The Tatas: How a Family Built a Business and a Nation by Girish Kuber, April 2019, Harper Business development	04	L1, L2

2	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	05	L2, L3, L4
3	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
4	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
5	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
6	Digital Business Management	Digital Business Management: Digital Business models (Subscription, Freemium <i>etc</i>), 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
3.	Entrepreneurship by Prof. C Bhaktavatsala Rao https://onlinecourses.nptel.ac.in/noc20_mg35/preview
4.	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	Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		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) 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	05	L1, L2
II	Empathy	Empathy: Foundation of empathy, Purpose of empathy, Observation for empathy, User observation technique, Creation of empathy map	05	L2, L3

		Self-learning Topics: Creation of empathy maps https://www.interaction-design.org/literature/topics/empathy-mapping		
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_gel7/preview
2	Introduction to Design Thinking by Dr. Rajeshwari Patil, Dr. Manisha Shukla, Dr.
3	Deepali Raheja, Dr. Mansi Kapoor https://onlinecourses.swayam2.ac.in/imb24_mg37/preview
4	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 08 to 10 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).

Term Work & Evaluation Scheme (Total 50 Marks):

Component	Marks
Performance in Experiments & Evaluation by Guide	15
Performance in mini project & Evaluation by Guide	10
Performance in mini project & Evaluation by Review Committee Evaluation	10
Logbook and Quality of Project Report	05
Research Paper	10