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)

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

परिपत्रक:-

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

मुंबई – ४०० ०३२
२७ मे, २०२५

(डॉ. प्रसाद कारंडे)
कुलसचिव

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2	The Deputy Registrar, Result unit, Vidyanagari drresults@exam.mu.ac.in
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
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19	Director, Department of Lifelong Learning and Extension (DLLE), dlleuniversityofmumbai@gmail.com

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To,

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AC – 20/5/2025

Item No. –6.74 (N)

As per NEP 2020

University of Mumbai

Syllabus for Major Vertical – 1, 4, 5 & 6		
Name of the Programme – B.E. (Instrumentation Engineering)		
Faulty of Engineering		
Board of Studies in Instrumentation Engineering		
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/-	Sd/-	Sd/-
Dr. B. N. Chaudhari BoS-Chairman- Instrumentation Engineering Faculty of Technology	Dr. Deven Shah Associate Dean Faculty of Science & Technology	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/-	**Sd/-**	**Sd/-**
Dr. B. N. Chaudhari	**Dr. Deven Shah**	**Prof. Shivram S. Garje**
BoS-Chairman- Instrumentation Engineering	**Associate Dean**	**Dean**
Faculty of Technology	**Faculty of Science & Technology**	**Faculty of Science & Technology**

Under Graduate Diploma in Instrumentation Engineering

Credit Structure (Sem. III & IV)

	R: 650 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: 650 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 III

Course Code	Course Description	Teaching Scheme (Contact Hours)			Credit Assigned			
		Theory	Practical	Tutorial	Theory	Tutorial	Practical	Total Credits
PC301	Mathematics III	2	--	1	2	1	--	3
PC302	Transducers and Sensors	3	–	--	3	--	--	3
PC303	Analog and Digital Electronics	3	--	--	3	--	--	3
PC304	Signals and Systems	2	--	--	2	--	--	2
OEC301	Open Elective	2#	--	--	2	--	--	2
PCL302	Transducers and Sensors Laboratory	--	2	–	--	--	1	1
PCL303	Analog and Digital Electronics Laboratory	--	2	–	--	--	1	1
PCL304	Signals and Systems Lab		2				1	1
CEP301	Mini Project (group project)	--	2*+2	–	--	--	2	2
HS301	Entrepreneurship Development	--	2*+2	---	--	--	2	2
VEC301	Environmental Science	--	2*+2	--	--	--	2	2
Total		**12**	**18**	**01**	**12**	**01**	**09**	**22**

* Two hours of practical class to be conducted for full class as demo/discussion.
Theory / Tutorial 1 credit for 1 hour and Practical 1 credit for 2 hours

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

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)					
PC301	Engineering Mathematics III	20	20	40	60	2	25	--	125
PC302	Transducers and Sensors	20	20	40	60	2	--	--	100
PC303	Analog and Digital Electronics	20	20	40	60	2	--	--	100
PC304	Signals and Systems	20	20	40	60	2	--	--	100
OEC301	Open Elective	20	20	40	60	2	--	--	100
PCL302	Transducers and Sensors Laboratory	--	--	--	--	--	25	25	50
PCL303	Analog and Digital Electronics Laboratory	--	--	--	--	--	25	25	50
PCL304	Signals and Systems Laboratory	--	--	--	--	--	25	25	50
CEP301	Mini Project (group project)	--	--	--	--	--	50	25	75
HS301	Entrepreneurship Development	--	--	--	--	--	50	--	50
VEC301	Environmental Science	--	--	--	--	--	50	--	50
Total		**100**	**100**	**200**	**300**	**10**	**250**	**100**	**850**

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. III

Detail Syllabus

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
PC301	Engineering Mathematics - III	2	-	1	2	-	1	3

		Theory					Term work	Pract /Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		Test1	Test2	Total					
PC301	Engineering Mathematics - III	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 Laplace Transform and Inverse Laplace Transform.
2. To familiarize with the concept of expanding periodic functions/signals in the form of Fourier Series.
3. To introduce the concept of Fourier Transform and its applications.
4. To familiarize with the concept of complex variables – differentiation.
5. To familiarize with the concept of Z-Transform for discrete function.
6. To introduce concepts and fundamentals of Matrix algebra for engineering problems.

Course Outcomes:

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

1. Understand Laplace Transform and Inverse Laplace Transform its application in solving ordinary differential equations.
2. Apply the Fourier series to expand the given periodic function/signal.
3. Apply Fourier Transform and its properties to transform the function/signal from one domain (time) to another domain (frequency).
4. Understand the concept of complex variables – differentiation.

5. Understand and apply Z-transform to discrete functions.
6. Apply the concepts of Eigen values and Eigen vectors in engineering problems.

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
1	**Laplace Transform**	Laplace Transform & Inverse Laplace Transforms of Standard Functions like e^{at}, sin(at), cos(at), sinh(at), cosh(at) and t^n, $where\ n \geq 0$ (without proof) First Shifting theorem, Laplace Transform of derivatives and integrals Properties (without proof) Inverse Laplace transform using First Shifting Theorem and Partial fractions method. **Self-Learning Topics:** Heaviside & Dirac Delta function, Applications of Laplace Transforms for Solutions to ODE.	**5**	**CO1**
2	**Fourier Series**	Fourier series for periodic function with period 2π and $2\,l$. Fourier series for even and odd functions. **Self-learning Topics :** Parseval's Identity, Half-range Cosine/sine Series, Complex form of Fourier Series $(-\infty,\infty)$(No deductions on the basis of Fourier Series), Fourier Integral.	**4**	**CO2**
3	**Fourier Transform**	Fourier transform, Fourier Transform of Heaviside Unit step Function and Dirac Delta Function. Linearity Property, Time shifting Property, Frequency Shifting Property, convolution and Modulation property, **Self-Learning Topics:** Standard Signals-Stop ,input, Delta, Exponential Signals	**5**	**CO3**
4	**Complex Variables – Differentiation.**	Functions of a complex variable, Analytic functions, Cauchy- Riemann equations in Cartesian co-ordinates, Harmonic functions, Harmonic conjugate, Milne Thomson methods to find f(z) for simple functions, Orthogonal trajectories. **Self-Learning Topics:** Conformal mapping, bilinear transformations, cross ratio, fixed points, bilinear transformation of straight lines and circles.	**4**	**CO4**

5	**Z-Transform**	Definition and Region of Convergence, Transform of Standard Function $\{a^k\}$, $\{sin\alpha k\}$, $\{cos\alpha k\}$, $\{sinh\alpha k\}$, $\{cosh\alpha k\}$. Properties of Z-Transform, Change of Scale, Shifting Property, Multiplication Property, and Convolution theorem. (without proof) Inverse Z transform: Partial Fraction Method. **Self-learning Topics:** Division by k property, Initial value theorem, Final value theorem, Inverse Using Convolution Theorem	**4**	**CO5**
6	**Linear Algebra: Theory of Matrices**	Characteristic Equation, Eigen values and Eigen vectors, and properties of Eigen values (without proof) Similarity of matrices, diagonalizable and non- diagonalizable matrices **Self-learning Topics**: Cayley-Hamilton Theorem and its usage in reduction of higher degree polynomials Derogatory and non-derogatory matrices, Function of a square Matrix	**4**	**CO6**

Note:

- **Tutorial shall be conducted batch wise.**
- **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, Wiley Eastern Limited.
3. Advanced Engineering Mathematics, R.K.Jain and S.R.K. Iyengar, Narosa publication
4. Signals and Systems, A Nagoor Kani, Tata McGraw Hill.
5. 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=2CP3m3EgL1Q
3.	https://www.youtube.com/watch?v=Hw8KHNgRaOE

Term Work:

General Instructions:

1. Batch wise 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 AssessmentII) 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 carrying15 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
PC302	Transducers and Sensors	03	02	--	03	01	--	04

Course Code	Course Name	Examination Scheme						
		Theory						
		Internal Assessment Test (IAT)			End Sem. Exam	Term Work	Pract./ Oral	Total
		IAT-I	IAT-II	IAT-I + IAT-II (Total)				
PC302	Transducers and Sensors	20	20	40	60	25	25 --	150

Course Objectives:

1. To introduce the students for the purpose of explaining the measurement systems, .
2. To understand the definition and classification of sensors and transducers based of their principle of operation and their applications in the various industries.
3. To familiarize the student with the identification, classification, construction,
4. working, principle and application of various transducers used for Flow, level, Temperature, Pressure measurement

Course Outcomes: Students will be able to…

1. Explain the measurement systems, sources errors of measurement.
2. Interpret and apply different temperature transducers/sensors for industrial applications
3. List and compare various Methods used for selection of Flow sensors.
4. Describe the working principles of various Level sensors and transducers.
5. Formulate and design the solutions for given applications using appropriate Pressure transducers.
6. Apply the techniques of advanced sensors measurement in different industries

DETAILED SYLLABUS

Module	Detailed Contents	Hrs.	CO Mapping
01	**Instrumentation System** Introduction, block diagram, functional elements of measurement system,Definition,workingprinciple,classification(active,passive,primary,secondary,mechanical,electrical,analog,digital),	02	CO1
02	Modes of heat transfer, laws of conduction, convection and radiation, Temperature scales, classification of Temperature Sensors, Overview of mechanical temperature Sensors (thermometer, thermostat). **Resistance temperature detector (RTD):** Principle, types, Configurations, construction and working of RTD, Material for RTD, Signal Measurement techniques for RTD, Comparative Response curves for RTD,2wire, 3wire and4wireRTD Element, Lead wire Compensation in RTD, self-heating effect, Specifications, advantages, disadvantages and applications of RTD and sums. **Thermistors**: Principle, types (NTC and PTC), characteristics, Construction and working of Thermistor, Materials, specifications of Thermistor, applications and sums. **Thermocouples:** Principle, thermoelectric effect, See beck effect, Peltier effect, laws of thermocouple, types of thermocouple with Characteristic curve, thermocouple table, Sensitivity, constructional Features of Thermocouples., Thermo couple specifications, electrical noise and noise reduction techniques, cold junction Compensation method, thermopile, thermocouple emf measurement method, Thermo well Material of construction and its specifications and sums. **Pyrometers:** Principle, Construction and working of Radiation and optical pyrometers and its Applications. Comparative study for Temperature Transducers.	08	CO2
03	**Flow measurement** Properties of fluid, types of fluid, dimensionless numbers, types of fluid flow, continuity equation, Bernoulli's equation, hydrostatic law, Pascal's law, flow through pipes – major and minor losses, flow measurement through open channel-weirs and notches. Materials used for flow sensors, performance of materials, corrosion resistors, erosion, effect of vapour pressure. **Head Type**: Orifice, Venturi, Nozzle, Pitot tube, Annular, characteristics of head type flow meters and its sums. **Variable Area Type** :Rotameter **Velocity and Inertia based flowmeters**: Turbine,Electromagnetic, Ultrasonic, Positive displacement, Anemometers,	10	CO3

	Mass flow measurement: Coriolis and Vortex flowmeter		
04	**Level Measurement** working principle, types, materials, design criterion: float, displacers, bubbler, Dipstick, Sight Glass and DP- cell, ultrasonic, capacitive, microwave, radar, radioactive type, laser type transducers, level gages, resistance, thermal, solid level detectors, fiber optic level detectors, Level switches. Comparative study for Level Transducers and Applications	**05**	**CO4**
05	**Pressure Measurement:** Pressure scales, units and relations, classification **Primary pressure sensors** - elastic elements like bourdon tube, diaphragm, bellows, properties and selection of elastic materials, Calibration using dead weight tester. **Electrical/Secondary Pressure Transducers**: Capacitive, piezo-electric and its material, variable reluctance, LVDT, strain gauge. **High Pressure Measurement**: Bulk modulus cell, Bridgeman type. **Differential pressure measurement**: Materials, construction and working of DP Cell. **Pressure measurement using manometer**: U-tube types, well type, inclined type, micro manometer and its sums. **Vacuum Measurement** Units and relations, McLeod gauge, Pirani gauge, thermocouple gauge, **Strain Measurement** Introduction, , gauge factor calculation, materials for strain gauge, resistance strain gauge bridges, temperature compensation and applications of strain gauges and its sums. .	08	**CO5**
06	**Advanced Sensors:** Smart sensors, MEMS Sensors, DHT Sensors, IR and PIR, Accelerometer and Gyroscope, Smoke Sensors, pH Sensor, Density and Viscosity	**06**	**CO6**

References:

1. B.C Nakra, K. K. Chaudhary, Instrumentation, MeasurementandAnalysis,TataMcGraw-HillEducation,01-Oct-2003-Electronicinstruments-632page.
2. Patranabis D, Sensors and Transducers, Prentice Hall India Learning Private Limited;2 edition(2003)-344pages.
3. A.K.Sawhney,PuneetSawhney,AcourseinElectricalandElectronicMeasurementandInstrumentation,DhanpatRaiandCo.Rai,1996-
4. Rangan, Mani, Sharma. InstrumentationsystemsandDevices,2nd Ed.,TataMcGrawHill.
5. D. V. S. Murthi,–Instrumentation and Measurement Principles‖, PHI, NewDelhi,Seconded.2003.
6. Doeblin E .D., Measurement system, Tata McGrawHill., 4thed,2003.

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
PC303	Analog and Digital Electronics	03	02	--	03	01	--	04

Course Code	Course Name	Examination Scheme						
		Theory						
		Internal Assessment Test (IAT)			End Sem. Exam	Term Work	Pract./ Oral	Total
		IAT-I	IAT-II	IAT-I + IAT-II (Total)				
PC303	Analog and Digital Electronics	20	20	40	60	--	--	100

Course Objectives:

1. To familiarize the student with basic electronic devices and circuits analog ang digital.
2. To analyze the DC biasing circuits. AC analysis of various electronic devices.
3. To introduce the students with basic construction and characteristics of FET, MOSFET and basic multistage amplifier.
4. To give knowledge about combinational circuits.
5. To describe working and design methods of sequential circuits.
6. To familiarize with the basics of asynchronous sequential circuits and design techniques.

Course Outcomes: Students will be able to…

1. Understand analog Electronics and Logic families of Digital Electronics. Conversions of binary to other number system
2. To formulate and attribute BJT biasing techniques, DC analysis and ac model of BJT AC Analysis
3. Apply the basic construction and characteristics of FET, MOSFET to analyze the DC and AC circuits. Discuss the power amplifiers
4. Analyze and design, digital combinational circuits using logic gates. To Formulate DeMorgans Law
5. Formulate and design sequential logic circuits.
6. Formulate and design asynchronous sequential logic circuits like counters. Study of Power supplies.

DETAILED SYLLABUS

Module	Detailed Contents	Hrs.	CO Mapping
01	**Introduction to Analog electronics and Digital Electronics** Introduction to Diodes, Bipolar Junction Transistor, Introduction to MOSFET, IGBT, Binary codes **Logic families:** Basics of digital integrated circuits, basic operational characteristics and parameters. TTL, Schottky clamped TTL, tri-state gate ECL, IIL, MOS devices CMOS. **Binary number system:** Binary Arithmetic, Binary codes: Weighted, BCD, 8421, ASCII, Conversion of Binary to Decimal, Octal to Decimal	03	CO1
02	**Bipolar Junction Transistor:** Bipolar Junction Transistor, Device structure and physical operation, characteristics, the BJT as an amplifier and a switch, DC Analysis of BJT Circuits, Biasing BJT Amplifier Circuits, Introduction to Stability. **BJT AC Analysis Introduction:** Amplification in AC domain, Introduction to BJT transistor r_e model, h Hybrid model for CE configuration, Single stage BJT amplifiers CE configuration (with and without feedback), Small Signal equivalent circuit, frequency response of a CE amplifier, Introduction to low frequency response, high frequency response.	06	CO2
03	**Field effect Transistors:** Introduction to JFET, Types, Construction, Operation, Static Characteristics, Pinch off voltage, FET Volt-Ampere characteristics, FET Configurations (CS/CD/CG) and their Comparison. Biasing of FET. FET as an amplifier and its analysis (CS) and its frequency response. **MOS Field effect Transistors:** Introduction to MOSFET as basic element in VLSI, Device structure and physical operation, current – voltage characteristics, the MOSFET as an amplifier and a switch, DC Analysis of MOSFET Circuits, Biasing MOSFET Amplifier Circuits, frequency response of a CS amplifier, low frequency response. **IGBT** **Power Amplifier:** Definition and amplifier types, Series fed class A amplifier, Transformer coupled class A amplifier, Class B amplifier operation and circuits, Amplifier distortion, Push Pull Amplifier	10	CO3

04	**Design of combinational logic circuits:** Adders, Subtractors, Parity checker, Magnitude comparators, BCD adder, Multiplexer, Demultiplexer, Encoder and Decoder. Implementation of combinational logic circuits using Multiplexer and Demultiplexer. Hazards in logic circuits and its elimination. **PWM,** Duty cycle, Data sheet study **Reduction methods:** Boolean laws, De-Morgan's Theorem, Minimization of Boolean expressions, Sum of Products (SOP), Product of Sums (POS), Karnaugh map Minimization, Don_t care conditions.	**09**	**CO4**
05	**Sequential logic circuits:** **Sequential logic circuits:** Flip flops- SR, D and Master slave JK, T, Realization of one flip flop using other flip flops	**05**	**CO5**
06	**Asynchronous & Synchronous counters** Asynchronous & Synchronous counters, Modulo n counter, shift registers. **Asynchronous sequential circuits:** Circuit Design – primitive state / flow table, Minimization of primitive state table, state assignment, Excitation table, Excitation map, cycles. **Power supply design** using 78xx series, 79xx series and adjustable voltage IC regulators like 723 and 317. Switched Mode Power Supply (SMPS) – Block diagram with advantages and disadvantages over conventional power supply.	06	**CO6**

References:

1. Robert L. Boylestad, Louis Nashelsky, *"Electronic Devices and Circuit Theory"*, PHI publishers, 2004
2. Thomas L. Floyd, "Electronic Devices", Pearson 2015.
3. M. Morris Mano, *"Digital Design"*, Prentice Hall of India, 2003.
4. John .M Yarbrough, *"Digital Logic Applications and Design"*, Thomson-Vikas publishing house, 2002.
5. Barry B. Brey, *"The Intel Microprocessors"*, Pearson/Prentice Hall, 2006.
6. Donald P. Leach and Albert Paul Malvino, *"Digital Principles and Applications"*, Tata McGraw Hill Publishing Company Limited, 2003.
7. R. P. Jain, *"Modern Digital Electronics"*, Tata McGraw–Hill publishing company limited, 2003.

Online References:

Sr. No.	Website Name
1.	https://books.google.co.in/books/about/Electronic_Devices_and_Circuit_Theory.html?id=32RJvfgkJgwC
2.	https://logicwork.in/pdf-download-modern-digital-electronics-by-rp-jain-book-pdf/
3.	https://recom-power.com/en/book-of-knowledge.html

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
PC304	Signals and Systems	02	02	--	02	01	--	03

Course Code	Course Name	Examination Scheme						
		Theory						
		Internal Assessment Test (IAT)			End Sem. Exam	Term Work	Pract./ Oral	Total
		IAT-I	IAT-II	IAT-I + IAT-II (Total)				
PC304	Signals and Systems	20	20	40	60	25	25 --	150

Course Objectives:

1. To learn fundamental characteristics of signals and systems.
2. To classify the signals and systems according to their property.
3. To acquire knowledge for the use of mathematical transforms and their applications.
4. Develop basic problem solving skills and become familiar with application area of signals and systems.

Course Outcomes: Students will be able to…

1. Describe the basic concept of signals and systems and their classification and operations on signals and plot the result.
2. Examine analysis of LTI systems using convolution and correlation.
3. Execute Fourier series analysis of periodic signals.
4. Demonstrate Fourier Transform and its applications.
5. Explain application of Laplace transform for analysis of CT signals and systems.
6. Demonstrate an ability to apply Z Transform for the analysis of DT signals and systems.

DETAILED SYLLABUS

Module	Detailed Contents	Hrs.	CO Mapping
01	**Introduction**:-Signals and Systems definition, Types of signals, continuous time and Discrete time signal operations, Amplitude scaling, Time shifting, Time reversal, Time scaling, Multiple transformation, Mathematical operations additions, subtraction, multiplication of signals, Classification of signals according to their property, Periodic/Aperiodic, Even/Odd, Energy/Power/Causal/Non causal, Deterministic/Random signals, Classification of systems according to their property, Linear/Nonlinear, Static /Dynamic, Time Invariant/Time variant, Causal/non causal, Stable/Unstable, Invertible/Non Invertible systems.	8	CO1
02	**Linear Time Invariant System**: -Characterizing CT LTI and DT LTI systems in terms of Impulse responses and Differential equations, Property of LTI systems, Convolution sum, Auto and Cross correlation of signals	4	CO2
03	**Fourier Series**: -Fourier series of CT and DT signals and their property ,Exponential and Trigonometric Fourier series of periodic signals, Amplitude and phase spectra of periodic signals.	4	CO3
04	**Fourier Transform Analysis of Signals**: -Fourier transform of CT and DT signals, Property of Fourier Transform, Magnitude and Phase calculation, Application of Fourier Transform.	4	CO4
05	**Application of Laplace Transform in Signal processing**: - Bilateral and Unilateral Laplace Transform of signals, Region of Convergence, Properties of Laplace Transform, Inverse Laplace Transform, Solution to differential equation, System transfer function and Response calculations, Poles and Zeros representation.	4	CO5
06	**Introduction to Z Transform**: -Z Transform definition, Region of convergence and it"s property, Bilateral and Unilateral Z Transform, Z Transform property, Relation between Laplace Transform, Fourier Transform and Z Transform, Inverse Z Transform by Inspection, Partial fraction and power series method, System function and Response calculations, Poles and Zeros representation, Concept of Causality and Stability, Frequency Response calculation by using Z Transform.	6	CO6

References:

1. Oppenheim, Willsky, S.Hamid Nawab, "Signals and Systems" PHI,2nd edition, 2002.
2. M.J. Roberts, "Signals and Systems" McGraw-Hill, 1st edition,2003.
3. B.P Lathi, "Principles of linear systems and signals" Oxford,2nd edition,2009.
4. Narayan ayer ,"Signals and systems" CENGAGE learning 1st edition 2011.
5. V. Krishnaveni, A. Rajeswari, "Signals and Systems", 1st editionWiley India,2012.
6. J.B. Gurung, "Signals and Systems", PHI,1st edition,2009
7. A Anandkumar, "Signals and Systems", PHI,3rd edition, 2013.
8. Rameshbabu, "Signals and Systems", SCITECH, 4thedition,2011.
9. Hwei P. Hsu, "Schaum's Outline of Signals and Systems", McGraw-Hill,2014.
10. Simon Haykin, "Signals and Systems", Wiley, 2ndedition,2003.
11. Rodger E. Ziemer, "Signals and Systems", Pearson, 4th edition, 1998

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
PCL302	Transducers and Sensors Lab	--	1	–	--	1	–	1

Course Code	Course Name	Examination Scheme						
		Theory Marks						
		Internal assessment (IAT)			End Sem. Exam	Term Work	Practical / Oral	Total
		IAT I	IAT- II	IAT-I + IAT-II (Total)				
PCL302	Transducers and Sensors Lab	--	--	--	--	25	25	50

Lab Objectives:

1. To introduce the students for the purpose of explaining the measurement systems, .
2. To understand the definition and classification of sensors and transducers based of their principle of operation and their applications in the various industries.
3. To familiarize the student with the identification, classification, construction,
4. Working, principle and application of various transducers used for Flow, level, Temperature, Pressure Measurement

Lab Outcomes (LO):

Learners will be able to..

1. Explain the measurement systems, sources errors of measurement.
2. Interpret and apply different temperature transducers/sensors for industrial applications
3. List and compare various Methods used for selection of Flow sensors.
4. Describe the working principles of various Level sensors and transducers.
5. Formulate and design the solutions for given applications using appropriate Pressure transducers.
6. Apply the techniques of advanced sensors measurement in different industries

List of Experiments. (Minimum Ten experiments required)

Sr. No	List of Experiments	Hrs	LO
01	Demonstrate the basic measurements techniques and Measuring Instruments.	**02**	**L1**
02	Plot response curve for Flapper Nozzle system and validate the results withstand values.	**02**	**L2**
03	Plot and validate the characteristics of RTD/thermistor/thermocouple	**02**	**L2**
04	Perform and validate Liquid Level Measurement using DP Cell	**02**	**L1**
05	Plot and validate performance characteristics of capacitive level sensor	**02**	**L2**
06	Study measurement of pressure using bellows, diaphragm, bourdon tube, manometer	**02**	**L1**
07	Test and calibration of pressure gauges using dead weight tester.	**02**	**L2**
08	Measurement of flow using orifice/venturi tube/nozzle/pitot tube.	**02**	**L1**
09	Measurement of flow using rotameter	**02**	**L2**
10	Study and characterization of pH meter	**02**	**L1**

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.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	TW/Pract.	Tut	Total
PC303	Analog and Digital Electronics	03	02	--	03	01	--	04

Course Code	Course Name	Examination Scheme						
		Theory						
		Internal Assessment Test (IAT)			End Sem. Exam	Term Work	Pract./ Oral	Total
		IAT-I	IAT-II	IAT-I + IAT-II (Total)				
PC303	Analog and Digital Electronics	20	20	40	60	--	--	100

Lab Objectives:

1. To familiarize the student with assembling circuits using basic electronic devices.
2. To demonstrate operation of bipolar and MOS transistors.
3. Demonstrate DC biasing circuits, Transistors as switching device,

Lab Outcomes (LO):

Learners will be able to

1. Demonstrate operation of basic electronic devices such as BJT .
2. Assemble and demonstrate electronic circuits using JFET
3. Design various circuits using Amplifiers
4. Design Universal GATE using BASIC GATEs and Demonstrate Multiplexer
5. Demonstrate the Truth Table for FLIP FLOP
6. Study and Demonstrate counters AND Design a power supply

List of Experiments. (Minimum Ten experiments required)

Sr. No	List of Experiments	Hrs	LO
01	Study of input / output characteristics of BJT- CB, CE, and CC Configuration. Demonstrate CE Characteristics	**02**	**LO1**
02	Study and perform input and transfer characteristics of FET.	**02**	**LO2**
03	Design and analysis of biasing circuit and observing performance of BJT as an amplifier at various operating points.	**02**	**LO3**
04	Build universal gates Using Basic gates	**02**	**LO4**
05	Study and perform Mux operation	**02**	**LO4**
06	Perform and verify SR Flipflop	**02**	**LO5**
07	Build MOD 10 UP Counter	**02**	**LO6**
08	Design Power supply to give +5V using IC 7805	**02**	**LO6**
09	Study of DeMorgan's Theorem	**02**	**LO5**
10	Read a Data sheet of digital IC and Find Power consideration	**02**	**LO6**

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.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
PCL304	Signals and Systems Lab	--	1	–	--	1	–	1

Course Code	Course Name	Examination Scheme						
		Theory Marks						
		Internal assessment (IAT)			End Sem. Exam	Term Work	Practical / Oral	Total
		IAT I	IAT-II	IAT-I + IAT-II (Total)				
PCL304	Signals and Systems Lab	--	--	--	--	25	25	50

Lab Objectives:

1. Study simulation software platform for signal processing and Plot different type. of signals.
2. To understand the concept of linear, circular convolution, correlation and simulate it by computer software.
3. To understand Fourier series in trignomatric and exponential co-efficient.
4. To understand Fourier transform and its algorithms and simulate it.
5. To understand laplace transform and its applications.
6. To understand Z-transform and their applications.

Lab Outcomes (LO):

Learners will be able to..

1. Verify basic signals in CT and DT using simulation software.
2. Demonstrate convolution and correlation concept using simulation software.
3. Perform Fourier series of a periodic signals.
4. Perform Fourier transform of aperiodic signals using simulation software platform.
5. Study laplace transform and their applications.
6. Study Z-transform and their applications.

List of Experiments. (Minimum Ten experiments required)

Sr. No	List of Experiments	Hrs	LO
01	Generate and plot the basic signals in time domain and also sketch its amplitude and phase spectrum.	**02**	**CO1**
02	Write the codes to plot the following signals also simulate the signals: (a) sin(200□t) (b) sin(200□t □$\pi/6$) (c) sin(200□t □□$\pi/6$) (d) cos(200□t) (e) cos(200□t □ $\pi/4$) (f) cos(200□t □$\pi/6$)	**02**	**CO1**
03	Develop codes to simulate, and plot the results for an exponential signal: $x(t)$ ┐ $k\,e^{\sqcup at}u(t)$ for the cases: (a) k □ 1, and a □ 0.35 (b) k □ 1.2 and a □ □0.45	**02**	**CO1**
04	Write a program for finding linear convolution by using MATLAB.	**02**	**CO2**
05	Write a program for finding Circular convolution by using MATLAB.	**02**	**CO2**
06	Write a program for finding cross correlation by using MATLAB.	**02**	**CO2**
07	Write a program for finding auto correlation by using MATLAB	**02**	**CO2**
08	The music signal has frequency components in the audio frequency range 20 Hz to 20000 Hz of the electromagnetic spectrum	**02**	**CO3**
09	Take any one periodic signal and find its Fourier series coefficients using exponential or trigonometric FS method. Write a program to find its Fourier series coefficients.	**02**	**CO3**
10	Write a program to find frequency response. Plot magnitude and phase response for different transfer functions using MATLAB.	**02**	**CO4**
11	Write a assignment on Laplace transform.	**02**	**CO5**
12	Write a assignment on Z-transform.	**02**	**CO6**

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.

Vertical – 1
Major
Sem. IV

Detail Syllabus

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

		Theory					Term work	Pract /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.	Nameof Module	DetailedContent	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. Jainand S.R.K. Iyengar, Narosa publication
4. Signals and Systems, A Nagoor 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=2CP3m3EgL1Q
3.	https://www.youtube.com/watch?v=Hw8KHNgRaOE

Term Work:

General Instructions:

1. Batchwisetutorialsaretobeconducted.Thenumberofstudentsperbatchshouldbeasper 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 AssessmentII)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						
		Internal Assessment Test (IAT)			End Sem. Exam	Term Work	Pract./ Oral	Total
		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 likeHydraulic, 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, differenttypes, 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 Control‖, ISA, 1992.
5. Bela G. Liptak, -Instrument Engineer's Hand Book – Process Control‖, Chilton Company, 3rd Edition, 1995.
6. Andrew Williams, -Applied instrumentation in the process industries‖, 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						
		Internal Assessment Test (IAT)			End Sem. Exam	Term Work	Pract./ Oral	Total
		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 cutest 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. Shyammohan 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						
		Internal Assessment Test (IAT)			End Sem. Exam	Term Work	Pract./ Oral	Total
		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 HallInternational, 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, 1stEdition, 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

Course Code	Course Name	Examination Scheme						
		Theory						
		Internal Assessment Test (IAT)			End Sem. Exam	Term Work	Pract./ Oral	Total
		IAT-I	IAT-II	IAT-I + IAT-II (Total)				
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 (dissolves oxygen),BOD (biological oxygen demand), COD (chemical oxygen demand), TOC (total organic carbon), Cox (carbon dioxides), NOx (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
PCL303	Analog and Digital Electronics Lab	--	1	–	--	1	–	1

Course Code	Course Name	Examination Scheme						
		Theory Marks						
		Internal assessment (IAT)			End Sem. Exam	Term Work	Practical / Oral	Total
		IAT I	IAT-II	IAT-I + IAT-II (Total)				
PCL303	Analog and Digital Electronics Lab	--	--	--	--	25	25	50

Lab Objectives:

1. To familiarize the student with assembling circuits using basic electronic devices.
2. To demonstrate operation of bipolar and MOS transistors.
3. Demonstrate DC biasing circuits, Transistors as switching device,

Lab Outcomes (LO):

Learners will be able to

1. Demonstrate operation of basic electronic devices such as BJT .
2. Assemble and demonstrate electronic circuits using JFET
3. Design various circuits using Amplifiers
4. Design Universal GATE using BASIC GATEs and Demonstrate Multiplexer
5. Demonstrate the Truth Table for FLIP FLOP
6. Study and Demonstrate counters AND Design a power supply

List of Experiments. (Minimum Ten experiments required)

Sr. No	List of Experiments	Hrs.	LO
01	Study of input / output characteristics of BJT- CB, CE, and CC Configuration. Demonstrate CE Characteristics	02	LO1
02	Study and perform input and transfer characteristics of FET.	02	LO2
03	Design and analysis of biasing circuit and observing performance of BJT as an amplifier at various operating points.	02	LO3
04	Build universal gates Using Basic gates	02	LO4
05	Study and perform Mux operation	02	LO4
06	Perform and verify SR Flipflop	02	LO5
07	Build MOD 10 UP Counter	02	LO6
08	Design Power supply to give +5V using IC 7805	02	LO6
09	Study of DeMorgan's Theorem	02	LO5
10	Read a Data sheet of digital IC and Find Power consideration	02	LO6

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.

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						
		Internal assessment (IAT)			End Sem. Exam	Term Work	Practical/ Oral	Total
		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.	Tut.	Theory	Pract.	Tut.	Total
MDL401	Feedback Control System Lab	--	1	–	--	1	–	1

Course Code	Course Name	Examination Scheme						
		Theory Marks 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 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 theprogramming environment
4. Select the data acquisition card or simulated software module and makeuser interface in the field of engineering.
5. Describe the concepts of different analysis tool.
6. Design and develop real world applications using graphical programmingsoftware.

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	**PLOTING 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 Factorialof 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?srsltid=AfmBOoqA9YtGBXykbWCbIW84BumlFyBWIlsqhoAZhXM6DSfiJ4rTmS3L
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. - III

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

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

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

Lab Objectives:

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

Lab Outcomes:

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

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

DETAILED SYLLABUS

Sr. No.	Module	Detailed Content	Hours	LO Mapping
0	**Prerequisite**	Fundamentals of communication and leadership skills.	01	--
I	**Introduction to Entrepreneurship**	Definition, Characteristics, and Types of Entrepreneurs. Entrepreneurial Motivation and Traits. Start-up Ecosystem in India. Challenges in Entrepreneurship	**02**	**LO1**
II	**Business Idea Generation &**	Ideation Techniques: Design Thinking, Brainstorming, Mind	**04**	**LO2**

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

Text Books:

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

References:

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

Online Resources:

Website Name
1. Startup India Portal – https://www.startupindia.gov.in 2. MIT OpenCourseWare – Entrepreneurship – https://ocw.mit.edu/courses/sloan- school-of-management/ 3. Coursera – Entrepreneurship Specialization – https://www.coursera.org/specializations/entrepreneurship

4. Harvard Business Review – Entrepreneurship Articles – https://hbr.org/topic/entrepreneurship
5. Udemy – Startup & Business Courses –

List of Experiments.

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

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

List of Open-Source Software

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

Assessment :

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

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

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

		Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		IAT-I	IAT-II	IAT-I+IAT-II					
2993512	Environmental Science	--	--	--	--	--	50	--	50

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

Rationale:

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

Lab Objectives:

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

Lab Outcomes:

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

DETAILED SYLLABUS:

Unit Name	Topic Name	Topic Description	Hours	LO Mapping
I	**The Multidisciplinary Nature of Environmental Studies**	Definition, scope and importance. Need for public awareness, Role of information technology in environment and human health. Human population and the environment: Population growth, variation among nations. Population Explosion- family welfare program. Environment and human health Women and child welfare	**03**	LO1
II	**Natural Resources**	Renewable and non-renewable resources. Natural resources & associated problems: a) Forest resources: b) Water resources: Natural resources & associated problems c) Mineral resources: d) Food resources: e) Energy resources: Role of an individual in conservation of natural resources: f) Equitable use of resources for sustainable lifestyles.	**04**	LO2
III	**Ecosystems**	Concepts of an ecosystem. Introduction, types, characteristic features, structure and function of the following ecosystem: a. Forest ecosystem b. Grassland ecosystem c. Desert ecosystem d. Aquatic ecosystem (ponds, streams, lakes, rivers, oceans, estuaries). Case study on various ecosystems in India.	**05**	LO3
IV	**Biodiversity and its Conservation**	Introduction-Definition: genetic species and ecosystem diversity. Bio-geographical classification of India Value of biodiversity : Consumptive use, productive use, social, ethical, aesthetic and option values, Bio-diversity at global, national, local levels India as a mega diversity nation Case study on Bio diversity in India.	**05**	LO4
V	**Environmental Pollution Definition**	Causes, effects and control measures of: a) Air pollution b) Water pollution c) Soil pollution. Solid waste management: Causes, effect and control measures of urban and industrial wastes. Role of an individual in prevention of pollution, Case study on Pollution Disaster management: floods, earthquake, cyclone and landslides. Carbon Credits for pollution prevention	**05**	LO5

VI	**Social Issues and Environment**	From unsustainable to sustainable development Urban problems related to energy, Water conservation, rain water harvesting, watershed management. Environmental ethics: issues and possible solution. Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust. Case studies. Consumerism and waste products. Environment protection act. Public awareness Case study on Environmental Ethics	**04**	LO6

Textbooks

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

Reference Books

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

Online References:

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

List of Experiments.

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

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

Assessment :

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

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

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 *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
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_ge17/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: *Says, Thinks, Feels, and Does*. Interview users or research their experiences to fill in the map.	3
02	Based on research, students will create user personas including demographic details, motivations, pain points, and goals. Each group will present their persona to the class.	3
03	Consider 3 examples of real-life products which have good design and bad design. Write down reasons why do you think they are good or bad designs. May take user survey to support your work.	3
04	Study any open-source design thinking tool and write a brief report about it.	3

Assessment:

Term Work: Term Work shall consist of 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).

Vertical – 6

Experiential Learning Courses

(CEP)

Detailed Syllabus

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	TW/Pract.	Tut.	Total
CEP301	Mini Project (group project)	--	02*+2	--	--	02	--	02

Course Code	Course Name	Examination Scheme						
		Theory						
		Internal Assessment Test (IAT)			End Sem. Exam	Term Work	Pract./ Oral	Total
		IAT-I	IAT-II	IAT-I + IAT-II (Total)				
CEP301	Mini Project (group project)	--	--	--	--	50	25 --	75

* 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 Objectives:

The course is aimed

1. To acquaint with the process of identifying the needs and converting it into the problem.
2. To familiarize the process of solving the problem in a group.
3. To acquaint with the process of applying basic engineering fundamentals to attempt solutions to the problems.
4. To inculcate the process of self-learning and research

Course Outcomes: Students will be able to…

1. Identify problems based on societal /research needs.
2. Apply Knowledge and skill to solve societal problems in a group.
3. Develop interpersonal skills to work as member of a group or leader.
4. Draw the proper inferences from available results through theoretical /experimental /simulations.
5. Analyze the impact of solutions in societal and environmental context for sustainable development.
6. Use standard norms of engineering practices
7. Excel in written and oral communication.
8. Demonstrate capabilities of self-learning in a group, which leads to lifelong learning.
9. Demonstrate project management principles during project work.

Guidelines for Mini Project

- Students shall form a group of 3 to 4 students, while forming a group shall not be allowed less than three or more than four students, as it is a group activity.
- Students should do survey and identify needs, which shall be converted into problem statement for mini project in consultation with faculty supervisor/head of department/internal committee of faculties.
- Students hall submit implementation plan in the form of Gantt/PERT/CPM chart, which will cover weekly activity of mini project.
- A log book to be prepared by each group, wherein group can record weekly work progress, guide/supervisor can verify and record notes/comments.
- Faculty supervisor may give inputs to students during mini project activity; however, focus shall be on self-learning.
- Students in a group shall understand problem effectively, propose multiple solution and select best possible solution in consultation with guide/ supervisor.
- Students shall convert the best solution into working model using various components of their domain areas and demonstrate.
- The solution to be validated with proper justification and report to be compiled in standard format of University of Mumbai.
- With the focus on the self-learning, innovation, addressing societal problems and entrepreneurship quality development within the students through the Mini Projects, it is preferable that a single project of appropriate level and quality to be carried out in two semesters by all the groups of the students. i.e. Mini Project 1 in semester III and IV. Similarly, Mini Project 2 in semesters V and VI.
- However, based on the individual students or group capability, with the mentor's recommendations, if the proposed Mini Project adhering to the qualitative aspects mentioned above gets completed in odd semester, then that group can be allowed to work on the extension of the Mini Project with suitable improvements/modifications or a completely new project idea in even semester. This policy can be adopted on case by case basis.

Guidelines for Assessment of Mini Project Practical/Oral Examination:

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

Mini Project shall be assessed based on following points;

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

Project Topic Selection and Approval:

1. A mini-project group shall consist of a minimum of THREE (03)
2. Project topic selection and approval should be done by a panel of two expert faculty members from the department.
3. Each group must maintain a logbook to record weekly work progress in terms of milestones. The guiding faculty should provide remarks/comments weekly. Both students and faculty must sign the logbook every week.

Project Report Format:

1. The mini-project report should include the following sections:
    - Abstract (maximum 1 page summarizing the complete report)
    - Introduction (justification for project selection, applications, and existing commercial products)
    - Implementation (proposed specifications, block diagram/circuit diagram, working principle/operation)
    - Results & Discussion (photographs, video links, recorded results such as waveforms/observations/demonstrations)
    - Conclusion and Learning Outcomes
    - References
    - Participation in Mini-project competition/Technical Paper Presentation (TPP), etc.
2. The report should not exceed 10 pages. Reports should be stapled to avoid the use of plastic.

Term Work & Practical/Oral Examination Evaluation:

1. Minimum six (06) experiments based on Modules 1, 2, 3, and 4 should be performed.
2. One mini project must be implemented.
3. It is not compulsory to select a project from the given sample list; students are encouraged to propose innovative ideas.
4. Students must deliver a presentation and demonstrate their mini project during the Practical and Oral Examination (25 Marks Evaluation).
5. Project reports must be checked for plagiarism using software such as Turnitin or any equivalent tool.
6. Evaluation should consider each student's individual contribution, understanding, and knowledge gained during the project execution. Marks should be awarded accordingly.

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