

University of Mumbai

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

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

क्र.वि.प्रा.स.से./आयसीडी/२०२५-२६/३७

दिनांक : २७ मे, २०२५

परिपत्रक:-

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

मुंबई - ४०० ०३२
२७ मे, २०२५


(डॉ. प्रसाद कारंडे)
कुलसचिव

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As Per NEP 2020

University of Mumbai



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

Name of the Programme – <u>B.E. (Automation and Robotics)</u>		
Faculty of <u>Engineering</u>		
Board of Studies in <u>Mechanical Engineering</u>		
U.G. Second Year Programme	Exit Degree	U.G. Diploma in <u>Engineering- Automation and Robotics</u>
Semester	IV	
From the Academic Year	2025-26	



University of Mumbai (As per NEP 2020)

Sr. No.	Heading	Particulars
1	Title of program O: _____	B.E. (<u>Automation and Robotics</u>)
2	Exit Degree	U.G. Diploma in <u>Engineering- Automation and Robotics.</u>
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-665C R. TEU-665D	Attached herewith
6	Semesters	Sem. IV
7	Program Academic Level	5.00
8	Pattern	Semester
9	Status	New
10	To be implemented from Academic Year	2025-26

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BoS-Chairman-Mechanical Engg
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Prof. Shivram S. Garje
Dean
Faculty of Science & Technology

Preamble

To meet the challenge of ensuring excellence and NEP 2020 policy in engineering education, the issue of quality needs to be addressed, debated, and taken forward systematically. Accreditation is the principal means of quality assurance in higher education. The major emphasis of the accreditation process is to measure the outcomes of the program that is being accredited. In line with this Faculty of Science and Technology (in particular Engineering) of the University of Mumbai has taken the lead in incorporating the philosophy of NEP 2020 education in the process of curriculum development.

The second-year engineering course is a core training program to impart scientific and logical thinking training to learners in general, with a choice of course selection from the program core course, multidisciplinary minor, and vocational skill-enhanced course. Simultaneously, the objectives of NEP 2020 demand nurturing the core program and skills required for the Information Technology Branch of engineering in the learner. Keeping this in view, a pool of courses is offered in Core Courses covering fundamentals required to understand core and modern engineering practices and emerging trends in technology. Considering the shift in pedagogy and the convenience of a stress-free learning process, a choice-based subject pool is offered in the coursework under the heads of Information Technology in 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.

Program Core Course Cover Information Technology 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 2054-26. 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
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Dean
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Under Graduate Diploma in Engineering- Automation and Robotics.

Credit Structure (Sem. III & IV)

	R. TEU-665C									
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	2033111 2033112 2033113 2033114 2033115 2033116	--	--	OE:2	--	VEC:2 HSL: 2	CEP:2	22	UG Diploma45
	R. TEU-665D									
	IV	2034111 2034112 2034113 2034114 2034115 2034116	--	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 4credits 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.

**Automation
and Robotics
Scheme**

Program Structure for Second Year of Automation and Robotics

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
2034111	Finite Element Analysis	3	--	--	3	--	--	3
2034112	Embedded System	3	--	--	3	--	--	3
2034113	Modern Control Systems -	3	--	--	3	--	--	3
203	Multidisciplinary minor	3	--	--	3	--	--	3
203	To be taken from the bucket provided by the University from other Faculty	2	--	--	2	--	--	2
2034114	Embedded System Lab	--	2	--	--	--	1	1
2034115	Modern Control Systems - Lab	--	2	--	--	--	1	1
203	Multidisciplinary minor	--	2	--	--	--	1	1
2034411	CNC Programming Lab	--	4	--	--	--	2	2
2994511	Business Model Development (Syllabus common to all Branches).	--	2*+2	--	--	--	2	2
2994512	Design Thinking (Syllabus common to all Branches).	--	2*+2	--	--	--	2	2
Total		14	18	--	14	--	09	23

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

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

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

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

Course Code	Course Description	Examination scheme							
		Internal Assessment Test (IAT)			End Sem. Exam Marks	End Sem. Exam Duration (Hrs)	Term Work (Tw)	Oral & Pract.	Total
		IAT-I	IAT-II	Total (IAT-I) + IAT-II)					
2034111	Finite Element Analysis	20	20	40	60	2	25	--	125
2034112	Embedded System	20	20	40	60	2	--	--	100
2034113	Modern Control Systems	20	20	40	60	2	--	--	100
203	Multidisciplinary minor	20	20	40	60	2	--	--	100
203	To be taken from the bucket provided by the University from other Faculty	20	20	40	60	2	--	--	100
2034114	Embedded System Lab	--	--	--	--	--	25	25	50
2034115	Modern Control Systems Lab	--	--	--	--	--	25	25	50
203	Multidisciplinary minor	--	--	--	--	--	25	--	25
2034411	CNC Programming Lab	--	--	--	--	--	50	25	75
2994511	Business Model Development (Syllabus common to all Branches).	--	--	--	--	--	50	--	50
2994512	Design Thinking (Syllabus common to all Branches).	--	--	--	--	--	50	--	50
Total		100	100	200	300	10	250	75	825

Vertical –1 Major

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2034111	Finite Element Analysis	3	-	-	3	-	-	3

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Total					
2034111	Finite Element Analysis	20	20	40	60	2	--	--	100

Rationale:

Finite Element Analysis (FEA) is a numerical method used to predict how a product or structure will behave under various conditions, such as stress, strain, and thermal effects, without needing physical prototypes.

Course Objectives:

1. To study the concept of FEM and various methods in it
2. To understand the knowledge of application of Matrix Algebra & Gaussian Elimination.
3. To study the finite element modeling approaches and understands the concept of boundary conditions.
4. To study 2D problems for Constant strain triangle, temperature effects, problem modeling and boundary conditions.
5. To study the concept of heat transfer and fluid flow.
6. It provides a bridge between hand calculations based on mechanics of materials and machine design and numerical solutions for more complex geometries and loading states

Course Outcomes: Learners will be able -

1. Apply the knowledge of principal of FEA, its types, governing equation, fundamental concept of solid mechanics.
2. Remember the mathematical understanding required for FEA and finite difference techniques.
3. Understand the knowledge of application of FEA such as related to stress on beams, three dimensional frames, and heat transfer.
4. Apply the knowledge of FEA in project work
5. Derive and use 1-D and 2-D element stiffness matrices and load vectors from various methods to solve for displacements and stresses.
6. Apply mechanics of materials and machine design topics to provide preliminary results used for testing the reasonableness of finite element results.

Prerequisites:

Knowledge of:

- Differential equations (Formulation and solution, Types-Ordinary, Partial, Order and degree of the DE and the boundary conditions)
- Matrix algebra (Matrix operations, gauss elimination method to get the inverse of matrix)
- Basics of the core field (Governing laws, relationship between the various variables and constants—like in structural field stress-strain, Thermal field-temp, heat transfer rate etc.

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
0	Prerequisite	Differential Equations, Matrix Algebra, Basics of strength of materials and heat transfer.	---	---
I	Introduction :	Brief History of FEM, Finite Element Terminology (nodes, elements, domain, continuum, Degrees of freedom, loads & constraints). Application, Advantages, Steps of FEM, Stress and Equilibrium, Boundary conditions, Strain Displacement Relations, Stress-strain Relations, Von mises stress, Temperature effect, Potential Energy & Equilibrium, Galerkin's Method, stiffness (Displacement) Method.	07	CO1

		Home Exercise 1: Introduction to Ansys Tools(Pre-Processing, Processing and Post-Processing)		
II	Matrix Algebra & Gaussian Elimination:	Matrix Multiplication, Transposition, Diagonal Matrix, Symmetric Matrix, Upper Triangular Matrix, Determinant of Matrix, Matrix Inversion Eigen values & Eigen vectors, Gaussian elimination. Home Exercise 2: Finite Element Analysis (element selection, assigning properties, meshing, assigning loads, and boundary conditions, analysis and result interpretation).	06	CO2
III	1D ELEMENT:	Types of 1D element: Displacement function, Global and local coordinate systems, Order of element, primary and secondary variables, shape functions and its properties. Formulation of elemental stiffness matrix and load vector for spring, bar, beam, truss and Plane frame. Transformation matrix for truss and plane frame, Assembly of global stiffness matrix and load vector, Properties of stiffness matrix, half bandwidth, Boundary conditions elimination method and penalty approach, Symmetric boundary conditions, Stress calculations. Home Exercise 3:Any two problems using bar element	07	CO3
IV	1D Steady State Heat Transfer Problems :	Introduction, Governing differential equation, steady-state heat transfer formulation of 1D element for conduction and convection problem, boundary conditions and solving for temperature distribution. Home Exercise 4:Any one problem on steady state heat conduction	06	CO4
V	Dynamic Analysis:	Types of dynamic analysis, General dynamic equation of motion, point and distributed mass, lumped and Consistent mass, Mass matrices formulation of bar and beam element. Undamped-free	06	CO5

		vibration- Eigen value problem, Evaluation of eigen values and eigenvectors (natural frequencies and mode shapes). Home Exercise 5: Any one problem of free vibration analysis using bar element		
VI	2D ELEMENTS:	Second Order 2D Equations involving Scalar Variable Functions — Variation formulation –Finite Element formulation — Triangular elements — Shape functions and element matrices and vectors. Application to Field Problems —Torsion of Non circular shafts –Quadrilateral elements. Stress analysis of CST. Home Exercise 6: Any two problems using CST element	07	CO6

Text Books:

1. Introduction to Finite Element Engineering – T.R.Chandrupatla, Belegunda; PHI
2. A First course in Finite Element Method- Darya Logon, Thompson Learning (TL Publisher)
3. Concepts and Applications of Finite Element Analysis, R. D. Cook, et al. Wiley, India

References:

1. Seshu P., —Text book of Finite Element Analysis, PHI Learning Private Ltd. New Delhi, 2010.
2. Bathe K. J., —Finite Element Procedures, Prentice-Hall of India (P) Ltd., New Delhi.
3. Fagan M. J., —Finite Element Analysis, Theory and Practice, Pearson Education Limited.
4. Kwon Y. W., Bang H., —Finite Element Method using MATLAB, CRC Press, 1997
5. S. Moaveni, —Finite element analysis, theory and application with Ansys,
6. Fundamental of Finite Element Analysis, David V. Hutton, Tata McGraw-Hill
7. The Finite Element Method in Engineering- S.S.Rao, Elsevier Pub.
8. An Introduction to Finite Element Method-J.N.Reddy, Tata McGraw-Hill

Online References:

Sr. No.	Website Name (NPTEL/SWAYAM Courses)
1.	https://nptel.ac.in/courses/112/104/112104193/
2.	https://nptel.ac.in/courses/105/106/105106051/
3.	https://nptel.ac.in/courses/112/104/112104115/
4.	https://nptel.ac.in/courses/112/103/112103295/
5.	https://nptel.ac.in/courses/112/106/112106135/
6.	https://nptel.ac.in/courses/112/106/112106130/
7.	https://nptel.ac.in/courses/105/105/105105041/
8.	https://nptel.ac.in/courses/112/104/112104116/

Assessment:

Internal Assessment (IA) for 20 marks:

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

Question paper format

- Question Paper will comprise of a total of **six questions each carrying 20 marks**. Q.1 will be **compulsory** and should **cover maximum contents of the syllabus**
- Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
- A total of **Three questions** need to be answered

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2034112	Embedded System	3	-	-	3	-	-	3

		Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Total					
2034112	Embedded System	20	20	40	60	2	--	--	100

Rationale:

The study of embedded systems equips engineers with the skills and knowledge necessary to design and develop intelligent, connected devices that are transforming our world.

Course Objectives: Six Course Objectives

1. **To understand** the fundamental concepts of embedded systems, including their characteristics, applications, and the distinction from general-purpose computing.
2. **To describe** the architecture and features of the 8051 microcontroller, and **compare** it with microprocessors. (Bloom's Taxonomy: Understand, Analyze)
3. **To apply** the 8051 instruction set and addressing modes to **develop** assembly language programs for basic arithmetic operations. (Bloom's Taxonomy: Apply, Create)
4. **To design** and **implement** interfacing solutions for the 8051 microcontroller with memory and various peripheral devices. (Bloom's Taxonomy: Apply, Create)
5. **To analyze** and **evaluate** the characteristics, advantages, and applications of the different Cortex processor families, with a focus on Cortex-M processors. (Bloom's Taxonomy: Analyze, Evaluate).
6. **To analyze** real-world embedded system applications, such as automotive ECUs, robotics control systems, and IoT sensor networks, and **explain** their design and functionality. (Bloom's Taxonomy: Analyze, Understand)

Course Outcomes:

1. Distinguish between embedded systems and general-purpose computing, and illustrate the characteristics and applications of embedded systems using relevant examples. (Bloom's Taxonomy: Understand, Apply).
2. Describe the internal architecture and pin configuration of the 8051 microcontroller, and compare its features with those of a microprocessor. (Bloom's Taxonomy: Understand, Analyze).
3. Implement assembly language programs for the 8051 microcontroller, utilizing appropriate instruction sets and addressing modes to perform arithmetic operations. (Bloom's Taxonomy: Apply, Create)
4. Design and demonstrate interfacing techniques for the 8051 microcontroller with memory and various peripheral devices, including sensors, displays, and actuators. (Bloom's Taxonomy: Apply, Create)
5. Analyze the differences between the Cortex-A, Cortex-R, and Cortex-M processor families, and summarize the key features, advantages, and applications of Cortex-M processors. (Bloom's Taxonomy: Analyze, Evaluate)
6. To analyze real-world embedded system applications, such as automotive ECUs, robotics control systems, and IoT sensor networks, and explain their design and functionality. (Bloom's Taxonomy: Analyze, Understand)

Prerequisite:

1. Basic Digital Logic
2. Basic Computer Architecture
3. Programming Fundamentals
4. Basic Electronics

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
0	Prerequisite:	1. Basic Digital Logic 2. Basic Computer Architecture 3. Programming Fundamentals 4. Basic Electronics		
I	Introduction to Embedded Systems & Fundamentals	1. Defining embedded systems: characteristics, applications, and examples. 2. Basic Components of an Embedded System 3. Differences between general-purpose computing and embedded systems.	4	CO1
II	8051 Microcontroller	1. CPU architecture (ALU, registers, control unit, RAM, ROM, registers, I/O ports) 2. Comparison between Microprocessor and Microcontroller. 3. Features, architecture and pin configuration.	7	CO2

III	Artificial Intelligence and Machine Learning for Embedded Systems (Edge AI/TinyML)	Advanced Embedded Architectures and Processors: 1. RISC-V Architecture 2. System-on-Package (SiP) and Chiplets: Introduction to advanced packaging technologies Advanced Communication and Networking for Embedded Systems: 1. Low-Power Wide-Area Networks (LPWANs) 2. Wireless Sensor Networks (WSNs) 1. Cellular IoT (LTE-M)	8	CO3
IV	Introduction to ATmega328P	1. ATmega328P architecture: CPU, memory organization (Flash, SRAM, EEPROM), registers 2. Pin configuration and functions 3. Data types, variables, operators, and control structures 4. Configuring GPIO pins as input and output 1. Controlling LEDs, switches, Sensors	8	CO4
V	Cortex Processors Family	1. Introduction to Cortex Processors 2. Cortex family Cortex-A Cortex-R, Cortex-M 3. Features of Cortex-M Processors. 4. Advantages & Applications of Cortex Processors	6	CO5
VI	Case Study	1. Automotive: Engine Control Unit (ECU) 2. Industrial Automation: Robotics Control System 3. Internet of Things (IoT): Smart Agriculture Sensor Network	6	CO6

Text Books:

1. Mazidi M.A., The 8051 Microcontroller & Embedded systems, Pearson Education Second edition.2006
2. Kenneth Ayala, The 8051 Microcontroller, Thomson Delmar Learning, Third Edition.2005
3. Steve Heath, Embedded Systems Design, Newness publication, Second edition, ISBN 0 7506 5546
4. The Definitive Guide to ARM® Cortex®-M0 and Cortex-M0+ Processors, 2nd Edition

References:

1. David Simon, Embedded Software Primer, Pearson Education, ISBN 81-7808-045
2. Tony Givargis, Embedded System Design: A Unified Hardware/Software Introduction, Wiley Student Edition. ISBN No.812650837X

3. P.S. Manoharan, P. S. Kannan, Microcontroller based system design, SciTech Publications (India) Pvt. Ltd. ISBN No. 8183715982

4. ATmega328P Datasheet

5. Microcontrollers-Architecture, Programming, Interfacing and System Design, Pearson Education India; Second edition (2011), ISBN-10: 8131759903.

6. Cortex-M0+ Technical Reference Manual r0p1

7. ARMv6-M Architecture Reference Manual

8. Steve Furber, “ARM System on chip Architecture”, Pearson, 2nd edition.

9. James A. Langbridge, “Professional Embedded Arm Development”, Wrox, John Wiley Brand & Sons Inc., Edition 2014

Online References:

Sr. No.	Website Name
3.	https://nptel.ac.in/courses/108102045
4.	https://archive.nptel.ac.in/courses/106/105/106105193/
3.	http://www.digimat.in/nptel/courses/video/106105159/L01.html

Assessment:

Internal Assessment (IA) for 20 marks:

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

□ Question paper format

- Question Paper will comprise of a total of **six questions each carrying 20 marks**. Q.1 will be **compulsory** and should **cover maximum contents of the syllabus**
- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
- A total of **Three questions** need to be answered

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2034113	Modern Control Systems	3		-	3	-	-	3

		Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Total					
2034113	Modern Control Systems	20	20	40	60	2	--	--	100

Rationale:

Most of the engineering branches are being off-spring to achieve increased efficiency in processes by minimizing human error using desired operational parameters through automated monitoring to improved productivity and cost reduction, making them ideal for complex industrial applications.

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 can be able to learn stability analysis of systems using Root locus.
- 4) The students can be able to learn frequency response using polar plot, Bode plot, Nyquist plot.
- 5) The students should be able to learn state models for different physical systems
- 6) The students should be able to learn practical working of various systems.

Course Outcomes:

1. Identify open and closed loop control system and formulate mathematical model for the physical systems.
2. Simplify representation of complex systems using reduction techniques.

3. Use standard test signals to identify performance characteristics of first and second-order systems.
4. Apply root locus technique for stability analysis.
5. Analyze performance characteristics of system using Frequency response
6. Analyze performance of different systems.

Prerequisite: Basic components of control system, mathematical foundation- complex variable, differential equation, Laplace transform, inverse, Laplace transform, matrix

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
I	Basic of Control System and Mathematical Models of Physical Systems	Definition of control system, open loop and closed loop system, examples. Development of control systems. Definition of physical systems, principle of superposition and homogeneity, linear/non-linear, time variant/time invariant systems, Types of dynamic models, linear elements of electrical and mechanical system	06	CO1
II	Transfer function	Definition of transfer function, transfer functions of physical (electrical and mechanical) systems, block diagram algebra, Rules for block diagram reduction (numerical), Signal flow graphs-definition, construction, properties and Mason's gain formula (numerical)	08	CO2
III	Time Response Analysis	Standard test signals, steady state errors in feedback control systems and their types, transient and steady state behavior of first and second order systems (numerical)	08	CO3
IV	Stability Analysis and Root Locus	Concepts of Stability: Concept of absolute, relative stability, Routh stability criterion. Root-locus concepts, general rules for constructing root-locus, root-locus analysis of control systems,	06	CO4

V	Frequency Response and Stability Analysis	Frequency Domain Specifications, Correlation between time and frequency response, Bode plots, stability analysis using-bode, Magnitude and phase plot, Concept of polar plot, Nyquist stability criterion, definitions and significance of gain margin and phase margin.	07	CO5
VI	Case studies	Robotic Arm Control in Manufacturing, Automatic Train Control (ATC), Traffic Light Control Systems, Temperature Control in a Furnace, Cruise Control in Cars, Smart Home Lighting	04	CO6

Textbooks:

1. Nagrath I. G., Gopal M., Control System Engineering, New Age International (P) Ltd. Publishers, 2021
2. Kuo Benjamin C., —Automatic Control Systems, 10th Edition, Prentice Hall of India, New Delhi, 2017.

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. K. Ogata, Modern Control Engineering, Prentice Hall of India, 4th edition, 2002.
4. Lewis Paul H., Chang Yang, —Basic Control Systems Engineering, Prentice Hall International, Inc. 1997.
5. 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.

Online References:

Sr. No.	Website Name
1.	https://onlinecourses.nptel.ac.in/noc24_me06/
2.	https://www.tutorialspoint.com/control_systems/control_systems_introduction.htm ntrol Systems - Part I: Block Diagrams and Transfer Functions
3.	https://www.tutorialspoint.com/control_systems/control_systems_introduction.htm

Assessment:

Internal Assessment (IA) for 20 marks:

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

□ **Question paper format**

- Question Paper will comprise of a total of **six questions each carrying 20 marks** Q.1 will be **compulsory** and should **cover maximum contents of the syllabus**
 - **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
 - A total of **Three questions** need to be answered

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2034114	Embedded System Lab	-	2	-	-	1	-	1

Course Code	Course Name	Examination Scheme						
		Theory Marks				Term Work	Practical/ Oral	Total
		Internal assessment			End Sem. Exam			
		Test	Test 2	Avg. of 2 Tests				
2034114	Embedded System Lab	--	--	--	--	25	25	50

Lab Objectives:

1. **Remembering:** Identify the fundamental components of the Arduino Integrated Development Environment (IDE) and recognize the basic electronic components (LED, push button, RGB LED, potentiometer, photoresistor, LM35, servo motor, buzzer, relay, ultrasonic sensor, DC motor).
2. **Understanding:** Explain the relationship between digital and analog signals in the context of Arduino input and output, and describe how each interfaced component interacts with the Arduino board.
3. **Applying:** Implement basic Arduino sketches to control individual LEDs with a push button, vary the blink rate of an LED using a potentiometer, and read sensor values from a photoresistor and LM35 temperature sensor.
4. **Analyzing:** Break down the process of interfacing and controlling more complex components like an RGB LED (controlling individual color channels), a servo motor (controlling angular position), an active buzzer (generating sound), and a relay (switching external circuits).

5. **Evaluating:** Determine the appropriate components and develop a logical sequence of operations required to build an intrusion detection system using an Arduino and an ultrasonic sensor, and justify the chosen approach for directional control of a DC motor.
6. **Creating:** Design and construct a functional prototype of the intrusion detection system and develop an Arduino sketch to achieve directional control of a DC motor based on specific input conditions.

Lab Outcomes:

1. **CO1 (Remembering):** Recall and identify the fundamental components of the Arduino Integrated Development Environment (IDE) and recognize the basic electronic components and sensors used in the course (LED, push button, RGB LED, potentiometer, photoresistor, LM35, servo motor, buzzer, relay, ultrasonic sensor, DC motor).
2. **CO2 (Understanding):** Explain the principles of digital and analog input/output as implemented on the Arduino platform and describe the operational characteristics of each interfaced component.
3. **CO3 (Applying):** Develop and implement Arduino sketches to control individual LEDs using push buttons, regulate LED blink rates with potentiometers, and read sensor data from photoresistors and LM35 temperature sensors.
4. **CO4 (Analyzing):** Investigate and differentiate the control mechanisms for more complex peripherals such as RGB LEDs (color mixing), servo motors (positional control), active buzzers (sound generation), and relays (circuit switching).
5. **CO5 (Evaluating):** Select and justify the appropriate hardware and software components and design a logical flow for building an intrusion detection system utilizing an Arduino and an ultrasonic sensor, and for implementing directional control of a DC motor based on specific requirements.
6. **CO6 (Creating):** Design, build, and test a functional prototype of a basic intrusion detection system using an Arduino and an ultrasonic sensor, and develop and implement an Arduino program to achieve bidirectional control of a DC motor.

List of Experiments.

Sr No	List of Experiments	Hrs
1	Introduction to Arduino (Integrated Development Environment)	02
2	Controlling the Light Emitting Diode (LED) with a push button	02
3	Interfacing the RGB LED with the Arduino	02
4	Controlling the LED blink rate with the potentiometer interfacing with Arduino	02
5	Detection of the light using photo resistor	02
6	Interfacing of temperature sensor LM35 with Arduino	02
7	Interfacing Servo Motor with the Arduino	02
8	Interfacing of the Active Buzzer with Arduino.	02
10	Interfacing of the Relay with Arduino.	02
11	Building Intrusion Detection System with Arduino and Ultrasonic Sensor	02
12	Directional Control of the DC motor using Arduino	02

Sr No	List of Assignments / Tutorials	Hrs
01	Design and implement an Arduino circuit where a push button controls the state of an LED. When the button is pressed, the LED should turn ON, and when released, the LED should turn OFF.	4
02	Interface an RGB LED with the Arduino and write a program that cycles through a sequence of at least five distinct colors (e.g., red, green, blue, yellow, magenta). The duration for which each color is displayed should be adjustable within the code.	4
03	Interface a potentiometer with the Arduino and use its analog input value to control the blink rate of an LED. Turning the potentiometer in one direction should increase the blink rate, while turning it in the other direction should decrease it.	4
04	Design and build a simple light-sensitive alarm system using a photoresistor and an active buzzer interfaced with Arduino. The buzzer should sound when the light level falling on the photoresistor drops below a certain threshold.	4
05	Interface an LM35 temperature sensor and a servo motor with the Arduino. Write a program that reads the temperature from the LM35 and controls the angle of the servo motor based on the temperature reading. For example, the	4

	servo motor could rotate to different positions for low, medium, and high temperature ranges.	
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Assessment:

Term Work: Term Work shall consist of at least 10 to 12 practicals' based on the above list. Also, Term work Journal must include at least 2 assignments.

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

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

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2034115	Modern Control Systems - Lab	-	2	-	-	1	-	1

Course Code	Course Name	Examination Scheme						
		Theory Marks				Term Work	Practical/ Oral	Total
		Internal assessment			End Sem. Exam			
		Test	Test 2	Avg. of 2 Tests				
2034115	Modern Control Systems - Lab	--	--	--	--	25	25	50

Lab Objectives:

1. The students should be able to examine time and frequency response of first-order system
2. The students should be able to examine steady-state and frequency response second order electrical systems.

3. The students should be able to examine transfer function, validate transient and steady-state response
4. The students should be able to examine steady-state and frequency response of the Type 0, 1, and 2 systems.
5. Students should inspect the stability of the system using Root locus
6. Students should inspect the stability of the system using Polar plot, Bode plot, Nyquist plot.

Lab Outcomes:

1. Plot time and frequency response of first-order electrical system.
2. Plot time response of second-order system.
3. Demonstrate the way to obtain the transfer function and validate transient and steady-state response using test signals such as step, ramp, and parabolic.
4. Understand the effect of the 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 the system.

List of Experiments

Sr No	List of Experiments	Hrs
01	To plot the effect of time constant on first – order systems response.	2
02	To plot the frequency response of first-order systems.	2
03	To plot the time response of second- order systems.	2
04	To obtained poles, zeroes and Gain of Transfer Function	2
05	To study the block diagram reduction technique by using simulation software	2
06	To examine steady state errors for Type 0, 1, 2 systems	2
07	To interpret the effect of the damping factor on the performance of the second order system.	2
08	To inspect the relative stability of systems by Root-Locus using simulation software.	2
09	To study the effect of addition of zeros or poles to the forward path transfer function of a control system.	2
10	To inspect the stability of systems by Bode plot using simulation software	2
11	To determine the frequency response specifications from Polar plot of system	2
12	To inspect the stability of systems by Nyquist plot using simulation software.	2

Sr No	List of Assignments / Tutorials	Hrs
01	Assignment based on open loop system and closed loop system, Mathematical Models of physical system.	2
02	Assignment based on transfer function, block diagram reduction, Signal flow graphs, Mason's gain formula	3
03	Assignment based on steady state errors, transient and steady state behavior of first and second order systems	2
04	Assignment based on Routh stability criterion, Root-locus concepts.	3
05	Assignment based on stability analysis using-bode, Magnitude and phase plot, Concept of polar plot, Nyquist stability criterion,	4

Assessment :

Term Work: Term Work shall consist of at least 8-10 practical's based on the above list. Also, Term work Journal must include at least 2 assignments.

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

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

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2034411	CNC Programming Lab	-	4	-	-	4	-	4

Course Code	Course Name	Examination Scheme						
		Theory Marks				Term Work	Practical/ Oral	Total
		Internal assessment			End Sem. Exam			
		Test 1	Test 2	Avg. of 2 Tests				
2034411	CNC Programming Lab	--	--	--	--	50	25	75

Course Objectives:

1. To familiarize with subtractive manufacturing process in particular CNC systems.
2. To acquaint with basic part programming process for specific operations.

3. Understanding CNC Machines and Programming Fundamentals
4. Development of Practical Programming Skills
5. Familiarize with CNC programming languages, especially G-codes and M-codes
6. Equip with troubleshooting skills to address common issues in CNC programming and machining.

Course Outcomes: On successful completion of course learner/student will be able to:

1. Understand the fundamentals of CNC machines and their operation.
2. Understand the basics of G-code programming, linear and circular interpolation concepts
3. Apply advanced G-code programming techniques to complex machining operations.
4. Analyze and troubleshoot CNC programs.
5. Understand CNC programming concepts for turning, milling, and grinding operations.
6. Apply advanced CNC programming techniques to improve machining efficiency and accuracy

DETAILED SYLLABUS: Syllabus related Lab experiment must be considered and mapped with Blooms Taxonomy.

Total six modules for each subject lab (13 weeks) to be distributed among six modules.

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
I	CNC Fundamentals and Machine Operation	Introduction to CNC machines: Definition and history of CNC machines, Types of CNC machines (lathe, milling, grinding, etc.), CNC machine components: - Overview of CNC machine components (spindle, axes, control system, etc.), Functions and operations of each component CNC machine operation: Understanding CNC machine controls and interfaces, Setting up and operating a CNC machine, Safety procedures and best practices. CNC machine calibration: Importance of calibration in CNC machining, Types of calibration (axis calibration, spindle calibration, etc.), Calibration procedures and troubleshooting.	08	CO1
II	G-Code Programming Basics	Introduction to G-code programming: Definition and history of G-code, Basic syntax and structure of G-code programs G-code programming basics: Understanding G-code commands (G00,	08	CO2

		G01, G02, etc.), Writing simple G-code programs, Using G-code to control CNC machine axes. Linear interpolation: Understanding linear interpolation concepts, Writing G-code programs for linear interpolation Circular interpolation: Understanding circular interpolation concepts, Writing G-code programs for circular interpolation		
III	Advanced G-Code Programming Techniques	Canned cycles: Understanding canned cycle concepts, Writing G-code programs for canned cycles Subprograms: Understanding subprogram concepts, Writing G-code subprograms Advanced G-code programming techniques: Using G-code to control CNC machine spindle and coolant, Writing G-code programs for complex machining operations	06	CO3
IV	CNC Programming Software and Program Analysis	Introduction to CNC programming software: Overview of CNC programming software (CAM systems, CNC editors, etc.), Features and functions of CNC programming software CNC programming software applications: Using CNC programming software to create, edit, and simulate CNC programs, Importing and exporting CNC programs. Program analysis and troubleshooting, Understanding CNC program structure and syntax, Analyzing and troubleshooting CNC programs.	06	CO4
V	CNC Programming for Manufacturing Operations	CNC programming for turning operations: Understanding turning operations and CNC programming concepts, Writing G-code programs for turning operations CNC programming for milling operations: Understanding milling operations and CNC programming concepts, Writing G-code programs for milling operations CNC programming for grinding operations: Understanding grinding operations and CNC programming concepts, Writing G-code programs for grinding operations	05	CO5

VI	Advanced CNC Programming and Optimization	CNC programming for complex shapes: Understanding complex shape machining concepts, Writing G-code programs for complex shapes (curves, splines, etc.) CNC program optimization: Understanding CNC program optimization concepts, Applying optimization techniques to reduce cycle times and improve accuracy Advanced CNC programming techniques: Using G-code to control CNC machine advanced features (e.g., high-speed machining, precision machining), Writing G-code programs for advanced machining operations	06	CO6
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Text Books:

1. Peter Smid, CNC Programming Handbook, Industrial Press Inc.
2. P. M. Agrawal and Dr. V. J, CNC Fundamentals and Programming, Tata McGraw-Hill Education (2015)
3. P. N. Rao, CNC Programming for Machining, Tata McGraw-Hill Education
4. John Stenerson, CNC Programming and Technology, Prentice Hall Publications.

References:

1. Michael Fitreman, Machining and CNC Technology, Cengage Learning (2018)
2. Alan Overby, CNC Machining Handbook, McGraw-Hill Education (2013)
3. Haas CNC Programming Manual, Haas Automation Inc. (2020)
4. Binit Kumar Jha, “CNC Programming Made Easy”, PHI Learning Pvt. Ltd. (2017)

Online Resources:

Sr. No.	Website Name
1.	https://archive.nptel.ac.in/courses/112/105/112105211/
2.	https://www.coursera.org/
3.	https://www.cnccookbook.com/
4.	https://www.gcodetutor.com/

List of Experiments.

Sr No	List of Experiments	Hrs
1	Familiarize with CNC machine controls, axes, and safety features.	CO1
2	Understand CNC machine calibration procedures.	CO1
3	Write G-code programs for basic CNC operations, such as moving axes and executing dwell commands	CO2
4	Write program and execute linear interpolation commands (G01) to create simple shapes.	CO2
5	Write program and execute circular interpolation commands (G02, G03) to create circular shapes.	CO2
6	Write program and execute canned cycles (G81, G82, etc.) for drilling, tapping, and boring operations.	CO3
7	create and execute subprograms to perform repetitive tasks	CO3
8	Understand CNC programming software to create, edit, and simulate CNC programs	CO4
9	Analyze and troubleshoot CNC programs to identify errors and optimize performance	CO4
10	Write program and execute CNC turning operations, such as facing, turning, and threading operations.	CO5
11	Write program and execute CNC milling operations, such as face milling, slot milling, and drilling.	CO5
12	Write program and execute CNC grinding operations, such as surface grinding and cylindrical grinding.	CO5
13	Write program and execute CNC programs for complex shapes, such as curves and splines.	CO6
14	Analyze and optimize CNC programs to reduce cycle times, improve accuracy, and minimize errors.	CO6
Sr No	List of Assignments / Tutorials	Hrs
01	Understanding CNC machines, programming languages (G-code, M-code), and basic programming concepts.	2
02	Writing G-code and M-code programs for specific machining operations.	2
03	Various types of operations on CNC Lathe & CNC Milling Machines.	2
04	CNC lathe programming, including turning, facing, and threading operations	2
05	CNC milling programming, including pocketing, profiling, and drilling operations	2
06	Simulation and verification of CNC programs using software tools.	2

Assessment:

Term Work: Term Work shall consist of at least 10 practical's based on the above list. Also, Term work Journal must include at least 4 assignments.

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

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

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	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	--
I	Introduction to Entrepreneurship	Introduction to Entrepreneurship: Definition, the role of entrepreneurship in the economic development, the entrepreneurial process, Women entrepreneurs, Corporate entrepreneurship, Entrepreneurial mindset Self-learning Topics: Case studies: Henry Ford https://www.thehenryford.org/docs/default-source/default-document-library/default-document-library/henryfordandinnovation.pdf?sfvrsn=0 The Tatas: How a Family Built a Business and a Nation by Girish Kuber, April 2019, Harper Business	04	L1, L2
II	Entrepreneurship Development	Entrepreneurship Development: Types of business ownerships: Proprietorship, Public and Private Companies, Co-operative businesses,	05	L2, L3, L4

		Micro, Small and Medium Enterprises (MSME): Definition and role of MSMEs in economic development		
III	Start-up financing	Start-up financing: Cost and revenue models, Sources of start-up fundings: Angel investors, Venture capitalists, Crowd funding, Government schemes for start-up funding Self-learning Topics: Successful business pitching	04	L2, L3, L4, L5
IV	Intellectual Property Rights (IPR)	Intellectual Property Rights (IPR): Types of IPR: Patents, trademarks and copyrights, Patent search and analysis, Strategies for IPR protection, Ethics in technology and innovation	04	L2, L3, L4
V	Business Model Development	Business Model Development: Types of business models, Value proposition, Customer segments, Customer relationships, Channels, Key partners, Key activities, Key resources, Prototyping and MVP Self-learning Topics: The Art of the Start 2.0: The Time-Tested, Battle-Hardened Guide for Anyone Starting Anything by Guy Kawasaki	04	L3, L4, L5, L6
VI	Digital Business Management	Digital Business Management: Digital Business models (Subscription, Freemium <i>etc</i>), Digital marketing: Search Engine Optimization (SEO), Search Engine Marketing (SEM), Social media and influencer marketing, Disruption and innovation in digital business Self-learning Topics: Case study: Airbnb https://www.prismetrix.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 Osterwalder 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/

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

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
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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

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 Self-learning Topics: Creation of empathy maps https://www.interaction-design.org/literature/topics/empathy-mapping	05	L2, L3
III	Define	Define: Significance of defining a problem, Rules of prioritizing problem solving, Conditions for robust problem framing, Problem statement and POV	05	L2, L3

		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		
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
5.	Design Thinking and Innovation by Ravi Poovaiah https://onlinecourses.swayam2.ac.in/aic23_ge17/preview
6.	Introduction to Design Thinking by Dr. Rajeshwari Patil, Dr. Manisha Shukla, Dr. Deepali Raheja, Dr. Mansi Kapoor https://onlinecourses.swayam2.ac.in/imb24_mg37/preview
3.	Usability Testing https://www.interaction-design.org/literature/topics/usability-testing

List of Experiments.

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

Sr No	List of Experiments	Hrs
01	Customer Journey Mapping: Visualize the steps users take to interact with a product or service. Map out the customer journey from discovering a product to making a purchase and using the product. Identify pain points and opportunities for improvement.	2
02	Stakeholder mapping: Identify all relevant stakeholders in a project. Create a stakeholder map, categorizing stakeholders based on their influence and interest. Include management of relationships with key stakeholders.	2
03	"How Might We" Problem Framing: Transform user insights into actionable problem statements. After empathizing with users, turn challenges into "How Might We" statements that define the problem without prescribing a solution.	2

04	Brainstorming Session: Generate a pool of ideas in a creative, non-judgmental environment. Using ideation techniques like mind mapping and brainwriting, students brainstorm as many solutions as possible to their "How Might We" problem statements.	2
05	Affinity Diagramming: Organize group ideas to find patterns and insights. After brainstorming, students will categorize their ideas into themes by placing sticky notes on a wall and moving them into groups based on similarities.	2
06	Rapid Prototyping: Create quick, low-fidelity versions of solutions. Use materials like paper, cardboard, and markers to build a prototype of their solution within 30 minutes. The focus is on speed and functionality, not aesthetics.	2
07	Wireframing: Create a visual guide for digital interfaces for mobile app / web app for the problems identified in earlier lab sessions. Students will sketch wireframes of the user interface for their product or service. Use tools like Balsamiq or paper and pen for low-fidelity wireframes.	2
08	Role-Playing: Walk through a prototype from the user's perspective. Students act as both users and designers, role-playing scenarios where they interact with their prototype (Developed in earlier lab sessions). Gather feedback from participants on how to improve the experience.	2
09	Usability Testing: Evaluation of the effectiveness and user-friendliness of a prototype (developed in earlier lab sessions). Students will have peers or target users test their prototypes, observe how they interact with it, and collect feedback on any issues or improvements needed.	2
10	Feedback Loop and Iteration: Refine solutions based on user feedback. After usability testing, students will refine their prototypes. Document changes made based on feedback and discuss how continuous iteration improves the design.	2

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

Assessment:

Term Work: Term Work shall consist of 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).