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 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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8	The Deputy Registrar, Executive Authorities Section (EA) eau120@fort.mu.ac.in He is requested to treat this as action taken report on the concerned resolution adopted by the Academic Council referred to the above circular.
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4	P.A to all Deans of all Faculties
5	P.A to Finance & Account Officers, (F & A.O), camu@accounts.mu.ac.in

To,

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

AC– 20/5/2025
Item No.– 6.55 (N)

As Per NEP 2020

University of Mumbai

Syllabus for Major Vertical – 1, 4, 5 & 6		
Name of the Programme –B.E. (Electronics and Computer Engineering)		
Faculty of Engineering		
Board of Studies in Electronics Engineering		
U.G. Second Year Programme	**Exit Degree**	**U.G. Diploma in Electronics and Computer Engineering.**
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. (Electronics and Computer Engineering)**
2	**Exit Degree**	**U.G. Diploma in Electronics and Computer 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-705C** **R. TEU-705D**	**Attached herewith**
6	**Semesters**	**Sem. IV**
7	**Program Academic Level**	**5.00**
8	**Pattern**	**Semester**
9	**Status**	**New**
10	**To be implemented from Academic Year**	**2025-26**

Sd/-	**Sd/-**	**Sd/-**
Dr. R.N.Awale	**Dr. Deven Shah**	**Prof. Shivram S. Garje**
BoS-Chairman-Electronics Engineering	**Associate Dean**	**Dean**
Faculty of Technology	**Faculty of Science & Technology**	**Faculty of Science & Technology**

Preamble

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

The second-year engineering course is a core training program to impart scientific and logical thinking training to learners in general, with a choice of course selection from the program core course, multidisciplinary minor, and vocational skill-enhanced course. Simultaneously, the objectives of NEP 2020 demand nurturing the core program and skills required for the 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 Electronics and Computer Engineering based core courses. The technical courses include Open Electives (OE) and Multidisciplinary (MDM)where a pool of subjects is 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 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/-Sd/-Sd/-
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Faculty of Technology

Dr. Deven Shah
Associate Dean
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Prof. Shivram S. Garje
Dean
Faculty of Science & Technology

UnderGraduateDiploma in Engineering- Electronics Engineering

Credit Structure (Sem. III & IV)

	R. TEU-705C								
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 PCC304:3 PCL301: 1 PCL302:1	--	--	OE:2	--	VEC:2 HSL: 2	CEP:2	22	**UG Diploma45**
	R. TEU-705D									
	IV	PCC401:3 PCC402:3 PCC403:3 PCL401:1 PCL402:1	--	MDM: 4	OE:2	VSEC:2	VEC:2 EEM:2	--	23	
	CumCr.	25	--	4	4	2	*2+2+2+2*	2	45	

Exit option: Award of UG Diploma in Major and MDM with 90credits 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 compulsorily 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]

SEM-IV

S.E. (Electronics and Computer Engineering)

Scheme

Program Structure for Second Year of Electronics and Computer Science

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
2274111	Mathematics-IV (Program Specific)	2	--	1	2	1	–	3
2274112	Analog Electronics	3	–	--	3	–	–	3
2274113	Discrete Structure and Automata Theory	3	--	--	3	–	–	3
MDC401	Multidisciplinary minor	3	–	--	3	–	–	3
OEC401	Open Elective	2#	–	--	2	–	–	2
2274114	Analog Electronics lab	–	2	–	–	–	1	1
2274115	Discrete Structure and Automata Theory Lab	–	2	–	–	–	1	1
MDL401	Multidisciplinary minor	–	2	–	–	–	1	1
2274411/2274412	Maintenance of Electronic Appliances and Network Administration/Creative Coding in Python	–	2*+2	–	–	–	2	2
2994511	Business Model Development	–	2*+2	–	–	–	2	2
2994512	Design Thinking	–	2*+2	–	–	–	2	2
Total		**13**	**18**	**01**	**13**	**01**	**09**	**23**

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

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

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

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

Course Code	Course Description	Ex amination 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)					
2274111	Mathematics-IV (Program Specific)	20	20	40	60	2	25	--	125
2274112	Analog Electronics	20	20	40	60	2	--	--	100
2274113	Discrete Structure and Automata Theory	20	20	40	60	2	--	--	100
MDC401	Multidisciplinary minor	20	20	40	60	2	--	--	100
OEC401	Open Elective	20	20	40	60	2	--	--	100
2274114	Analog Electronics lab	--	--	--	--	--	25	25	50
2274115	Discrete Structure and Automata Theory Lab	--	--	--	--	--	25	25	50
MDL401	Multidisciplinary minor	--	--	--	--	--	25	--	25
2274411/2274412	Maintenance of Electronic Appliances and Network Administration/Creative Coding in Python	--	--	--	--	--	25	25	75
2994511	Business Model Development	--	--	--	--	--	50	--	50
2994512	Design Thinking	--	--	--	--	--	50	--	50
Total		**100**	**100**	**200**	**300**	**10**	**225**	**75**	**825**

Vertical –1
Major

Course Code	Course Name	Teaching Scheme (Hrs./week)			Credits Assigned			
		L	T	P	L	T	P	Total
		2	1	--	2	1	-	3
2274111	Engineering Mathematics-IV	Examination Scheme						
			IA1	IA2	ESE		Total	
		Theory	20	20	60		100	

Course Objectives:

1. To build a strong foundation in mathematics, provide students with the mathematics fundamentals necessary to formulate, solve and analyze complex engineering problems.
2. To prepare the students to apply reasoning informed by contextual knowledge to engineering practice, and to work as part of teams on multi-disciplinary projects.

Pre-requisite Course Codes	BSC101-Applied Mathematics-I, BSC102-Applied Mathematics-II	
Course Outcomes	After the successful completion, students should be able to	
	CO1	Find eigenvalues and eigenvectors of the matrix, apply Caley Hamilton theorem, find a matrix function, and distinguish derogatory and diagonalizable matrices.
	CO2	Reduce a quadratic form to canonical forms using congruent and orthogonal transformations and characterize it based on rank, index and class value.

	CO3	Identify vector spaces and their bases, calculate the norm and inner products, prove the associated properties, and find an orthogonal and orthonormal basis using the Gram-Schmidt process.
	CO4	Compute probability using probability distribution of discrete and continuous random variables, Binomial, Poisson, and Normal distributions.
	CO5	Apply testing of the hypothesis associated with the Sampling distribution of large samples, small samples and chi-square distribution.
	CO6	Apply the concept of correlation and regression, fitting the curve to estimate the parameters for a given data set.

Module No.	Topics	No. of Hours	References
01	**Linear Algebra (Theory of Matrices):** 1.1 Eigenvalues and eigenvectors and properties. 1.2 Cayley-Hamilton Theorem (without proof), Functions of Square Matrix. 1.3 Derogatory and non-derogatory matrices. 1.4 Similarity of matrices, diagonalizable and non-diagonalizable matrices.	4	[1], [3]
02	**Linear Algebra (Quadratic Forms):** 2.1 Quadratic forms over the real field, the linear transformation of quadratic form, reduction of quadratic form to canonical forms (diagonal and normal) using a congruent transformation. 2.2 Rank, index and signature of a quadratic form, Sylvester's law of inertia, value-class of a quadratic form-Definite, Semi-definite and Indefinite. 2.3 Reduction of quadratic form to canonical forms (diagonal and normal) using an orthogonal transformation.	4	[1], [3]
03	**Linear Algebra (Vector Space, Basis and Orthonormal Basis):** 2.1 Vector spaces over real field, subspaces. 2.2 Vectors in n-dimensional vector space, linear combinations, linear dependence and independence set of vectors, basis of a vector space. 2.3 Norm, inner product, distance between two vectors, angle between two vectors, orthogonal vectors, triangular and Cauchy-Schwarz inequality. 2.4 Orthogonal and orthonormal bases, Gram-Schmidt process to construct an orthonormal basis.	4	[1], [3]
04	**Probability:** 4.1 Discrete and continuous random variable with a probability distribution and density function. 4.2 Expectation, variance, moment generating function, raw and central moments, covariance, correlation coefficient and their properties. 4.4 Probability distribution: Binomial, Poisson and Normal distributions.	5	[2], [4]
05	**Probability Distribution and Sampling Theory:** 5.1 Sampling distribution, test of hypothesis, level of significance, critical region, one-tailed and two-tailed test, test of significance of	5	[2], [4]

	mean and difference between the means of two samples for large samples. 5.2 Degree of freedom, Student's t-distribution, test of significance of mean and difference between the means of two samples for small samples. 5.3 Chi-Square Test: Test of goodness of fit, contingency table and test of independence of attributes, Yate's correction.		
06	**Statistical Techniques:** 6.1 Karl Pearson's coefficient of correlation. 6.2 Spearman's rank correlation coefficient (with repeated and non-repeated ranks). 6.3 Fitting of first- and second-degree curves. 6.4 Linear regression.	4	[2], [4]
	Total	**26**	

Course Assessment:

Theory:

IA1:20 Marks written one-hour examination should be conducted when approximately 40% of the syllabus is completed.
IA2:20 Marks written one-hour examination should be conducted when approximately 80% of the syllabus is completed.

ESE:60 Marks written two-hour examination should be conducted based on 100% of the syllabus.

End Semester Theory Examination:
1 Question paper will be worth 60 marks.
2 Question paper will have a total of five questions.
3 All questions have equal weightage and carry 20 marks each.
4 Any three questions out of five need to be solved.

Recommended Books:

Text Books:
[1] D. C. Lay, Linear Algebra and its Applications, Pearson.
[2] Gupta and Kapoor, Fundamental of Mathematical Statistics, S Chand.

References:
[3 Howard Anton and Chris Rorres, Elementary Linear Algebra with Supplemental Applications, Wiley.
[4] T. Veerarajan, Probability, Statistics and Random Processes, McGraw-Hill.

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
		L	T	P	L	T	P	Total
		3	--	--	3	--	1	4
2274112	**Analog Electronics**	**Examination Scheme**						
			IA1	**IA2**	**ESE**		**Total**	
		Theory	20	20	60		100	

Pre-requisite Course Codes	PC 302 Electronic Devices	
Course Outcomes	After the successful completion students should be able to	
	CO1	To evaluate performance of single or multi-stage MOSFET amplifier using frequency response.
	CO2	To analyze various performance parameters of op-amp.
	CO3	To apply the concepts of feedback while selecting amplifiers for the given specifications/ applications.
	CO4	To design Oscillators using op-amp.
	CO5	To examine the operation of OPAMP for different application.
	CO6	To select and use the suitable integrated circuit for a specific application.

Module No.	Unit No.	Topics	Reference	Hrs.
1		**Frequency Response of MOSFET Amplifiers**		7
	1.1	Low frequency response & analysis, effect of the coupling, bypass & load capacitances on single stage MOSFET amplifier for common source (CS) configuration (mathematical analysis & Numerical examples included)	R1, R3	
	1.2	High frequency response & analysis, effect of parasitic capacitances on MOSFET amplifier, high frequency equivalent circuit of MOSFET, Miller's theorem, effect of Miller's capacitance, unity gain bandwidth (mathematical analysis & numerical examples included).	R1, R3	
	1.3	Introduction to multi-stage amplifiers – need & necessity, different types of couplings (DC, R-C & transformer) with advantages & disadvantages, the MOSFET Cascode amplifier (theoretical description only)	R1, R3	
2		**Differential Amplifier and Op-amp**		9
	2.1	Basic MOSFET differential amplifier, DC characteristics, transfer characteristics, small signal (AC) analysis of only dual input balanced output (DIBO) for differential mode gain & common mode gain, Common mode rejection ratio (CMRR) & input resistance / impedance.	R1	
	2.2	MOSFET differential amplifier with an active load (theoretical description & only mathematical analysis (no numerical examples).	R1	
	2.3	The ideal operational amplifier (op-amp), internal block diagram of op-amp, characteristics of op-amp, ideal & practical op-amp parameters / specifications (no detailed description or any Analysis), mathematical model of op-amp, IC 741 op-amp with pin diagram & description.	R1, R7	
3		**Op-amp and Feedback**		5
	3.1	Open loop & closed loop configurations (theoretical description only), the concept of virtual ground & virtual short.	R1, R2	
	3.2	Basic concepts of feedback, Types of feedback – positive and negative and its effect on gain (block diagram and derivation of gain expected).	R2, R3	
	3.3	Types of negative feedback – voltage series, voltage shunt, current series & current shunt (block diagram and	R2, R3,	

		derivation expected), the op-amp inverting amplifier & op-amp noninverting amplifier (mathematical analysis for derivation of output voltage only, numerical examples & designing)	R7	
4		**Oscillators and Waveform Generator**		6
	4.1	Oscillators: Barkhausen's criteria for sustained oscillations, RC phase shift oscillator, Wien bridge oscillator & the crystal oscillator (theoretical description only–no mathematical analysis), numerical example & design problem on RC phase shift oscillator & Wien bridge oscillator.	R2, R4	
	4.2	Waveform Generator: Square wave generator & triangular wave generator (only theoretical description – no mathematical analysis or designing examples).	R2, R4, R7	
5		**Applications of Op-amp**		6
	5.1	Adder, summing amplifier, averaging circuit, subtractor, integrator (ideal), differentiator (ideal), difference amplifier, current amplifier & 3 op-amp instrumentation amplifier (only mathematical analysis for derivation of output voltage with numerical examples & designing included).	R2, R7	
	5.2	Current to voltage converters (I to V) & voltage to current converters (V to I) – floating load & grounded load (mathematical analysis only – no numerical).	R2, R7	
6		**Non-Linear Integrated Circuits**		6
	6.1	Comparators: Inverting comparator, non-inverting comparator, zero crossing detectors, window detector.	R2, R4, R7	
	6.2	Schmitt Triggers: Inverting Schmitt trigger, non-inverting Schmitt trigger	R2, R4, R7	
	6.3	IC 555 Timer: pin configuration and block diagram, Operation in astable and monostable multivibrator with mathematical analysis & numerical examples, applications in astable and monostable configurations.	R2, R7	
Total				**39**

Course Assessment:

Theory:

IA1: One hours 20 Marks written examination for one hour
IA2: One hours 20 Marks written examination for one hour

ESE: Two hours 60 Marks written examination for two hours

Recommended Books:

[1] Donald A. Neamen, "Electronic Circuit Analysis and Design", TATA McGraw Hill, 2nd Edition
[2] Ramakant A. Gayakwad, "Op-Amps and Linear Integrated Circuits", Pearson Prentice Hall, 4th Edition.
[3] Robert Boylestad," Electronic Devices and Circuit Theory", Pearson.
[4] David A. Bell,"Electronic Devices and Circuits", Oxford, Fifth Edition.
[5] Muhammad H. Rashid, "Microelectronics Circuits Analysis and Design", Cengage.
[6] S. Salivahanan, N. Suresh Kumar,"Electronic Devices and Circuits", Tata McGraw Hill.
[7] D. Roy Choudhury and S. B. Jain, "Linear Integrated Circuits", New Age International

Publishers, 4th Edition.
[8] Sergio Franco, "Design with operational amplifiers &analog integrated circuits", Tata McGraw Hill, 3rd edition
[9] William D. Stanley, "Operational Amplifiers with Linear Integrated Circuits", Pearson, 4th Edition.

Online References:

https://nptel.ac.in/courses/108107142
https://nptel.ac.in/courses/108102112
https://nptel.ac.in/courses/108105158

Course Code	Course Name	Teaching Scheme (Hrs./week)			Credits Assigned			
		L	T	P	L	T	P	Total
2274113	Discrete Structures and Automata Theory	3	--	--	3	--	1	4
		Examination Scheme						
			IA1	IA2	ESE		Total	
		Theory	20	20	60		100	

Pre-requisite Course Codes: PC 303 Data Structure and Algorithms

Course Outcomes	After the successful completion students should be able to	
	CO1	Understand the notion of mathematical thinking, mathematical proofs and to apply them in problem solving.
	CO2	Reason Logically.
	CO3	Perform operations with Sets, Relations, Functions, Graphs and their applications.
	CO4	Design Deterministic Finite Automata (DFA) and Non-deterministic Finite Automata (NFA) and Pushdown Automata with understanding of power and limitations.
	CO5	Design Context Free Grammar and perform the operations like simplification and normal forms.
	CO6	Apply Discrete Structures and Automata Theory concepts into solving real world computing problems in the domain of Formal Specification, Verification, Artificial Intelligence etc.

Module No.	Unit No.	Topics	Reference	Hrs.
1	**Set Theory and Logic**		T1,2 R1,2,5	7
	1.1	Set Theory: Fundamentals - Sets and Subsets, Venn Diagrams, Operations onsets, Laws of Set Theory, Power Set, Principle of Inclusion and Exclusion, Mathematical Induction.		
	1.2	Propositions and Logical operations, Truth tables, Equivalence, Implications		
	1.3	Laws of Logic, Normal Forms, Inference, Predicates and Quantifiers		
2	**Relations and Functions**		T 1,2	9

	2.1	Relations- Definition, Properties of Relations, Types of binary relations (Equivalence and partial ordered relations),	R 1,2, ,4,6	
	2.2	Closures, Poset, Hasse diagram and Lattice Functions-Definition, Types of Functions (Injective, Surjective and Bijective)		
	2.3	Identity and Inverse Functions, Pigeonhole Principle, Extended Pigeonhole Principle		
3	**Graph Theory**		T-3,4 R 6,7,8,9	5
	3.1	Graphs and their basic properties-degree, path, cycle, subgraphs, Types of graphs.		
	3.2	Definitions, Paths and circuits: Eulerian and Hamiltonian, Planner Graph.		
	3.3	Isomorphism of graphs, Dijkstra Shortest Path Algorithm, Trees, Types of Trees		
4	**Finite Automata**		T-3,4 R 6,7,8,10	6
	4.1	Introduction of Automata and its applications		
	4.2	Deterministic Finite Automata (DFA) and Nondeterministic Finite Automata (NFA): Definitions, transition diagrams and Language recognizers, NFA to DFA Conversion.		
	4.3	Eliminating epsilon-transitions from NFA. FSM with output: Moore and Mealy machines.		
5	**Regular Expression (RE) and Regular Grammar (RG)**		T-3,4 R 6,7,8,10	6
	5.1	Regular Grammar and Regular Expression (RE): Definition, Equivalence and Conversion from RE to RG and RG to RE.		
	5.2	Equivalence of RE and FA, Converting RE to FA and FA to RE. Applications of RE and RG.		
6	**Context Free Grammar (CFG) and Push Down Automata (PDA)**		T-3,4 R 6,7,8,10	6
	6.1	Grammars: Chomsky hierarchy, CFG-Definition, Sententia lforms, Leftmost and Rightmost derivations.		
	6.2	Context Free languages(CFL): Parsing and Ambiguity. CFLs: Simplification and Applications.		
	6.3	Normal Forms: Chomsky Normal Form (CNF)		
	6.4	PDA-Definition, Transitions (Diagrams, Functions and Tables), Design of PDA with Graphical Notation and Instantaneous Descriptions.		
Total				**39**

Course Assessment:

Theory:

IA1: One hours 20 Marks written examination for one hour
IA2: One hours 20 Marks written examination for one hour

ESE: Two hours 60 Marks written examination for two hours

Recommended Books:

Text Books:

1. Bernad Kolman, Robert Busby, Sharon Cutler Ross, Nadeem-ur-Rehman, "Discrete Mathematical Structures", Pearson Education.
2. C.L.Liu, , "Elements of Discrete Mathematics", second edition 1985, McGraw-Hill Book Company. Reprinted 2000.
3. John E. Hopcroft, Rajeev Motwani, Jeffery D. Ullman, "Introduction to Automata Theory, Languages and Computation", Pearson Education.
4. Vivek Kulkarni, "Theory of Computation", Oxford University Press, India.

Reference Books:

1. K.H.Rosen, "Discrete Mathematics and applications", fifth edition 2003, Tata McGraw Hill publishing Company.
2. Y N Singh, "Discrete Mathematical Structures", Wiley-India.
3. J .L.Mott, A.Kandel, T.P .Baker, Discrete Mathematics for Computer Scientists and Mathematicians, second edition 1986, Prentice Hall of India.
4. J. P. Trembley, R. Manohar "Discrete Mathematical Structures with Applications to Computer Science", Tata Mcgraw-Hill.
5. Seymour Lipschutz , Marc Lars Lipson," Discrete Mathematics" Schaum's Outline, McGraw Hill Education.
6. Daniel I. A. Cohen," Introduction to Computer Theory", Wiley Publication.
7. Michael Sipser, "Theory of Computation", Cengage learning.
8. J. C. Martin, "Introduction to Languages and the Theory of Computation", Tata McGraw Hill.
9. Krishnamurthy E. V., "Introductory Theory of Computer Science", East-West Press.
10. Kavi Mahesh, "Theory of Computation: A Problem Solving Approach", Wiley-India.

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
		L	T	P	L	T	P	Total
2274114	Analog Electronics Lab	--	--	2	--	--	1	1
		Examination Scheme						
		Term work		Orals			Total	
		25		25			75	

Pre-requisite Course Codes	Electronic Devices Laboratory	
Laboratory Objectives	1.	To practically analyze& compute performance parameters of various electronic circuits
	2	To familiarize with principles of designing of practical electronic circuits as per given specifications
	3.	To develop overall approach for students from selection of integrated circuit, specification, functionality and

		applications
Laboratory Outcomes	After the successful completion students should be able to	
	LO 1	Experimentally evaluate performance of amplifiers through frequency response
	LO 2	Analyze differential amplifiers for various performance parameters
	LO 3	Implement practically various applications and circuits based on operational amplifiers.

Laboratory Experiments:

Sr. No.	Title of experiment	Module	Reference
1.	To implement single stage MOSFET CS amplifier and study its frequency response	1	R1, R3
2.	To implement CS-CG MOSFET Cascode amplifier and study its frequency response.	1	R1, R3
3.	To determine input and output impedance of CS amplifier with and without feedback.	1	R1, R3
4.	To study Op-amp as Differential amplifier.	2	R1, R7
5.	To measure parameters of Op-amp.	2	R1, R7
6.	To study Inverting and Non-inverting configuration of Op-amp.	3	R7
7.	To study and calculate frequency of oscillations of Wien bridge oscillator	4	R2, R4
8.	To study and calculate frequency of oscillations of RC Phase shift oscillator	4	R2, R4
9.	To study voltage gain of three Op-amp instrumentation amplifier	5	R2, R7
10.	To study the operational amplifier as summing amplifier.	5	R2, R7
11.	To determine upper and lower threshold voltage in Schmitt trigger using IC 741.	6	R2, R4, R7
12.	To study and implement Astable multi-vibrator using 555 timer IC.	6	R2, R7
13.	To study Op-amp as comparator and zero crossing detector	6	R2, R4, R7

Laboratory Assessment:

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 2 assignments.

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

Practical/ Oral Exam: An Oral examination will be held based on the above syllabus.

Recommended Books:

[1] Donald A. Neamen, "Electronic Circuit Analysis and Design", TATA McGraw Hill, 2nd Edition

[2] Ramakant A. Gayakwad, "Op-Amps and Linear Integrated Circuits", Pearson Prentice Hall, 4th Edition.

[3] Robert Boylestad," Electronic Devices and Circuit Theory", Pearson.

[4] David A. Bell,"Electronic Devices and Circuits", Oxford, Fifth Edition.

[5] Muhammad H. Rashid, "Microelectronics Circuits Analysis and Design", Cengage.

[6] S. Salivahanan, N. Suresh Kumar,"Electronic Devices and Circuits", Tata McGraw Hill.

[7] D. Roy Choudhury and S. B. Jain, "Linear Integrated Circuits", New Age International Publishers, 4th Edition.

[8] Sergio Franco, "Design with operational amplifiers &analog integrated circuits", Tata McGraw Hill, 3rd edition

[9] William D. Stanley, "Operational Amplifiers with Linear Integrated Circuits", Pearson, 4th Edition

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
		L	T	P	L	T	P	Total
2274115	Discrete Structures and Automata Theory Tutorials	--	1	--	--	1	--	1
		Examination Scheme						
		Term work		Orals/Presentation			Total	
		25		25			50	

Pre-requisite Course Codes: PC 303 Data Structure and Algorithms		
After the successful completion students should be able to		
Laboratory Outcomes	1.	To cultivate clear thinking for Creative Problem Solving.
	2.	To introduce the notions of Sets, Relations, Functions, Graphs and their applications.
		To build concepts of theoretical design of Basic machines, Deterministic and Non-Deterministic Finite state machines and Pushdown Machines.
	LO 1	Train students to understand and construct Mathematical Proofs.
	LO 2	Analyze differential amplifiers for various performance parameters
	LO 3	Implement practically various applications and circuits based on operational amplifiers.

Tutorial Assessment:
Assessment:

Term Work: Term Work shall consist of at least 10 to 12 tutorials based on the above list.

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

Seminar Presentation: Presentation on applications based on concepts at above syllabus. Report making 10 marks and Presentation: 15 marks

Vertical - 4

Detail Syllabus

VSC

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
		L	T	P	L	T	P	Total
VSEC 2274411	Maintenance of Electronic Instruments/ Network Administration	--	--	4	--	--	2	2
		Examination Scheme						
		Term work		Orals			Total	
		25		25			50	

Pre-requisite Course Codes	Basics of measurements and Network	
Course Outcomes	After the successful completion students should be able to	
	CO1	Have a working knowledge about the measurement process, units of measurements, static and dynamic characteristics of instrument.
	CO2	Identify and classify types of test & measuring instruments that are available in the laboratory
	CO3	Understand the networking, OSI Concepts and Recognize the Network technologies.
	CO4	Recognize the Linux features, basic commands Installing and configuring the networking, servers and storage systems
	CO5	To understand the method of installing, configuring, outlook and concepts of anti-virus.

Module No.	Unit No.	Topics	Reference	Hrs.
1. Introduction to Basic Concepts of Measurements and Standards	**1.1**	Introduction to the measurement process & its aim, functional elements of an instrumentation system, Need of Inspection, Go-No Go Gauges. Difference between measuring instrument and Comparator.	1	8
	1.2	Introduction to Standards such as IS/ BIS, NABL standards. Errors in measurement, types, classification, Calibration & its importance, Calibration method.	2	
2. Static and Dynamic Characteristics of Transducer and Instruments	**2.1**	Difference between sensor and transducer, classification of Types of electrical, electronic, and mechanical sensors	1	9
		Performance characteristics of instruments – static characteristics & dynamic characteristics, List of Manufacturers/ vendors dealing with sale, service, and repair of measuring and test instruments.	2, 3	
3. Hardware and Network Essentials	**3.1**	Different component of computer, Assembly of system troubleshooting of the system, Layout, Components and from factors of mother broad, form factors, slot types and different memory types, Storage and to recognize the methods of storage and different hardware components used for storage.	4	9
	3.2	Hardware components in the computer, the methods of troubleshooting storage, power supplies. Different types of printers and scanner, Installing and configuring of operating system and it drives. Safety consideration.		
	3.3	Networking, OSI Concepts, recognize the Network technologies, types of application functionality, the colour coding for the Ethernet cable to be crimping & Punching, Recognize network adaptor configuration, the network design structure, the different configuration methods of device		
4 .Windows Essentials and Server	**4.1**	Features of windows client, performance information, tool configuration, Installation, upgrading and its features, Configuring, maintaining, backup and recovery	5	9
	4.2	Directory services and different functional levels, installing configuring Directory services, the methods of disaster recovery and		

		backup, the method of implementing secure domain, administrating and creation of user, maintaining group policies, e goals set, improving the reading skills		
5. Linux Server	**5.1**	The Linux features, basic commands, the methods of installing, configuring server and services, the method of fault analysis, filesystem corruption.	4,5	9
	5.2	Installing, configuring network adaptor, basic services, managing of storage.		
6. IT Security fundamentals	**6.1**	The method of installing, configuring, outlook and concepts of anti-virus, Methods of identifying types and indication of virus, worms, Trojan etc. , understand the compatibility		8
			Total	**52**

Recommended Books:

1 Electronic Instrumentation By W. D. Cooper
2. Instrumentation By A. K. Shawney
3. Sensors and Transducers, Second Edition, D. Patranabis, PHI publications, 2003
4. The Linux Command Line by William Shotts for beginners, or "How Linux Works" by Brian Ward
5. Windows Operating System Fundamentals, by Crystal Panek ,Released November 2019
Publisher(s): Sybex

Course Code	**Course Name**	**Teaching Scheme (Hrs/week)**			**Credits Assigned**			
VSEC 2274412	**Creative Coding in Python**	L	T	P	L	T	P	Total
		--	--	4	--	--	2	2
		Examination Scheme						
		Term work		**Orals**			**Total**	
		25		25			50	

Pre-requisite Course Codes: Python programming		
Laboratory Objectives	1.	To familiarize learners with Python's basic syntax, variables, data types, operators, and input/output functions.
	2	To introduce learners with file handling, exception management, and Python packaging.
	3.	To reinforce the understanding and application of GUI.
	4	To explore advanced libraries such as Numpy, Pandas, Matplotlib, Seaborn, Scipy.
	5	To explore data visualization tools.
	6	To introduce and demonstrate the use of DJANGO for web applications.

Laboratory Outcomes	After the successful completion students should be able to	
	LO 1	Identify the fundamental Python programming to design object- oriented programs with Python classes
	LO 2	Demonstrate the file handling operations like reading, writing to create the programs
	LO 3	Express proficiency in the handling Python libraries to Design GUI Applications
	LO 4	Design interactive visualizations that allow users to explore data creatively
	LO 5	Develop interactive projects with the help of Machine learning libraries to develop different applications
	LO 6	Create the web development applications with the help of DJANGO.

DETAILED SYLLABUS:

Module No. 1	**Unit No.**	**Introduction to Creative Coding with Python**	**Reference**	**Hrs.**
1		**Python Programming Basics**	R1	**04**
	1.1	Basic Syntax and Data Types - Variables and data types, Operators, Input and output, Data Structures- list, tuple, set and dictionary Understanding the Syntax Transition: From C to Python		
	1.2	Conditional Statements: if, else, elif , Loops: for and while loop Functions- Defining functions, Parameters and return values, Scope and lifetime of variables.		
2		**Functions, File I/O Handling and Classes**	R1, R2	**04**
	2.1	File Input/Output: Files I/O operations, Read / Write Operations, File Opening Modes, with keywords, Moving within a file, Manipulating files and directories, OS and SYS modules		
	2.2	Classes and Objects, Public and Private Members, Class Declaration and Object Creation, Object Initialization, Class Variables and methods, Accessing Object and Class Attributes. Intricacies of Classes and Objects, Inheritance, Constructor in Inheritance, Exception Handling, Link list, Stack, Queues.		
3		**Graphical User Interface and Image processing**	R3	**06**
	3.1	Graphical User Interface using Tkinter Library module, creating simple GUI; Buttons, Labels, entry fields, widget attributes.		
	3.2	Database: Sqilite database connection, Create, append, update, delete records from database using GUI.		
	3.3	Basic Image Processing using OpenCV library, simple image manipulation using image module.		
4		**Numpy, Pandas, Matplotlib, Seaborn, Scipy and Data Science**	R3, R4	**08**
	4.1	Introduction to Numpy, Creating and Printing Ndarray, Class and Attributes of Ndarray, Basic operation, Copy and view, Mathematical Functions of Numpy		

	4.2	Introduction to Pandas, Understanding Dataframe, View and Select Data, Missing Values, Data Operations, File read and write operation.		
	4.3	Introduction to Matplotlib library, Line properties, Plots and subplots, Types of Plots, Introduction to Seaborn		
	4.4	Introduction to Scipy, Scipy Sub packages – Integration and Optimization, Eigen values and Eigen Vectors, Statistic, Weave and IO.		
	4.5	Dataframes, Data analysis commands, Data visualization: Line chart, Bar Diagram, Histogram, Pie chart		
5		**Web Development**	R3, R4, R5	**04**
	5.1	Introduction to web development application, Web Architecture and applications.		
	5.2	Introduction to DJANGO Framework: History of DJANGO, DJANGO-Design philosophies, DJANGO features and Environment set up.		
			Total	**26**

Recommended Books:

1. Yashvant Kanetkar, "Let us Python: Python is Future, Embrace it fast", BPB Publications; 1st edition (8 July 2019).
2. Dusty Phillips, "Python 3 object-oriented Programming", Second Edition PACKT Publisher, August 2015.
3. John Grayson, "Python and Tkinter Programming", Manning Publications (1 March 1999).
4. Core Python Programming, Dr. R. Nageswara Rao, Dreamtech Press
5. Beginning Python: Using Python 2.6 and Python 3.1. James Payne, Wrox publication
6. Introduction to computing and problem solving using python, E Balagurusamy, McGraw Hill Education

Online Resources:

- Python Tutorial: http://docs.python.org/release/3.0.1/tutorial/
- Python for everybody specialization: https://www.coursera.org/specializations/python.
- Machine Learning Algorithm Documentation: https://scikit-learn.org/stable/
- https://nptel.ac.in/courses/106/106/106106182/

Laboratory Experiments:

The following experiments serve as samples to illustrate the application of concepts covered in each unit. Instructors are encouraged to modify and adapt these experiments to meet the specific needs of the course and the learning objectives. It is essential to ensure that the fundamental concepts and skills outlined in each unit are adequately covered, even with modifications

Sr. No.	Title of experiment	Module	Reference
1.	1. Write python programs to understand expressions, variables, quotes, basic math operations, list, tuples, dictionaries, arrays etc. 2. Write Python program to implement byte array, range, set and different STRING Functions (len, count, lower, sorted etc) 3. Write a Python program to implement control structures. 4. Assume a suitable value for distance between two cities (in km). 5. Write a program to convert and print this distance in meters, feet,	Module 1	R1

	inches and centimeter.		
2.	1. Write python program to understand different File handling operations 2. Create 3 lists – a list of names, a list of ages and a list of salaries. 3. Generate and print a list of tuples containing name, age and salary from the 3 lists. From this list generate 3 tuples – one containing all names, another containing all ages and third containing all salaries. 4. Write Python program to implement classes, object, Static method and inner class 5. If any integer is given as in input through the keyboard, write a program to find whether it is odd or even number. 6. Write a program that prints square root and cube root of numbers from 1 to 10, up to 4 decimal places. Ensure that the output is displayed in separate lines, with number center-justified and square and cube roots right-justified. 7. Write a program to find the factorial value of any number entered through the keyboard.	Module 2	R2
3.	1. Write Python program to create, append, update, delete records from database using GUI. 2. Write Python program to obtain histogram of any image 3. Write Python Program to split color image in R,G,B and obtain a. individual histograms. 4. Write Python program for histogram equalization 5. Write Python Program for edge detection 6. Write Python Program for image segmentation 7. Write Python program to implement GUI Canvas application using Tkinter 8. Write Python program to implement GUI Frame application using Tkinter	Module 3	R3
4.	1. Write Python program to study define, edit arrays and perform arithmetic operations. 2. Write python program to study selection, indexing, merging, joining, concatenation in data frames 3. Evaluate the dataset containing the GDPs of different countries to: • Find and print the name of the country with the highest GDP • Find and print the name of the country with the lowest GDP • Print text and input values iteratively • Print the entire list of the countries with their GDPs • Print the highest GDP value, lowest GDP value, mean GDP, value, standardized GDP value, and the sum of all the GDPs 4. Analyze the Federal Aviation Authority (FAA) dataset using Pandas to do the following: • View: aircraft make name, state name, aircraft model name, text information, flight phase, event description type, fatal flag • Clean the dataset and replace the fatal flag NaN with "No". • Find the aircraft types and their occurrences in the dataset • Remove all the observations where aircraft names are not available • Display the observations where fatal flag is "Yes" 5. Analyze the "auto mpg data" and draw a pair plot using seaborn	Module 4	R4,5,6

	library for mpg, weight, and origin. (a) Origin: This dataset was taken from the StatLib library maintained at Carnegie Mellon University. • Number of Instances: 398 • Number of Attributes: 9 including the class attribute • Attribute Information: • mpg: continuous • cylinders: multi-valued discrete • displacement: continuous • horsepower: continuous • weight: continuous • acceleration: continuous • model year: multi-valued discrete • origin: multi-valued discrete • car name: string (unique for each instance) 6. Write python program to use SciPy to solve a linear algebra problem.		
5.	1. Write python program to study linear regression 2. Write python program to study multiple linear regression 3. Write python program to study logistic regression 4. Write python program to study Support Vector Machine 5. Write python program to study decision tree algorithm 6. Write python program to study two-way communication between client and server.	Module 5	R4,5,6

Laboratory Assessment:

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 examination will be held based on the above syllabus.

Vertical – 5

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

Course Code	Course Name	Examination Scheme						
		Theory Marks				Term Work	Practical/ Oral	Total
		Internal assessment			End Sem. Exam			
		Test1	Test 2	Avg. of 2 Tests				
2994511	**Business Model Development**	--	--	--	--	25	25	50

Lab Objectives:

1. To introduce a learner to the 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 to the building blocks of a business
5. To teach a learner to plan their own business with the help of Business Model Canvas

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
7. prepare a complete Business Model Canvas for their own business / busine

DETAILED SYLLABUS:

Sr. No.	Module	Detailed Content	Hours	LO Mapping
0	Prerequisite	Basic Design Thinking principles	1	L2
I	1	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	**4**	**L2, L3**
II	2	Entrepreneurship Development: Types of business ownerships: Proprietorship, Public and Private Companies, Co-operative businesses, Micro, Small and Medium Enterprises (MSME): Definition and role of MSMEs in economic development	5	L2, L3
III	3	**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	4	L2, L3
IV	4	**Intellectual Property Rights (IPR):** Types of IPR: Patents, trademarks and copyrights, Patent search and analysis, Strategies for IPR protection, Ethics in technology and innovation	**4**	**L2,L3**
V	**5**	**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:**	**4**	**L5, L6**

		The Art of the Start 2.0: The Time-Tested, Battle-Hardened Guide for Anyone Starting Anything by Guy Kawasaki		
VI	**6**	**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		**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
10		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 10 lab activities based on the above list. Also, Term work journal must include any 2 assignments from the above list.
Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiment) + 5 Marks (Assignments) + 5 Marks (Attendance)
Oral Exam: An oral 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
2994512	Design Thinking	-	2*+2 Hours Batch-Wise	-	-	2	-	2

Course Code	Course Name	Examination Scheme						
		Theory Marks				Term Work	Practical/ Oral	Total
		Internal assessment			End Sem. Exam			
		Test1	Test 2	Avg. of 2 Tests				
2994512	Design Thinking	--	--	--	--	25	25	50

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 expose a learner to various case studies of Design Thinking

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	1	**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	5	**L1, L2**
II	**2**	**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	5	**L2, L3**
III	3	**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	**5**	**L2, L3**
IV	4	**Ideate:** What is ideation? Need for ideation, Ideation techniques, Guidelines for ideation: Multi-disciplinary approach, Imitating with grace, Breaking patterns, Challenging assumptions,	**5**	**L3, L7**

		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		
V	5	**Prototype:** Low and high-fidelity prototypes, Paper prototype, Story board prototype, Scenario prototype	**3**	**L6**
VI	6	**Test:** 5 guidelines of conducting test, The end goals of test: Desirability, Feasibility and Viability, Usability testing	**3**	**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: *Says, Thinks, Feels, and Does*. Interview users or research their experiences to fill in the map.	3
02	Based on research, students will create user personas including demographic details, motivations, pain points, and goals. Each group will present their persona to the class.	3
03	Consider 3 examples of real-life products which have good design and bad design. Write down reasons why do you think they are good or bad designs. May take user survey to support your work.	3
04	Study any open-source design thinking tool and write a brief report about it.	3

Assessment:

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

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

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

Vertical – 6

(Open Electives and MDM Courses)

Detailed Syllabus

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
OE401	Robotics and Its Applications	L	T	P	L	T	P	Total
		2	--	--	2	--	--	2
		Examination Scheme						
			IA1	IA2	ESE		Total	
		Theory	20	20	60		100	

Course Objectives:

1. To introduce Robotics and discuss the Functional concepts of Robots
2. To explore and learn Configurations of Robots and their Kinematics
3. To introduce path planning techniques for Robotics
4. To explore sensors and understand the concepts of drives and grippers
5. To understand the applications of Robotics
6. To learn about Humanoid Robotics Technology and Social Robots

Course Outcomes	After the successful completion students should be able to	
	CO1	Understand the significance, social impact and future prospects of robotics and automation in various engineering applications.
	CO2	Understand the various configurations and kinematics of robots
	CO3	Know about various path planning techniques
	CO4	Learnt about sensors used in robots along with concepts of drives and grippers
	CO5	Explored the domains of applications for robotics
	CO6	Know about the Humanoid Robotics Technology and Social Robots.

Module No.	Topics	Reference	Hrs.
1	**Introduction:**	T1	4

	Introduction to Robotics, Laws of robot, brief history of robotics, basic components of robot, robot specifications, classification of robots, human system and robotics, safety measures in robotics, social impact, Robotics market, and the future prospects, advantages and disadvantages of robots.	T3 R6	
2	**Configuration and Kinematics** Robot configurations: polar, cylindrical, Cartesian, and jointed arm configurations, Robot links and joints, Degrees of freedom: types of movements, vertical, radial and rotational traverse, roll, pitch and yaw, Wok volume/envelope, Robot kinematics: Introduction to direct and inverse kinematics, transformations and rotation matrix.	T1 T3 R3	4
3	**Sensors** Characteristics of sensing devices, Criterion for selections of sensors, Classification, & applications of sensors. Internal sensors: Position sensors, & Velocity sensors, External sensors Internal sensors: Position sensors, & Velocity sensors, External sensors: Proximity sensors, Tactile Sensors, & Force or Torque sensors	T3 T5 R3	5
4	**Drives and Grippers:** Drives – Basic types of drives. Advantages and Disadvantages of each type. Selection / suitability of drives for Robotic application. Controllers, Types of Controllers, and introduction to close loop controller Grippers – Mechanisms for actuation, Magnetic gripper vacuum cup	T1 T5 R5	5
5	**Robotics Applications:** Material Handling: pick and place, palletizing and depalletizing, machining loading and unloading, welding & assembly, Medical, agricultural and space applications, unmanned vehicles: ground, Ariel and underwater applications, robotic for computer integrated manufacturing. Types of robots: Manipulator, Legged robot, wheeled robot, aerial robots, Industrial robots, Humanoids, Robots, Autonomous robots, and Swarm robots	T1 T3 R6	5
6	**Humanoid Robotics Technology and Social Robots:** Sensors in Humanoid Robot, Control of Humanoid Robot, actuation types for humanoid Robot, System Integration in Humanoid Robot, Social Robot, Need of Social Robots, Assistive and Social Robots in the Healthcare Sector and other, Case study On Humanoid Robot.	T4 T5 R5	5
Total			**26**

Course Assessment:

Theory:

IA1: One hours 20 Marks written examination for one hour
IA2: One hours 20 Marks written examination for one hour

ESE: Two hours 60 Marks written examination for two hours

Reference Books:

1. S. K. Saha, Introduction to Robotics, TATA McGraw Hills Education, 2014.
2. S. B. Nikku, Introduction to Robotics – Analysis, Control, Applications, 3rd edition, John Wiley & Sons Ltd., 2020.
3. Mikell Groover, Mitchell Weiss, Roger N. Nagel, Nicholas Odrey, Ashish Dutta, Industrial Robotics 2nd edition, SIE, McGraw Hill Education (India) Pvt. Ltd., 2012
4. Ganesh S Hegde, "A textbook on Industrial Robotics", University science press,

3rdedition, 2017.
5. S.R. Deb, Robotics Technology and flexible automation, Tata McGraw-Hill Education, 2009.

Text Books:

1. John J. Craig, Introduction to Robotics, Pearson Education Inc., Asia, 3rd Edition, 2005.
2. Asitava Ghoshal, Robotics: Fundamental concepts and analysis, Oxford University Press, 2006.
3. Elmer P. Dadios, "Humanoid Robot: Design and Fuzzy Logic Control Technique for Its Intelligent Behaviors", 2012.
4. Fu K S, Gonzalez R C, Lee C.S.G, "Robotics: Control, Sensing, Vision and Intelligence",McGraw Hill, 1987.

Letter Grades and Grade Points:

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

Sd/-

Dr. R.N.Awale
BoS-Chairman-Electronics Engineering
Faculty of Technology

Sd/-

Dr. Deven Shah
Associate Dean
Faculty of Science & Technology

Sd/-

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