Department of
Electronics and Telecommunication Engineering

Syllabus (NEP Scheme)

Sem-V and Sem -VI
w.e.f. A.Y. 2025-26

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Department of Electronics and Telecommunication

Semester V Scheme								
Course Type	**Course Name**	**Teaching scheme (Contact Hours)**			**Credits Assigned**			
		Th	**Pr**	**Tut**	**Th**	**Pr**	**Tut**	**Total**
Programme Core Course (PCC)	Antenna and Wave Propagation	3	2	-	3	1	-	4
Programme Core Course (PCC)	Microprocessor and Microcontrollers	3	2	-	3	1	-	4
Programme Core Course (PCC)	Digital Signal Processing	3	2	-	3	1	-	4
Programme Elective	Program Elective Course -I	4	-	-	4	-	-	4
Multidisciplinary Minor (MDM)	MDM Course -III	4	-	-	4	-	-	4
Open Elective(OE)	Open Elective Course -II	4	-	-	4	-	-	4
Total Credits					21	03	--	**24**

* Tutorial for complete class

Program Elective Course -I

Course Code	Name Of The Subject
NETPE51	Digital and IPTV Engineering
NETPE52	Control Systems for space crafts
NETPE53	Microelectronics

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Department of Electronics and Telecommunication

Multidisciplinary Minor (MDM Course III)

Course Code	Name Of The Subject
NETMM51	Information & Web App Management

Open Elective Course-II

Course Code	Name Of The Subject
NOE502	Geographical Information System
NOE503	AI For HealthCare
NOE504	Social Media Analytics
NOE505	Mobile App Development

Semester V Marks Scheme							
Course Type	**Course Name**	**TH**	**MT**	**CA**	**TW**	**PR/OR**	**Total**
Programme Core Course (PCC)	Antenna and Wave Propagation	60	20	20	25	25	150
Programme Core Course (PCC)	Microprocessor and Microcontrollers	60	20	20	25	25	150
Programme Core Course (PCC)	Digital Signal Processing	60	20	20	25	25	150
Programme Core Course (PCC)	Program Elective Course -I	60	20	20	-	-	100
Multidisciplinary Minor (MD M)	MDM Course -III	60	20	20	-	-	100
Open Elective(OE)	Open Elective Course -II	60	20	20	-	-	100
Total Marks							**750**

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Department of Electronics and Telecommunication

COURSE NAME: ANTENNAS AND WAVE PROPAGATION

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/ PR	Tut	Total
NETPC51	Antennas and Wave Propagation	03	02	---	03	01	---	04

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Department of Electronics and Telecommunication

Antennas and Wave Propagation

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/ PR	Tut	Total
NETPC51	Antennas and Wave Propagation	03	02	---	03	01	---	04

Course Code	Course Name	Examination Scheme					
		Theory			Term Work	Practical & Oral	Total
		Internal Assessment		End Sem Exam			
		Mid-Term Test	CA				
NETPC51	Antennas and Wave Propagation	20	20	60	-	-	100

Course Prerequisite: Electromagnetic Field Two port network Transmission Line	
Course Objectives:	
1	To learn the fundamental parameters of Antenna
2	To learn about linear wire antenna and its types
3	To learn about Antenna arrays and synthesis
4	To learn about various Special types of Antennas
5	To learn about Radio wave propagation
Course Outcomes: After successful completion of the course students will be able to:	
1	To understand the significance of antenna parameters like radiation pattern, directivity, gain etc.
2	To understand the field equations of linear wire antennas.
3	To design linear antenna arrays and understand the concept of synthesis.

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Department of Electronics and Telecommunication

4	To design and understand the various applications of Special types of Antennas.
5	To understand the different modes of Radio wave propagation.

Antennas and Wave Propagation

Module		Content	Hrs
1		**Antenna Fundamentals**	**06**
	1.1	Introduction : Types and Applications of Antennas, Radiation mechanism. Antenna Parameters: Radiation pattern, Radiation power density, Radiation Intensity, Gain, Directivity, HPBW, FNBW, Beam efficiency, Bandwidth, Polarization, Input Impedance, Reflection coefficient, Return loss, VSWR, Antenna Efficiency, Effective Aperture, Friis transmission equation.	
2		**Linear Wire Antennas**	**06**
	2.1	Introduction : Infinitesimal dipole, Small dipole, Finite-length dipole, Half-wave dipole - Radiation zones, Total radiated power, Radiation resistance, Directivity, Effective area. Comparative study of Dipole, Monopole and Folded Dipole antenna.	
3		**Antenna Arrays**	**12**
	3.1	Introduction : Two-element array - Array factor and Pattern multiplication, Case study of two Isotropic point sources, N-element Linear Array (uniform spacing and amplitude), Broad-side and End-fire arrays, Phased array, Directivity of Hansen woodyard endfire array, N-element Linear Array (uniform spacing and non uniform amplitude) Binomial array, Dolph-Chebyshev array, Examples, Planar arrays.	
	3.2	Array Pattern synthesis: Fourier series method, Binomial arrays, The array polynomial, Chebyshev arrays, Super directive arrays.	
4		**Special Antennas I:**	**05**
	4.1	**Broadband Antennas** : Introduction, Principle of Helical Antenna, Introduction and design of Yagi Uda array	

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Department of Electronics and Telecommunication

		Frequency Independent Antenna : Introduction, Principle and design of Log Periodic Antenna **Narrowband Antenna** : Introduction, Principle and design of Rectangular Microstrip Antenna	
5		**Special Antennas II:**	**05**
	5.1	**Aperture Antennas** : Introduction, Principle of Plane Reflector, Corner Reflector, Parabolic Reflector Antenna. **Advanced Antennas** : Introduction - Dielectric Resonator Antenna, Wearable Antenna, Reconfigurable Antenna.	
6		**Radio Wave Propagation**	**05**
	6.1	Modes of propagation, Structure of atmosphere, Ground wave propagation, Tropospheric propagation, Duct propagation, Troposcatter propagation, Flat earth and Curved earth concept, Sky wave propagation – Virtual height, critical frequency, Maximum usable frequency – Skip distance, Fading, Multi hop propagation.	
		Total	**39**

Textbooks:	
1	C. A. Balanis, "Antenna Theory Analysis and Design", John Wiley & Sons, Third Edition, 2016.
2	J.D. Kraus, R.J. Marhefka, and A.S. Khan, "Antennas & Wave Propagation", Fourth Edition, McGraw Hill 2011.
3	R. E. Collin, "Antennas and Radio Wave Propagation", International Student Edition, McGraw Hill, Fourth Edition, 1985.
4	G. Kumar, K. P. Ray, "Broadband Microstrip Antenna", Artech House, First Edition, 2002.
5	K.D. Prasad, SatyaPrakashan, "Antennas and Wave Propagation," Tech. India Publications, New Delhi, 2001.
Reference Books:	

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1	Warren L. Stutzman, Gary A. Thiele, "Antenna Theory and Design", John Wiley & Sons, 1981.

Access to NPTEL course:

	https://archive.nptel.ac.in/courses/108/101/108101092/

Any other (Access to AI tools / Data driven insights (if applicable) or any other):

	https://www.mathworks.com/products/matlab.html
	https://www.scilab.org/

Internal Assessment:

1) Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks.
2) Mid Term test is to be conducted when approx. 50% syllabus is completed.
3) Duration of the midterm test shall be one hour.

Continuous Assessment:

Continuous Assessment is of **20 marks**. The rubrics for assessment will be considered on approval by the subject teachers. The rubrics can be any 2 or max 4 of the following:

Sr. No	Rubrics	Marks
1	Certificate course for 4 weeks or more: NPTEL/ Coursera/ Udemy/any MOOC	10 marks
2	Wins in the event/competition/hackathon	10 marks
3	Content beyond syllabus presentation	10 marks
4	Creating Proof of concept	10 marks
5	Mini Project / Extra Experiments/ Virtual Lab	10 marks
6	GATE Based Assignment test/Tutorials etc	10 marks
7	Participation in event/workshop/ talk / competition followed by small report and certificate of participation relevant to the subject (in other institutes)	05 marks

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Department of Electronics and Telecommunication

8.	Multiple Choice Questions (Quiz)	05 marks
9.	Peer Review and participation in the class	05 Marks

End Semester Theory Examination:	
1	Question paper will be of 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.

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Department of Electronics and Telecommunication

COURSE NAME: Antennas and Wave Propagation Lab

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/ PR	Tut	Total
NETPCL51	Antennas and Wave Propagation Lab	---	2	---	---	1	---	1

Course Code	Course Name	Examination Scheme					
		Theory			Term Work	Practical & Oral	Total
		Internal Assessment		End Sem Exam			
		Mid-Term Test	CA				
NETPCL51	Antennas and Wave Propagation Lab	---	---	---	25	25	50

Prerequisite : Antennas and Wave Propagation Laboratory 1. Fundamentals of Electromagnetics	
Lab Objectives:	
1	To study the radiation mechanism of an antenna and its various parameters.
2	To study the radiating principles of various Special types of Antennas.
Lab Outcomes:	
1	To understand the radiation mechanism of an antenna and its basic parameters like radiation pattern, directivity, gain etc.

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Department of Electronics and Telecommunication

2	To understand the radiation properties of Antenna Array and Special Antennas such as Yagi Uda Antenna, Horn Antenna, Reflector Antenna, Microstrip Antenna etc.

Antennas and Wave Propagation laboratory

Sr. No.	Title of Experiment
1	To plot the radiation pattern of the Dipole antenna.
2	To plot the radiation pattern of Yagi Uda antenna.
3	To simulate the FRIIS Transmission Equation.
4	To simulate the principle of Pattern Multiplication of two dipoles.
5	To plot the Array Factor pattern for a Uniform Linear Broadside array.
6	To plot the Array Factor pattern for a Uniform Linear Endfire array.
7	To plot the radiation pattern of a log Periodic antenna.
8	To plot the radiation pattern of a Helical antenna.
9	To plot the radiation pattern of the Parabolic Reflector antenna.
10	To design, simulate, fabricate and test Microstrip antenna.

Term Work:	
1	Term work should consist of 8 experiments.
2	The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
3	Total **25 Marks** (Experiments: 20-marks, Attendance Theory & Practical: 05-marks)
Practical & Oral Exam:	
1	Based on the experiments, practical exam and oral should be conducted
2	Total **25 Marks**

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COURSE NAME: Microprocessor and Microcontrollers

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/ PR	Tut	Total
NETPC52	Microprocessor and Microcontrollers (Theory)	03	02	---	03	01	---	04

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Department of Electronics and Telecommunication

Microprocessor and Microcontrollers (Theory)

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/ PR	Tut	Total
NETPC52	Microprocessor and Microcontrollers (Theory)	03	---	---	03	---	---	03

Course Code	Course Name	Examination Scheme					
		Theory			Term Work	Practical & Oral	Total
		Internal Assessment		End Sem Exam			
		Mid-Term Test	CA				
NETPC52	Microprocessor and Microcontrollers (Theory)	20	20	60	---	---	100

Course Prerequisite: Digital System Design	
Course Objectives:	
1	To equip students with the fundamental knowledge and basic technical competence in the field of Microprocessors.
2	To understand the architecture of 8051
3	To understand the architecture of the ARM7 core
4	To write programs for 8051 microcontrollers.
5	To understand the design of Microcontroller Applications.

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Department of Electronics and Telecommunication

Course Outcomes:	
After successful completion of the course students will be able to:	
1	Learn the architecture and pin configuration of 8086 Microprocessor
2	Understand the detailed architecture of 8051.
3	Understand the detailed architecture of ARM7 Core.
4	Write programs for 8051 microcontrollers.
5	Design an application using a microcontroller.

Microprocessor and Microcontrollers (Theory)

Module		Content	Hr
1		**8086 Microprocessor**	**5**
	1.1	Introduction to 8086, features, architecture, pin description, memory banking, memory segmentation, External memory interfacing, bus cycle.	
	1.2	Maximum mode bus cycle, memory interfacing, Minimum mode System configuration, Maximum mode system configuration, Interrupts processing	
2		**8051 Microcontroller**	**10**
	2.1	Comparison between Microprocessor and Microcontroller	
	2.2	Features, architecture and pin configuration	
	2.3	CPU timing and machine cycle	
	2.4	Input / Output ports	
	2.5	Memory organization	
	2.6	Counters and timers	
	2.7	Interrupts	

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Department of Electronics and Telecommunication

	2.8	Serial data input and output	
3		**8051 Assembly Language Programming and Interfacing**	**11**
	3.1	Addressing modes, Need of Assembler & Cross Assemble, Assembler Directives	
	3.2	Instruction Set	
	3.3	Programs related to: arithmetic, logical, delay subroutine , input, output, timer, counters, port, serial communication, and interrupts	
	3.4	Interfacing with LEDs, Relay and Keys	
4		**ARM7**	**4**
	4.1	Introduction & Features of ARM 7	
	4.2	Concept of Cortex-A, Cortex-R and Cortex-M	
	4.3	Architectural inheritance, Pipelining	
5		**ARM7 Instruction Set**	**6**
	5.1	Programmer's model	
	5.2	Brief introduction to exceptions and interrupts handling	
	5.3	Instruction set: Data processing, Data Transfer, Control flow	
6		**ARM7 based microcontroller**	**3**
	6.1	Understanding features, architecture & addressing modes of STM32.	
		Total	**39**

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Department of Electronics and Telecommunication

Textbooks:	
1	Krishna Kant, "Microprocessors and Microcontrollers", Prentice Hall of India, 2013.
2	M. A. Mazidi, J. G. Mazidi and R. D. Mckinlay, "The 8051 Microcontroller & Embedded systems", Pearson Publications, Second Edition 2006.
3	C. Kenneth J. Ayala and D. V. Gadre, "The 8051 Microcontroller & Embedded system using assembly & 'C' ", Cengage Learning, Edition 2010.
4	Steve Furber, "ARM System on chip Architecture", Pearson,2nd edition, 2001
Reference Books:	
1	Doughlas V.Hall, —Microprocessors and Interfacing, Programming and Hardware, TMH, 2012.
2	"MCS@51 Microcontroller, Family User's Manual" Intel
3	James A. Langbridge, "Professional Embedded Arm Development", Wrox, John Wiley Brand & Sons Inc., Edition 2014
4	Warren Gay, "Beginning STM32, 2018 edition.
Access to software:	
	https://www.st.com/resource/en/datasheet/stm32f205rf.pdf
	https://www.tutorialspoint.com/index.htm
	https://www.tutorialspoint.com/microprocessor/microprocessor_8086_overview.htm
Any other (Access to AI tools / Data driven insights (if applicable) or any other):	
	https://www.geeksforgeeks.org/arithmetic-instructions-8086-microprocessor/
	https://onlinecourses.nptel.ac.in/noc20_ee11/preview
	https://nptel.ac.in/courses/108105102

Internal Assessment:
1) Assessment consists of one Mid Term Test of **20 marks** and Continuous Assessment of **20 marks**.
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3) Duration of the midterm test shall be one hour.

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Department of Electronics and Telecommunication

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6	GATE Based Assignment test/Tutorials etc	10 marks
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8.	Multiple Choice Questions (Quiz)	05 marks
9.	Peer Review and participation in the class	05 Marks

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Department of Electronics and Telecommunication

COURSE NAME: Microprocessor and Microcontrollers Lab

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/PR	Tut	Total
NETPCL52	Microprocessor and Microcontrollers Lab	---	2	---	---	1	---	1

Course Code	Course Name	Examination Scheme					
		Theory			Term Work	Practical & Oral	Total
		Internal Assessment		End Sem Exam			
		Mid-Term Test	CA				
NETPCL52	Microprocessor and Microcontrollers Lab	---	---	---	25	25	50

Lab Objectives:	
1	To understand development tools of microcontroller based systems.
2	To learn programming for different microcontroller operation & interface to I/O devices.
3	To develop microcontroller based applications.
4	To learn programming and application based on STM32 board
Lab Outcomes:	

After successful completion of the course students will be able to:

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Department of Electronics and Telecommunication

1	Understand different development tools required to develop microcontroller based systems.
2	Write assembly language programs for arithmetic and logical operations, code conversion & data transfer operations.
3	Write assembly language programs for general purpose I/O, Timers & Interrupts.
4	Interface & write programs for Input and Output devices
5	Develop microcontroller based Applications.

Suggested Experiments: Students are required to complete at least 10 experiments.

Sr. No.	Name of the Experiment
1	Perform Arithmetic and Logical Operations (Using Immediate, Direct and Indirect addressing)
2	Code Conversion
3	Transfer of data bytes between Internal and External Memory
4	Experiments based on General Purpose Input-Output, Timers, Interrupts, Delay, etc.
5	Interfacing of Matrix Keyboard, LED, 7 Segment display, LCD, Stepper Motor, UART
6	Interfacing of STM32 with LED, Seven segment display, LCD, Keypad & Motors
7	Interfacing of STM32 with sensors like gas sensors, proximity sensors & temperature senator.

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Department of Electronics and Telecommunication

Term Work:		
1	Term work should consist of 10 experiments.	
2	The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.	
3	Total **25 Marks** (Experiments: 20-marks, Attendance Theory & Practical: 05-marks)	
Practical & Oral Exam:		
1	Based on the experiments, practical exam and oral should be conducted	
2	Total **25 Marks**	

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Department of Electronics and Telecommunication

COURSE NAME: Digital Signal Processing

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract	Tut	Theory	Pract	Tut	Total
NETPC53	Digital Signal Processing	3	--	--	3	--	--	3

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Pract & oral	Total
		Internal Assessment		End Sem Exam	Exam Duration (Hrs)				
		Mid Test (MT)	Continuous Assessment (CA)						
NETPC53	Digital Signal Processing	20	20	60	2		--	--	100

Course Code:	Course Title	Credit
NETPC53	Digital Signal Processing	3
Prerequisite: Mathematics for Communication		
Course Objectives:		

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Department of Electronics and Telecommunication

1	To introduce students to the idea of signal and system analysis and characterization in time and frequency domain.
2	To develop a thorough understanding of discrete fourier transforms and its use in spectral analysis and frequency domain filter designing.
3	To design and realize IIR filters and FIR filters, introduce the effects of finite word lengths on the filters.
4	To introduce applications of digital signal processing in the field of biomedical and audio signal processing.

Course Outcomes:

1	Classify and analyze different types of signals and systems.
2	Analyze LTI signals and systems in the transform domain.
3	Understand the concepts of discrete fourier transforms, fast Fourier transform and apply in system analysis. Recall the system representations and understand the relation between different transforms.
4	Design digital IIR and FIR filters and Comprehend the impact of finite word length effects on the digital filters.
5	Interpret the different realization structures of digital IIR and FIR filters.
6	Apply signal processing concepts, algorithms in applications related to the field of real-world signal processing.

Module		Content	Hrs
1		**Fundamentals of Discrete Time Signals and Systems**	**6**
		Introduction to analog and discrete signals: Definition, Basic Elementary signals - exponential, sine, step, impulse, ramp, rectangular, triangular. Operations on signals.	
	1.1	**Classification of Signals:** Even and odd signals, periodic and	

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Department of Electronics and Telecommunication

		non-periodic signals, deterministic and non-deterministic signals, energy and power signals.	
	1.2	**Discrete systems and classification of systems:** Discrete system representation, system with and without memory, causal and non-causal system, linear and nonlinear system, time invariant and time variant system, stable system.	
2		**Time domain analysis of discrete time systems**	**5**
	2.1	**Linear Time Invariant (LTI) systems:** Representation of discrete time systems using difference equations, impulse response, system stability and causality.	
	2.2	Use of convolution sum for analysis of LTI systems, properties of convolution sum, impulse response of interconnected systems, analogy between convolution and correlation.	
3		**Discrete Time Fourier Transform and Fast Fourier Transform**	**8**
	3.1	Discrete Time Fourier transform (DTFT), Discrete Fourier transform (DFT), Properties of DFT, DFT as a linear transformation, Relationship of the DFT to other transforms.	
	3.2	**Analysis of discrete time LTI systems using z-Transform:** Systems characterized by linear constant coefficient difference equation, transfer function, plotting poles and zeros of a transfer function, frequency response, causality and stability of systems, total response of a system.	
	3.3	Fast Fourier Transform: Radix-2 Fast Fourier Transforms (FFT), Radix-2 decimation in time , Inverse FFT , Introduction to decimation in frequency FFT algorithms, difference between DFT and FFT.	
4		**IIR Digital Filters**	**7**
	4.1	LTI systems as frequency-selective filters like low pass, high pass, band pass, notch, comb, and all-pass filters, Analog filter approximations for Butterworth Filters.	

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Department of Electronics and Telecommunication

	4.2	Mapping from s-plane to the z-plane - impulse invariant and bilinear transformation, Design of IIR Butterworth digital filter -from analog filter using impulse invariant and bilinear transformation techniques.	
5		**FIR Digital Filters**	**9**
	5.1	Characteristics of linear phase FIR digital filters, Symmetric and antisymmetric FIR filter, Location of the zeros of linear phase FIR filters, Minimum, maximum and mixed phase systems.	
	5.2	Design of FIR filters using Window techniques (Rectangular, Hanning, Bartlett).	
	5.3	Realization structures for IIR and FIR systems: Direct form 1, direct form 2, Cascade form and parallel form structures.	
	5.4	Introduction to the effects of Finite Word Length Effects on Digital Filters.	
6		**Applications of Digital Signal Processing**	**4**
	6.1	Introduction to Bio-medical signals: ECG, EEG, EMG, and EOG features. Removal of Artifacts and Interferences in ECG and EEG.	
	6.2	Introduction to Speech Processing analysis using DSP, Voiced and Unvoiced speech signal feature extraction: Energy and Zero Crossing Rate.	
		Total	**39**

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Department of Electronics and Telecommunication

Textbooks:	
1	Proakis J., Manolakis D., "Digital Signal Processing", 4th Edition, Pearson Education
2	Emmanuel C. Ifeachor, Barrie W. Jervis," Digital Signal Processing", A Practical Approach", Pearson Education
3	A Nagoor Kani "Digital Signal Processing", 2nd Edition, Tata Mc Graw Hill Education Private Limited
4	Nagoor Kani, Signals and Systems, Tata McGraw Hill, Third Edition, 2011.
Reference Books:	
1	Sanjit K. Mitra, "Digital Signal Processing – A Computer Based Approach ", 4th Edition McGraw Hill Education (India) Private Limited, 2013
2	Oppenheim A., Schafer R., Buck J., "Discrete Time Signal Processing", 2nd Edition, Pearson Education, 3rd Edition, 2010
3	L. R. Rabiner and B. Gold, "Theory and Applications of Digital Signal Processing", Prentice Hall of India, 2006
4	S Salivahan, C Gnanapriya, "Digital Signal Processing", McGraw Hill Education (India) limited, 4 th Edition, 2015
5	Monson H Hayes, "Digital Signal Processing", Schaum's Outline Series, 2 nd Edition, 2011
6	Rangaraj M. Rangayyan, "Biomedical Signal Analysis- A Case Study Approach", Wiley 2002
7	Fundamentals of Speech Recognition, L Rabinar, B. H. Juang, and B. Yegnanarayana, Pearson Publications, 2008.

VIVEKANAND EDUCATION SOCIETY'S
Institute of Technology

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Department of Electronics and Telecommunication

NPTEL/Swayam Courses:	
1	**Digital Signal Processing, Prof. T. K. Basu, IIT Kharagpur, https://archive.nptel.ac.in/courses/108/105/108105055/**

Internal Assessment:

Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks.

Mid Term test is to be conducted when approx. 50% syllabus is completed Duration of the midterm test shall be one hour.

Continuous Assessment:-

Continuous Assessment **is of 20 marks.** The assessment tools for the continuous assessment will be considered on approval by the subject teachers. The assessment tools can be any 2 or max 4 of the following:-

Sr.no	Assessment Tools	Marks
1.	*Certificate course for 4 weeks or more:- NPTEL/ Coursera/ Udemy/any MOOC	10 marks
2.	Wins in the event/competition/hackathon	10 marks
3.	Content beyond syllabus presentation	10 marks
4.	Creating Proof of concept	10 marks
5.	Mini Project / Extra Experiments/ Virtual Lab	10 marks
6.	GATE Based Assignment test/Tutorials etc	10 marks
7.	Participation in event/workshop/talk / competition followed by small report and certificate of participation relevant to the subject(in other institutes)	5 marks
8.	Multiple Choice Questions (Quiz)	5 Marks

*For sr.no.1, the date of the certification exam should be within the term and in case a student is unable to complete the certification, the grading has to be done accordingly.

VIVEKANAND EDUCATION SOCIETY'S

Institute of Technology

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Department of Electronics and Telecommunication

End Semester Theory Examination:	
1	Question paper will be of 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.

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Department of Electronics and Telecommunication

COURSE NAME: Digital Signal Processing Lab

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract	Tut	Theory	Pract	Tut	Total
NETPCL53	Digital Signal Processing Lab	--	2	--	--	1	--	1

Course Code	Course Name	Examination Scheme						
		Theory					Term Work	Pract & oral	Total
		Internal Assessment		End Sem Exam	Exam Duration (Hrs)			
		Mid Test (MT)	Continuous Assessment (CA)					
NETPCL53	Digital Signal Processing Lab	--	--	--	--	25	25	50

Lab Code	Lab Name	Credit
NETPCL53	Digital Signal Processing Lab	1

Prerequisite: C Programming Language.
Lab Objectives:

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Department of Electronics and Telecommunication

1	To carry out basic discrete signal processing operations
2	To implement and design FIR filters and IIR filters.
3	To implement applications related to the field of biomedical signal processing and audio signal processing. To develop troubleshooting abilities among students

Lab Outcomes:	
1	Perform basic discrete time signal processing operations such as Linear Convolution, Circular Convolution, Autocorrelation, Cross Correlation, etc. and interpret the results.
2	Demonstrate their ability towards interpreting and performing frequency analysis of different discrete time sequences and systems.
3	Design and implement the FIR and IIR Filters for given specifications.
4	Implement and analyze applications related to the field of biomedical signal processing and audio signal processing.

Suggested Experiments: Students are required to complete 8 to 10 experiments.	
Star (*) marked experiments are compulsory.	
Sr. No.	**Name of the Experiment**
1 *	To plot exponential, sine, step, impulse, ramp, rectangular, triangular, and perform operations on signals.
2 *	To classify system with and without memory, causal and non-causal system, linear and nonlinear system, time invariant and time variant system, stable system.
3 *	To perform linear convolution of two signals, auto correlation of non-periodic signals, periodic signals and random noise and interpret the results obtained.
4 *	To obtain cross correlation of a signal with its delayed and attenuated version (Concept of radar signal processing).

VIVEKANAND EDUCATION SOCIETY'S
Institute of Technology
(An Autonomous Institute Affiliated to University of Mumbai, Approved by A.I.C.T.E & Recognized by Govt. of Maharashtra)

Department of Electronics and Telecommunication

5 *	To determine impulse, magnitude, phase response and pole-zero plot of given transfer functions.
6*	To perform circular convolution and linear convolution of two sequences using DFT.
7 *	To perform the DFT of DT sequence and sketch its magnitude and phase spectrum or To Generate a discrete time signal having minimum three frequencies and analyse its frequency spectrum.
8	Implementation of fast Fourier transform algorithm to find DFT of a discrete time sequence.
9 *	Design of IIR digital filters and use the designed filter to filter an input signal which has both low and high frequency components or real-world signals like ECG/EEG, speech signal etc).
10	Design FIR filter using windowing method and use the designed filter to filter an input signal which has both low and high frequency components or real-world signal like ECG/EEG, speech signal etc.
11	Design of minimum phase, maximum phase and mixed phase systems.
12 *	To verify the location of zeros in symmetric and antisymmetric FIR filters.
13	To generate the ECG signal and detect the characteristic points
14	To extract delta, theta, alpha, sigma, and beta waveforms from EEG signals.
15*	Musical tone generation.
16	DTMF tone generation and detection.
17*	Speech signal analysis for voiced and invoice segments using energy and zero crossing rate.

Useful Links:	
1	Virtual Laboratory-http://vlabs.iitkgp.ernet.in/dsp/ for demonstration of concepts like DFT and its inverse, FIR filter using windowing method etc
2.	Virtual Laboratory: DSP Toolkit https://bmsip-iitr.vlabs.ac.in/exp/dsp-toolkit/theory.html?

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Department of Electronics and Telecommunication

Term Work:	
1	Term work should consist of 8 to 10 experiments.
2	The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
3	Total 25 Marks (Experiments: 15-marks journal writeup, : Performance and Knowledge and skills in the experimentation: 05- marks, Regularity in Practicals: 05-marks)

VIVEKANAND EDUCATION SOCIETY'S
Institute of Technology

(An Autonomous Institute Affiliated to University of Mumbai, Approved by A.I.C.T.E & Recognized by Govt. of Maharashtra)

Department of Electronics and Telecommunication

COURSE NAME: Digital & IPTV Engineering

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/ PR	Tut	Total
PEC501	Digital & IPTV Engineering (Theory)	04	---	---	04	---	---	04

VIVEKANAND EDUCATION SOCIETY'S
Institute of Technology

(An Autonomous Institute Affiliated to University of Mumbai, Approved by A.I.C.T.E & Recognized by Govt. of Maharashtra)

Department of Electronics and Telecommunication

Digital & IPTV Engineering (Theory)

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/ PR	Tut	Total
NETPE51	Digital & IPTV Engineering (Theory)	04	---	---	04	---	---	04

Course Code	Course Name	Examination Scheme					
		Theory			Term Work	Practical & Oral	Total
		Internal Assessment		End Sem Exam			
		Mid Term Test	CA				
NETPE51	Digital & IPTV Engineering (Theory)	20	20	60	---	---	100

Course Prerequisite: Basics of various Television standards and operation, TCP/IP Protocol, Basics of conventional video camera and standards	
Course Objectives:	
1	To provide in depth knowledge about Digital Television system
2	To familiarize students about various types of advanced types of Video cameras and Displays
3	To introduce the students to different television standards and applications
4	Acquaintance with HDTV and 3D TV system
5	To familiarize the students to IPTV, its architecture, protocols and hardware
6	To Introduce students to IP delivery networks, threats and mitigation
Course Outcomes:	

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Institute of Technology

Department of Electronics and Telecommunication

After successful completion of the course students will be able to:	
1	To understand the fundamentals and working principles of advanced digital television systems
2	To enable to choose or develop an appropriate camcorder and displays devices based on applications
3	To become familiar with current digital advanced TV standards
4	To understand fundamentals of IPTV
5	To acquire knowledge of IPTV and develop hardware and communication protocols
6	To provide customized IPTV services to end user with knowledge of IP delivery networks, threats and mitigation

Digital & IPTV Engineering (Theory)

Module		Content	Hrs
1		**Fundamentals of Digital Television**	**10**
	1.1	Fundamentals of colour television, Compatibility, and reverse compatibility, colour perception, Three colour theory, luminance, hue and saturation. Interlaced scanning, Composite video signal	
	1.1	Introduction to Digital TV, Digital TV signals and parameters	
	1.2	Digital TV transmitter and receiver its merits and demerits	
	1.3	MAC Signals and advanced MAC Signal Transmission	
	1.4	Digitization, Chroma subsampling, Digital audio compression techniques and video compression techniques MPEG1, MPEG2, H.264, MPEG- 4, AVC, H.265, SMPTE 421M	
	1.5	Set Top Box with recording	
2		**Digital Video Cameras, Displays and Streaming media device**	**6**
	2.1	Colour TV Digital cameras, Camcorders, Handycams, and Digicams	
	2.2	LED, LCD, OLED, PLASMA, Quantum Dot LED Displays	
	2.3	Chromecast	
	2.4	Consumer applications: DVD, Blu-Ray Disc	

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Institute of Technology

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Department of Electronics and Telecommunication

3		**Digital TV standards and advanced TV**	12
	3.1	DVB-T, and its successors	
	3.2	ISDB –T	
	3.3	ATSC	
	3.4	ISD TV	
	3.5	DTMB	
	3.6	Ultra HDTV	
	3.7	CCTV	
	3.8	Direct to Home TV(DTH)	
	3.9	Smart TV and its functions	
	3.10	3D TV	
4		**IPTV**	8
	4.1	Introduction to IPTV	
	4.2	IPTV hardware	
	4.3	Features of IPTV	
	4.4	Architecture of IPTV	
	4.5	Bandwidth requirement	
	4.6	IPTV Set top Box, Smart TV comparison	
5		**IPTV Protocols and Applications**	8
	5.1	Internet Group Management Protocol (IGMP)	
	5.2	Real-Time Streaming Protocol (RTSP)	
	5.3	Real-Time Messaging Protocol (RTMP)	
	5.4	Hypertext Transfer Protocol (HTTP)	
	5.5	Applications of IPTV	
	5.6	IPTV Delivery: Broad cast, Unicast, Multicast	
	5.7	IPTV Streaming: Time Shifted Stream-On -the- fly streaming	
6		**IPTV Network Security: Threats and Countermeasures**	8
	6.1	Threats on IPTV Delivery Networks, Theft or Abuse of Network Assets, Theft of Service, Theft of IPTV-Related Data, Disruption of Service, Privacy Breach, Compromise of Platform Integrity	
	6.2	Security Issues of IPTV Delivery Networks: Protocols, Vulnerabilities, Countering the threats	
	6.3	Advantages and disadvantages of IPTV	

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(An Autonomous Institute Affiliated to University of Mumbai, Approved by A.I.C.T.E & Recognized by Govt. of Maharashtra)

Department of Electronics and Telecommunication

	6.4	Future of IPTV		
			Total	**52**

Textbooks:	
1	A. M. Dhake, *"Television and video Engineering,"* Tata McGraw Hill Publication, Second Edition, 2017.
2	Kelth jack, *"Video Demystified"*, Hand book for Digital Engineers, Newness, Elsevier, 4th Edition, 2005.
3	Marcelo S. Alencar, *"Digital Television Systems"*, Cambridge University Press, March 2009
4	Gilbert Held, *"Understanding IPTV"*, CRC Press, Auerbach Publication, First Edition, 2007.
Reference Books:	
1	D. Gerbarg, *" The digital evolution of Television"*, Springer, (Author: Darcy Gerbarg Publication: Springer eBook, Publisher: Springer Nature, Date: Jan 1, 2009)
2	Maris Jos Abisolo, "Applications and Usability of interactive TV", Springer (Publisher: Springer International Publishing AG, ISBN: 9783319389066, Number of pages: 161, 1st edition 2016.)
3	Suliman Mohamed Fati, Saiful Azad, Al-Sakib Khan Pathan, *"IPTV Delivery Network"*, Wiley Publications, 2018
4	R. G. Gupta, *"Television Engineering & Video Systems"*, McGraw Hill Publication, Second Edition, 2017.
5	Morteza Sasani Ghamsari, *"Quantum dot based light emitting diodes"*, Google book, 2020

Internal Assessment:

1) Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks.
2) Mid Term Test is to be conducted when approx. 50% syllabus is completed.
3) Duration of the midterm test shall be one hour.

VIVEKANAND EDUCATION SOCIETY'S
Institute of Technology

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Department of Electronics and Telecommunication

Continuous Assessment:

Continuous Assessment is of **20 marks**. The rubrics for assessment will be considered on approval by the subject teachers. The rubrics can be any 2 or max 4 of the following:

Sr. No	Rubrics	Marks
1	Certificate course for 4 weeks or more: NPTEL/ Coursera/ Udemy/any MOOC	10 marks
2	Wins in the event/competition/hackathon	10 marks
3	Content beyond syllabus presentation	10 marks
4	Creating Proof of concept	10 marks
5	Mini Project / Extra Experiments/ Virtual Lab	10 marks
6	GATE Based Assignment test/Tutorials etc	10 marks
7	Participation in event/workshop/talk / competition followed by small report and certificate of participation relevant to the subject (in other institutes)	05 marks
8.	Multiple Choice Questions (Quiz)	05 marks
9.	Peer Review and participation in the class	05 Marks

End Semester Theory Examination:	
1	Question paper will be of 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.

VIVEKANAND EDUCATION SOCIETY'S
Institute of Technology

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Department of Electronics and Telecommunication

COURSE NAME: CONTROL SYSTEM FOR SPACE CRAFTS

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/ PR	Tut	Total
NETPE52	Control System for space crafts (Theory)	04	---	---	04	---	---	04

VIVEKANAND EDUCATION SOCIETY'S

Institute of Technology

(An Autonomous Institute Affiliated to University of Mumbai, Approved by A.I.C.T.E & Recognized by Govt. of Maharashtra)

Department of Electronics and Telecommunication

Control System for space crafts(Theory)

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/ PR	Tut	Total
NETPE52	Control System for space crafts (Theory)	04	---	---	04	---	---	04

Course Code	Course Name	Examination Scheme					
		Theory			Term Work	Practical & Oral	Total
		Internal Assessment		End Sem Exam			
		Mid-Term Test	CA				
NETPE52	Control System for space crafts (Theory)	20	20	60	---	---	100

Course Prerequisite: Matrices and Differential Calculus, Integral Calculus and Complex Numbers	
Course Objectives:	
1	To build a strong foundation in mathematics, provide students with mathematics fundamentals necessary to formulate, solve and analyse complex engineering problems.
2	To prepare students to apply reasoning informed by the contextual knowledge to engineering practice, to work as part of teams on multi-disciplinary projects.
Course Outcomes:	
After successful completion of the course students will be able to:	

VIVEKANAND EDUCATION SOCIETY'S

Institute of Technology

(An Autonomous Institute Affiliated to University of Mumbai, Approved by A.I.C.T.E & Recognized by Govt. of Maharashtra)

Department of Electronics and Telecommunication

1	Construct the mathematical models of the physical systems.
2	Analyze the system using transient response and steady-state specifications.
3	Determine the stability of the system in the frequency domain.
4	Determine the controllability and observability properties of the system.
5	Design the controller and observer via pole-placement techniques.
6	Design the linear state-feedback control for a spacecraft that has a nonlinear model.

Control System for space crafts(Theory)

Module		Contents	Hrs.
1		**Introduction to Control Systems and Mathematical Modelling**	8
	1.1	Introduction to Control Systems: The block diagram representation of open loop and closed loop control systems. Linear vs Nonlinear Systems, Linear time invariant vs Linear time varying systems.	
	1.2	Mathematical Modelling: Modelling of electrical and mechanical systems in time domain, linearization of the system at the operating point, state space representation of linear systems with physical variables. Frequency domain modelling : Transfer function.	
2		**Time response analysis of first and second order LTI systems**	8
	2.1	Time response analysis: Pole-zero mapping of first and second order systems and their implications, standard test signals, time response of first and second order systems, time response specifications	
	2.2	Steady state analysis: steady state errors and error constants.	
3		**Frequency domain stability analysis**	10
	3.1	Stability analysis : Stability analysis using Routh stability criterion, Root locus technique.	

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(An Autonomous Institute Affiliated to University of Mumbai, Approved by A.I.C.T.E & Recognized by Govt. of Maharashtra)

Department of Electronics and Telecommunication

	3.2	Stability analysis using Bode plots.	
4		**State space analysis**	**10**
	4.1	State space representation in various in canonical forms, invariance of eigenvalues and non-uniqueness of state space representation,	
	4.2	Controllability and observability properties, state transition matrix and solution to the state equation.	
	4.3	Concept of stability via Lyapunov theorems, Lyapunov equation, stability analysis via Lyapunov equations for physical systems.	
5		**State Feedback control and observer design**	**8**
	5.1	Concept of state feedback control, computation of state feedback gain via comparison of characteristic equations and Ackermann's formula.	
	5.2	Need of observer, full order observer design.	
6		**Case Study : Control of Spacecraft**	**8**
	6.1	Modelling of spacecraft, linearization to get a LTI model.	
	6.2	State Feedback Controller design using modern control schemes.	
		Total	**52**

Textbooks:	
1	I. J. Nagrath, M. Gopal, "Control System Engineering", 5th edition, New Age International Publishers.
2	B. S. Manke, "Linear Control Systems", Khanna Publishers, New Delhi.
3	Franklin Powell, "Digital Control of Dynamic Systems", Addison-Wesley Publications.

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Institute of Technology
(An Autonomous Institute Affiliated to University of Mumbai, Approved by A.I.C.T.E & Recognized by Govt. of Maharashtra)

Department of Electronics and Telecommunication

Reference Books:	
1	K. Ogata, "Modern Control Engineering", PHI, New Delhi.
2	Norman S. Nise, "Control System Engineering", John Wiley and Sons.
3	B. C. Kuo, "Automatic Control Systems", PHI, New Delhi.

Internal Assessment:
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3) Duration of the midterm test shall be one hour.

Continuous Assessment:

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Sr. No	Rubrics	Marks
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3	Content beyond syllabus presentation	10 marks
4	Creating Proof of concept	10 marks
5	Mini Project / Extra Experiments/ Virtual Lab	10 marks
6	GATE Based Assignment test/Tutorials etc	10 marks
7	Participation in event/workshop/talk / competition followed by small report and certificate of participation relevant to the subject (in other institutes)	05 marks
8.	Multiple Choice Questions (Quiz)	05 marks

VIVEKANAND EDUCATION SOCIETY'S
Institute of Technology

(An Autonomous Institute Affiliated to University of Mumbai, Approved by A.I.C.T.E & Recognized by Govt. of Maharashtra)

Department of Electronics and Telecommunication

End Semester Theory Examination:	
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VIVEKANAND EDUCATION SOCIETY'S
Institute of Technology

(An Autonomous Institute Affiliated to University of Mumbai, Approved by A.I.C.T.E & Recognized by Govt. of Maharashtra)

Department of Electronics and Telecommunication

COURSE NAME: Microelectronics

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract	Tut	Theory	Pract	Tut	Total
NETPE53	**Microelectronics**	**4**	--	--	**4**	--	--	**4**

Course Code	Course Name	Examination Scheme						
		Theory					Term Work	Pract & oral	Total
		Internal Assessment		End Sem Exam	Exam Duration (Hrs)			
		Mid Test (MT)	Continuous Assessment (CA)					
NETPE53	**Microelectronics**	**20**	**20**	**60**	**2**	--	--	**100**

Course Code:	Course Title	Credit
NETPE53	Microelectronics	4
Prerequisite: Electronics Devices and Circuits		
Course Objectives:		
1	To understand integrated circuit biasing using MOSFET.	
2	To analyze a single stage active load MOS amplifier.	
3	To understand implementation of passive components in ICs.	

VIVEKANAND EDUCATION SOCIETY'S
Institute of Technology
(An Autonomous Institute Affiliated to University of Mumbai, Approved by A.I.C.T.E & Recognized by Govt. of Maharashtra)

Department of Electronics and Telecommunication

4	To analyze active load differential amplifier
5	To understand the Basics of IC Design and Fabrication.

Course Outcomes:	
1	To introduce the physics of semiconductor materials for understanding the device modeling of semiconductor devices.
2	Analyze various constant current source circuits using MOS .
3	To design and implement an active load MOS amplifier.
4	To design and implement an active load differential amplifier.
5	Analyze how scaling influences parasitic elements such as capacitances and resistances, especially in modern high-speed ICs.
6	To develop an understanding of how different fabrication steps work together to create functional ICs

Module		Content	Hrs
1		**Semiconductor Electronics**	**06**
	1.1	Physics of Semiconductor Materials, Band Model of Solids, Thermal-Equilibrium Statistics, Carriers in Semiconductors.	
	1.2	Drift Velocity, Mobility and Scattering, Drift & Diffusion Current, Hall-Effect.	
2		**Integrated Circuit Biasing & Active Loads using MOSFET**	
	2.1	Current Mirror, cascade current source, Wilson current source, bias independent current source using MOSFET,DC analysis and small signal analysis of MOS active load, DC analysis and small signal analysis of MOS advanced active load	**10**
3		**Single Stage MOS Active Load amplifiers**	
	3.1	CS amplifier with current source load, CS amplifier with diode connected load, CS amplifier with current source load, Common	**08**

VIVEKANAND EDUCATION SOCIETY'S
Institute of Technology
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Department of Electronics and Telecommunication

		gate circuit, Cascode amplifier, Double Cascoding, Folded Cascode.	
4		**Active Load MOSFET Differential Amplifier**	
	4.1	Basic MOS Differential Amplifier, DC transfer characteristics, small signal equivalent analysis, MOS differential amplifier with active load, MOS differential amplifier with cascode active load,	**10**
5		**Basic Circuit Element**	**08**
	5.1	Monolithic resistors construction and characteristics- Diffused resistors, Epitaxial resistors, pinched resistors, Ion implantation resistors.	
	5.2	MOS resistors, monolithic capacitors-Junction Capacitor, MOS capacitors, poly-poly capacitors, MOS device as capacitor,IC Inductors.	
6		**Introduction to IC Fabrication**	**10**
	6.1	General classification of Monolithic Circuits, Definition of LSI , MSI, VLSI. Thin film Technology, Thin film conductor material , resistor material and substrate material, Thin film processing techniques, thin film resistor and capacitor design guidelines,Concept of sheet resistance.	
	6.2	Various important steps of Mos bipolar IC fabrication Crystal growing, wafer cleaning, oxidation, annealing, patternization using photolithography technique, diffusion, metallization, ion-implantation etc (only qualitative treatment)	
		Total	**52**

VIVEKANAND EDUCATION SOCIETY'S
Institute of Technology

(An Autonomous Institute Affiliated to University of Mumbai, Approved by A.I.C.T.E & Recognized by Govt. of Maharashtra)

Department of Electronics and Telecommunication

Textbooks:	
1	A. Sedra, K. Smith, adapted by A. Chanorkar —"Microelectronic Circuits-Theory and Application Advanced engineering mathematics", Oxford Higher Education, 7th Edition
2	D. Neamen, —"Electronic Circuits Analysis and Design", McGraw Hill Education, 3rd Edition
3	B. Razavi, —"Design of Analog Integrated Circuits", McGraw Hill Education, Indian Edition.
4	Integrated circuits - K.R. Botkar (9th Edition),Khanna Publication.
Reference Books:	
1	B. Razavi, "R F Microelectronics", Pearson Publication, 2nd Edition
2	Physics of Semiconductor Devices by S. M. Sze and Kwok K. Ng, 3rd Edition, (John Wiley & Sons, 2002).
3	"Microelectronics: Semiconductor Devices and Circuits" by Jacob Millman and Arvin Grabel, 2nd Edition, McGraw-Hill Education-1987
4	Semiconductor Device Fundamentals by Robert F. Pierret, Addison-Wesley Publishing, 1996
NPTEL/Swayam Courses:	
1	https://onlinecourses.nptel.ac.in/noc21_ee86/

Internal Assessment:

Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks.

Mid Term test is to be conducted when approx. 50% syllabus is completed Duration of the midterm test shall be one hour.

Continuous Assessment:-

Continuous Assessment **is of 20 marks.** The assessment tools for the continuous assessment will be considered on approval by the subject teachers. The assessment tools can be any 2 or max 4 of the following

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Department of Electronics and Telecommunication

Sr.no	Assessment Tools	Marks
1.	*Certificate course for 4 weeks or more:- NPTEL/ Coursera/ Udemy/any MOOC	10 marks
2.	Wins in the event/competition/hackathon	10 marks
3.	Content beyond syllabus presentation	10 marks
4.	Creating Proof of concept	10 marks
5.	Mini Project / Extra Experiments/ Virtual Lab	10 marks
6.	GATE Based Assignment test/Tutorials etc	10 marks
7.	Participation in event/workshop/talk / competition followed by small report and certificate of participation relevant to the subject(in other institutes)	5 marks
8.	Multiple Choice Questions (Quiz)	5 Marks

*For sr.no.1, the date of the certification exam should be within the term and in case a student is unable to complete the certification, the grading has to be done accordingly.

End Semester Theory Examination:	
1	Question paper will be of 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.

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Department of Electronics and Telecommunication

COURSE NAME: INFORMATION & WEB APP MANAGEMENT

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/PR	Tut	Total
NETMM51	Information & Web App Management	04	---	---	04	---	---	04

Course Code	Course Name	Examination Scheme					
		Theory			Term Work	Practical & Oral	Total
		Internal Assessment		End Sem Exam			
		Mid-Term Test	CA				
NETMM51	Information & Web App Management (Theory)	20	20	60	---	---	100

Course Prerequisite: Computer Networks, Cryptography, Ethical hacking & forensic	
Course Objectives:	
1	To focus on cybercrime and need to protect information.
2	Understand the types of attacks, how to tackle the amount of risk involved and access control techniques
3	Discuss the role of industry standards and legal requirements with respect to compliance.
4	The terms, concept and countermeasures of application Security, Threats, and Attacks

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Institute of Technology
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Department of Electronics and Telecommunication

5	Understand the Secure Application Design and Architecture
6	Interpret different threat modeling approaches

Course Outcomes:
After successful completion of the course students will be able to:

1	Understand the scope of policies and measures of information security.
2	Apply risk assessment methodology and the role of access control to Identity management.
3	Interpret various standards available for information security.
4	Enumerate the terms of application Security, Threats , Attacks and describe the countermeasures for the threats discussed.
5	Explain the Secure Application Design and Architecture.
6	Review the different Security Scanning -testing techniques and threat modeling approach

Information & Web App Management (Theory)

Module		Content	Hrs
1		**Basics of Information Security**	**6**
	1.1	Basics Principles of Confidentiality, Integrity & Availability. Administrative Measures and Technical Measures, People, Process, Technology, IT ACT 2000, IT ACT 2008	
	1.2	Standards available for InfoSec: Cobit, ISO 27001, OWASP, OSSTMM	
2		**Risk Management and IAM**	**10**
	2.1	Threat, Threat-Source, Vulnerability, Attacks . Risk Assessment Frameworks: ISO 31010, NIST-SP-800-30, OCTAVE	
	2.2	Concepts of Identification, Authentication, Authorization and Accountability. Access Control Models: Discretionary, Mandatory, Role based and Rule-based.	

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Institute of Technology
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Department of Electronics and Telecommunication

	2.3	Access Control Techniques: Constrained User, Access control Matrix, Content-dependent, Context – dependent	
	2.4	Threats to Access Control: Various Attacks on the Authentication Systems.	
3		**Operation Security**	**10**
	3.1	Concept of Availability, High Availability, Redundancy and Backup.	
	3.2	Calculating Availability, Mean Time Between Failure (MTBF), Mean Time to Repair (MTTR)	
	3.3	Disaster Recovery:Metric for Disaster Recovery, Recovery Time Objective (RTO), Recovery Point Objective (RPO), Work Recovery Time (WRT), Maximum Tolerable Downtime (MTD), Business Process Recovery, Facility Recovery (Hot site, Warm site, Cold site, Redundant site), Backup & Restoration	
	3.4	Types of Audits in Windows Environment , Endpoint protection, Shadow Passwords, SUDO users, etc.	
4		**Introduction to Application Security, Threats and Attacks**	**7**
	4.1	Introduction to Web Application Reconnaissance, Finding Subdomains, API Analysis, Identifying Weak Points in Application Architecture	
	4.2	Offence and defence against it: Cross-Site Scripting (XSS), Cross-Site Request Forgery (CSRF), XML External Entity (XXE) Injection, Injection Attacks, Denial of Service (DoS), Cross-Origin Resource Sharing Vulnerabilities	
5		**Secure Application Design and Architecture**	**9**
	5.1	Secure Software Development Lifecycle Averting Disaster Before It Starts, Team Roles for Security, Security in the Software Development Lifecycle	
	5.2	Design Flaw vs. Security Bug, Secure Design Concepts, Segregation of Production Data, Application Security Activities	

VIVEKANAND EDUCATION SOCIETY'S

Institute of Technology

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Department of Electronics and Telecommunication

6		**Security Scanning-Testing and Threat Modeling**	**10**
	6.1	Testing Your Code, Testing Your Application, Testing Your Infrastructure, Testing Your Database, Testing Your APIs and Web Services, Testing Your Integrations, Testing Your Network, Dynamic Web Application Profiling	
	6.2	Objectives and Benefits of Threat Modeling, Defining a Risk Mitigation Strategy, Improving Application Security, Building Security in the Software Development Life Cycle	
	6.3	Existing Threat Modeling Approaches Security, Software, Risk-Based Variants Threat Modeling Within the SDLC Building Security in SDLC with Threat Modeling, Integrating Threat Modeling Within the Different Types of SDLCs	
		Total	**52**

Textbooks:	
1	Shon Harris, Fernando Maymi, CISSP All-in-One Exam Guide, McGraw Hill Education, 7 th Edition, 2016.
2	Andrei Miroshnikov, Introduction to Information Security - I, Wiley, 2018
3	Ron Lepofsky, The Manager's Guide to Web Application Security, Apress; 1st ed. edition, 2014
4	Alice and Bob Learn Application Security, by Tanya Janca Wiley; 1st edition (4 December 2020)
5	Web Application Security, A Beginner's Guide by Bryan Sullivan McGraw-Hill Education; 1st edition (16 January 2012)
6	Web Application Security: Exploitation and Countermeasures for Modern Web Applications by Andrew Hoffman Shroff/O'Reilly; First edition (11 March 2020)
7	The Security Development Lifecycle by Michael Howard Microsoft Press US; 1st edition (31 May 2006)
8	Risk Centric Threat Modeling Process for Attack Simulation And Threat Analysis, Tony Ucedavélez and Marco m. Morana, Wiley

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Institute of Technology

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Department of Electronics and Telecommunication

9	Iron-Clad Java: Building Secure Web Applications (Oracle Press) 1st Edition by Jim Manico
Reference Books:	
1	Rich-Schiesser, IT Systems Management: Designing, Implementing and Managing World - Class Infrastructures, Prentice Hall; 2 edition, January 2010.
2	Dr. David Lanter – ISACA COBIT – 2019 Framework - Introduction and Methodology
3	NIST Special Publication 800-30, Guide for Conducting Risk Assessments, September 2012
4	Software Security: Building Security In by Gary McGraw Addison-Wesley Professional; 1st edition (January 23, 2006)
5	A Guide to Securing Modern Web Applications by Michal Zalewski
6	Threat Modeling: A Practical Guide for Development Teams by Izar Tarandach and Matthew J. Coles Dec 8, 2020
Online Resources:	
1	https://www.ultimatewindowssecurity.com/securitylog/book/Default.aspx
2	http://www.ala.org/acrl/resources/policies/chapter14
3	https://advisera.com/27001academy/what-is-iso-27001/
4	https://owasp.org/www-project-top-ten/
5	https://owasp.org/www-pdf-archive/OWASP_SCP_Quick_Reference_Guide_v2.pdf
6	https://pentesterlab.com/
7	https://app.cybrary.it/browse/course/advanced-penetration-testing
Any other (Access to AI tools / Data driven insights (if applicable) or any other/Courses):	
1	NPTEL Course: - Introduction to Information Security – I (URL: https://nptel.ac.in/noc/courses/noc15/SEM1/noc15-cs03/)

Internal Assessment:

1)   Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks.

2)   Mid Term test is to be conducted when approx. 50% syllabus is completed.

3)   Duration of the midterm test shall be one hour.

Continuous Assessment:

Continuous Assessment is of **20 marks**. The rubrics for assessment will be considered on approval by the subject teachers. The rubrics can be any 2 or max 4 of the following:

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Department of Electronics and Telecommunication

Sr. No	Rubrics	Marks
1	Certificate course for 4 weeks or more: NPTEL/ Coursera/ Udemy/any MOOC	10 marks
2	Wins in the event/competition/hackathon	10 marks
3	Content beyond syllabus presentation	10 marks
4	Creating Proof of concept	10 marks
5	Mini Project / Extra Experiments/ Virtual Lab	10 marks
6	GATE Based Assignment test/Tutorials etc	10 marks
7	Participation in event/workshop/talk / competition followed by small report and certificate of participation relevant to the subject (in other institutes)	05 marks
8.	Multiple Choice Questions (Quiz)	05 marks
9.	Peer Review and participation in the class	05 Marks

End Semester Theory Examination:	
1	Question paper will be of 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.

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Department of Electronics and Telecommunication

Open Elective Course -II

Geographical Information Systems

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/ PR	Tut	Total
NOE502	Geographical Information Systems	03	01	–	03	01	-	04

VIVEKANAND EDUCATION SOCIETY'S
Institute of Technology

(An Autonomous Institute Affiliated to University of Mumbai, Approved by A.I.C.T.E & Recognized by Govt. of Maharashtra)

Department of Electronics and Telecommunication

Geographical Information Systems (Theory)

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/PR	Tut	Total
NOE502	Geographical Information Systems	03	01	–	03	01	-	04

Course Code	Course Name	Examination Scheme					
		Theory			Term Work	Practical & Oral	Total
		Internal Assessment		End Sem Exam			
		Mid-Term Test	CA				
NOE502	Geographical Information Systems	20	20	60	---	---	100

Course Objectives: The course aims to:

1	Provide fundamental understanding of Geographic Information Systems (GIS) and Remote Sensing (RS) technologies
2	Introduce concepts of geospatial data, spatial data models, and data quality
3	Teach spatial analysis methods and GIS data visualization techniques
4	Explore principles of remote sensing, image interpretation, and sensor systems
5	Familiarize students with map projections, coordinate systems, and cartographic design

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Department of Electronics and Telecommunication

6	Equip students with the knowledge to apply GIS in urban planning, infrastructure,disaster management, and environmental monitoring

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

1	**Define** the core concepts of GIS and Remote Sensing, and explain their components, structure, and applications
2	**Differentiate** between spatial data models and understand data input, storage,quality issues
3	**Interpret** geospatial data using map projections, coordinate systems, and cartographic principles
4	**Perform** vector and raster-based spatial analyses including buffering, overlay,and spatial interpolation
5	**Explain** the principles of remote sensing, energy interactions, satellite platforms,and image interpretation
6	**Apply** GIS and RS techniques in real-world applications such as urban planning, environmental monitoring, and disaster management

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Department of Electronics and Telecommunication

Syllabus

Sr. No.	Module	Detailed Content	Hours
I	Introduction to GIS	Defining GIS, GIS Systems, GIS Applications Spatial data, Geo information, Understanding maps and data, Data layers,Spatial data types, Characteristics of spatial data, Metadata, Making great maps, Data visualization principles, GIS software GIS architecture and functionality, Spatial Data Infrastructure(SDI), Spatial data handling and preparation, Spatial data and maintenance, Spatial query and analysis, Spatial data presentation, Linking GIS and DBMS, Spatial database functionality	6
II	Geospatial Data And Mapping Concepts	Geospatial data, Geographic coordinate system, Datum and reference systems, Map projections, Commonly used map projections, UTM grid system, Map scale, Types of maps, Cartographic symbolization, Typography in maps, Map design principles, Map production techniques, Layout design, Cartographic generalization, Interpretation Of topographic maps	6
III	Data Models and Quality Issues	Vector data model, Topological models, Non-topological models, Attribute data entry, Vector data query, Field and attribute manipulation, Raster data model, Elements of raster structure, Types of raster data, Raster queries,Data compression, Data conversion, Raster-vector integration, Data input methods, Data editing techniques, Data quality components, Accuracy, Precision, Resolution, Consistency, Completeness, Common Sources of error in GIS	6

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Institute of Technology
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Department of Electronics and Telecommunication

IV	GIS data Analysis & Spatial Modelling	Data exploration, Descriptive statistics, Graphical Data and representation, Dynamic graphics, Vector data analysis, Buffering, Overlay, Distance Measurement, Pattern analysis Map manipulation, Raster data analysis, Local operations, Neighborhood operations, Zonal operations, Data extraction, Data generalization, Comparison of raster and vector analysis,Spatial interpolation, Global interpolation methods, Local interpolation methods, Slope analysis, Aspect analysis, Terrain Mapping	7
V	GIS Project Planning & Applications	Principles of remote sensing, Electromagnetic spectrum basics, Energy sources in remote sensing, Interaction of energy with Earth's surface, Atmospheric interaction, Spectral reflectance characteristics, Remote sensing platforms, Satellite systems, Sensor parameters, Imaging sensors, Earth resource satellites, Meteorological satellites, Remote sensing data formats, Standard products, Image interpretation, Elements of image interpretation	7
VI	GIS Project Planning & Applications	GIS project planning, Project implementation stages, Project management in GIS, Case study of GIS application, Multimedia GIS, Internet GIS, Web-based GIS, Mobile GIS, GISplanning, GIS in municipal applications, GIS for infrastructure development, GIS for disaster management, GIS for environmental monitoring	7
		Total	**39**

Text Books:

1	Introduction to Geographic Information Systems by Kang-tsung Chang, published by Tata McGraw-Hill, 3rd Edition.
2	Remote Sensing and Geographical Information Systems by M. Anji Reddy, published by B.S.Publications, 2nd Edition.
3	Remote Sensing and GIS by Basudeb Bhatta, published by Oxford University Press, 2nd Edition.
4	An Introduction to Geographical Information Systems by Ian Heywood, SarahCornelius, others, published by Pearson Education, 2nd Edition.

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Department of Electronics and Telecommunication

References:

1	*Concepts and Techniques of Geographic Information Systems* by **C.P. Lo andAlbertK.W. Yeung**, published by **Prentice Hall**, 2nd Edition
2	*Geographic Information Systems and Science* by **Paul A. Longley, Michael F. Goodchild, David J. Maguire, and David W. Rhind**, published by **Wiley**, 3rd Edition
3	*Manual of Remote Sensing – Vol. 1 & 2* edited by **Robert A. Ryerson andAndrewN.Rencz**, published by **American Society for Photogrammetry and Remote Sensing(ASPRS)**

End Semester Theory Examination: 60 Marks	
1	The question paper will consist of 5 questions, each carrying 20 marks.
2	The students need to solve any 3 questions.
Internal Assessment: 40 Marks (Mid Term Test 20 Marks + Continuous assessment 20 Marks)	
The assessment consists of one Mid-team Test of 20 Marks and a Continuous Assessment of 20 Marks. The Mid Term Test is to be conducted when approximately 50%syllabus is completed and its duration will be one hour.	

Continuous Assessment: 20 marks
Continuous Assessment is of 20 marks. The Continuous Assessment marks would be assigned by the subject teacher based on the practical's done by the student.

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Department of Electronics and Telecommunication

Geographical Information Systems (Lab)

Syllabus:

Sr. No.	Detailed Content	Hrs
I	GIS software basics, GUI components, layer loading, spatial vs. non-spatial data, symbology, file formats (shapefiles, GeoTIFF)	2
II	Coordinate systems, map projections, control points, transformation methods, RMS error ,Vector data model, editing tools, topology, snapping, attribute creation	2
III	Geographic/projected coordinate systems, datum, UTM/WGS84, re-projection, Attribute tables, field types, SQL basics, spatial and attribute queries	3
IV	Buffering principles, overlay tools, spatial relationships, topology rules,Terrain Analysis: Generating slope, aspect, hillshade from DEM **Topics:** DEM, slope/aspect, hillshade	2
V	Remote sensing basics, tone, texture, shape, resolution Spectral signatures, classification algorithms, training data, accuracy assessment	2
VI	Cartographic design principles, layout manager, exporting maps	2
	Total	**13**

Note: Suggested List of Tutorials is indicative. However, flexibility lies with individual course instructors to design and introduce new, innovative and challenging tutorials, (limited to maximum 30% variation to the suggested list) from within the curriculum, so that the fundamentals and applications can be explored to give greater clarity to the students and they can be motivated to think differently.

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Department of Electronics and Telecommunication

Course Name : Artificial Intelligence for Healthcare

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/ PR	Tut	Total
NOE503	Artificial Intelligence for Healthcare (Theory)	03	---	01	03	---	01	04

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/ PR	Tut	Total
NOE503	Artificial Intelligence for Healthcare (Theory)	03	---	01	03	-	01	04

Course Code	Course Name	Examination Scheme					
		Theory			Term Work	Practical & Oral	Total
		Internal Assessment		End Sem Exam			
		Mid-TermTest	Continuous Assessment				
NOE503	Artificial Intelligence for Healthcare (Theory)	20	20	60	---	---	100

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Institute of Technology

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Department of Electronics and Telecommunication

Course Objectives: The course aims :	
1	Understand fundamentals of AI and ML and their applications in medicine
2	Explore advanced AI techniques like deep learning, RL, and NLP
3	Learn AI applications in medical imaging, diagnostics, disease prediction, and treatment planning
4	Examine ethical, legal, and social issues of AI in medicine
5	Gain hands-on experience through tools and projects
6	Critically evaluate AI research and real-world applications in healthcare
Course Outcomes: After successful completion of the course, the student will be able to:	
1	To understand the fundamentals of artificial intelligence and machine learning and their applications in medicine.
2	To explore advanced AI techniques, including deep learning, reinforcement learning, and natural language processing.
3	To learn about the use of AI in medical imaging, diagnostics, disease prediction, and treatment planning.
4	To examine the ethical, legal, and social implications of AI in medicine, including issues of bias, privacy, and equity.
5	To gain hands-on experience with AI tools and platforms through practical exercises and projects.
6	To critically evaluate research studies and applications of AI in healthcare.

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Department of Electronics and Telecommunication

Detailed Syllabus:

Unit No.	Module Title	Course Content (Topics and Subtopics)	Hours
1	Introduction to AI in Healthcare	Definition and scope of AI in healthcare, Role of AI in modern healthcare systems, AI-assisted diagnostics and treatments, Applications of AI in clinical decision support systems (CDSS), AI in medical research and drug discovery, Examples of AI-powered healthcare systems	6
2	AI for Medical Diagnostics and Imaging	Overview of Machine Learning and Deep Learning, Basics of medical image analysis, Image classification and segmentation using AI, Computer Vision applications in radiology and pathology, AI-assisted diagnosis for diseases, Introduction to Generative AI in medical imaging	7
3	Predictive Analytics and Disease Management	AI models for disease prediction and prognosis,Predictive modeling for early disease detection,Personalized healthcare using AI, Monitoring chronic diseases using AI-based wearable devices, Case studies on AI in disease management (e.g., Diabetes, Heart disease)	6
4	Natural Language Processing (NLP) in Healthcare	Fundamentals of NLP in medical data analysis,Clinical text processing and medical report analysis, Information extraction from Electronic Health Records (EHR),AI chatbots and virtual assistants for patient support Applications of NLP in medical analysis	7
5	Data Mining and Big Data Analytics in Healthcare	Introduction to Data Mining in Healthcare,Techniques for data extraction, preprocessing, and cleansing, **Big Data Analytics in Healthcare:** Characteristics of big data in healthcare,Tools for big data management (e.g., Hadoop, Spark) **IBM Watson in Healthcare:** Watson's role in medical diagnostics and decision-making,Case studies of IBM Watson applications	7

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Institute of Technology
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Department of Electronics and Telecommunication

6	Ethics, Challenges, and Future Trends in AI Healthcare	Ethical considerations in AI healthcare applications,Bias, fairness, and explainability in medical AI,Data privacy and security concerns (HIPAA, GDPR compliance),Regulatory frameworks for AI in healthcare,Emerging trends: Generative AI, Digital Twins, Federated Learning in healthcare	6
		Total	**39**

References:	
1	Russell, S. and Norvig, N. Artificial Intelligence: A Modern Approach. Prentice Hall Series in Artificial Intelligence
2	AI-First Healthcare by Kerrie L. Holley, Siupo Becker Released April 2021, Publisher(s): O'Reilly Media, Inc.ISBN: 9781492063155
3	"AI and Machine Learning for Healthcare" – Arvind Rajan (O'Reilly)
4	"Machine Learning and AI for Healthcare: Big Data for Improved Health Outcomes" – by Arjun Panesar
5	"Healthcare Analytics Made Simple: Techniques in Healthcare Computing Using Machine Learning and Python" – by Vikas (Vik) Kumar

Useful Links:	
1	https://onlinecourses.nptel.ac.in/noc21_cs84/preview – NPTEL: AI for Healthcare by IIT Madras
2	https://ai4health-course.github.io/ – AI for Health Course (MIT, Harvard, Stanford inspired)
3	https://monai.io/ – MONAI: Medical Open Network for AI (PyTorch framework for healthcare)
4	https://www.deeplearning.ai/programs/ai-for-medicine/ – DeepLearning.AI: AI for Medicine Specialization

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Department of Electronics and Telecommunication

5	https://mimic.physionet.org/ – MIMIC-III: Medical Information Mart for Intensive Care (Clinical Dataset)

Sr. No.	Rubrics	Marks
1	Continuous Assessment, Quizzes based on Tutorial	20 marks

End Semester Theory Examination:	
1	Question paper will be of 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.

VIVEKANAND EDUCATION SOCIETY'S

Institute of Technology

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Department of Electronics and Telecommunication

Course Name : Social Media Analytics

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/PR	Tut	Total
NOE504	Social Media Analytics (Theory)	03	---	01	03	---	01	04

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/PR	Tut	Total
NOE504	Social Media Analytics (Theory)	03	---	01	03	---	01	04

Course Code	Course Name	Examination Scheme					
		Theory			Term Work	Practical & Oral	Total
		Internal Assessment		End Sem Exam			
		Mid- Term Test	Continuous Assessment				
NOE504	Social Media Analytics (Theory)	20	20	60	---	---	100

VIVEKANAND EDUCATION SOCIETY'S

Institute of Technology

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Department of Electronics and Telecommunication

Course Objectives: The course aims :	
1	Introduce and familiarize learners with the basics of social networks (nodes, edges, graphs, paths)
2	Introduce various fundamental measures in social networks (centrality, density, clustering).
3	Explore various community detection and network clustering techniques.
4	Familiarize the learners with concepts of link analysis and prediction.
5	Familiarize the learner with advanced social network topics like text analytics and social information filtering.
6	Introduce the concept of Social media analytics and its various applications across popular social media.
Course Outcomes: After successful completion of the course, the student will be able to:	
1	Understand the concept of Social networks and how to represent them.
2	Analyze and interpret social networks using different Social network measures.
3	Detect and analyze communities in Social networks.
4	Implement and design algorithms for Link analysis and link prediction in Social networks.
5	Analyze the effectiveness of social media for business applications.
6	Interpret the social media landscape and implement projects for real life social media applications.

Social Media Analytics (Theory)

Module	Detailed Content	Hours
1	**Introduction to Social Networks/Media:** Overview and Basic Concepts, Definition and importance of Social Networks and Social Network Analysis.(SNA), Historical background and evolution of SNA.Three Levels of SNA, Applications and tools. Preliminaries and Basic concepts: nodes, edges, graphs, networks. Graph Visualisation Tools, Social Media Analytics (SMA) Cycle, Challenges to Social Media Analytics, SMA Tools.	6

VIVEKANAND EDUCATION SOCIETY'S

Institute of Technology

(An Autonomous Institute Affiliated to University of Mumbai, Approved by A.I.C.T.E & Recognized by Govt. of Maharashtra)

Department of Electronics and Telecommunication

2	**Network Measures:** **Network Basics** - Degree and Degree Distributions, Paths, Clustering Coefficient, Connected Components **Node Centrality** – Degree centrality, Closeness Centrality, Betweenness centrality, Edge Betweenness centrality, Assortativity, Transitivity and Reciprocity, Similarity. **Properties of Real-World Networks –** High Average Local Clustering Coefficient, Small-world Property, Scale-free Property. **Random Network Model**- Degree Distribution of Random Network, Evolution of a Random Network, Average Path Length, Clustering Coefficient, Random Network vs. Real-world Network	8
3	**Community Structure in Networks:** Definition of Communities in social networks, Applications of Community Detection, Types of Communities. **Community Detection Methods:** Disjoint Community Detection- Node-Centric Community Detection, Modularity and Community Detection- Louvain Algorithm, Girvan Newman; Overlapping Community Detection: Clique Percolation, Link Partition; Local Community Detection	7
4	**Link Analysis:** Applications of Link Analysis, **Signed Networks** - Balance Theory of Undirected Signed Networks, Status Theory of Signed Networks, Triad Balance vs Status, **Strong and Weak Ties** - Strength of a Ties, Triadic Closure, Dunbar Number, Local Bridges and Importance of Weak Ties. **Link Prediction-** Applications of Link Prediction, Temporal Changes in a Network, Heuristic Models, Probabilistic Models, Latest Trends in Link Prediction	6
5	**Social Information Filtering:** **Social Media Text Analytics**- Types of Social Media Text, Purpose of Text Analytics, Steps in Text Analytics, Social Media Text Analysis. **Social Information Filtering**- Social Sharing and filtering , Automated Recommendation systems, Traditional Vs social Recommendation Systems. Understanding Social Media and Business Alignment, Social Media KPI, Formulating a Social Media Strategy, Managing Social Media Risks.	4

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Institute of Technology

(An Autonomous Institute Affiliated to University of Mumbai, Approved by A.I.C.T.E & Recognized by Govt. of Maharashtra)

Department of Electronics and Telecommunication

6	**Social Media Analytics and Applications:** Introduction to popular social media platforms, (Facebook, Twitter, Instagram, LinkedIn etc), Key characteristics of social media data, (unstructured, large-scale, user-generated).Differences between traditional data and social media data. Tools for Social media Analytics Applications of Social media Analytics with Case studies - Mining Twitter (X), Facebook, Instagram, LinkedIn, Github	8
	TOTAL	39

Textbooks:	
1	Social Network Analysis, Tanmoy Chakraborty, Wiley Publications 2021
2	Mining the Social Web, 3rd Edition, by Matthew A. Russell, Mikhail Klassen
3	Analyzing the Social Web 1st Edition by Jennifer Golbeck

References:	
1	P.M., Krishna & Mohan, Ankith & Srinivasa, K..Practical Social Network Analysis with Python. Springer
2	Mining the Social Web, 3rd Edition, by Matthew A. Russell, Mikhail Klassen
3	Social Media Analytics: Techniques and Insights for Extracting Business Value Out of Social Media, Matthew Ganis, Avinash Kohirkar, IBM Press
4	Python Social Media Analytics: Analyze and visualize data from Twitter, YouTube, GitHub, and more Kindle Edition by Siddhartha Chatterjee , Michal Krystyanczuk
5	Learning Social Media Analytics with R, byRaghav Bali, Dipanjan Sarkar, Tushar Sharma.

Useful Links:	
1	https://cse.iitkgp.ac.in/~pawang/courses/SC16.html
2	https://onlinecourses.nptel.ac.in/noc20_cs78/preview
3	https://nptel.ac.in/courses/106106146

VIVEKANAND EDUCATION SOCIETY'S
Institute of Technology

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Department of Electronics and Telecommunication

| 4 | https://www.cs.cornell.edu/home/kleinber/networks-book |
| 5 | https://networksciencebook.com/ -   Albert-László Barabási |

Sr. No.	Rubrics	Marks
1	Continuous Assessment and Quizzes based on tutorials.	20 marks

*For sr. no.1, the date of the certification exam should be within the term and in case a student is unable to complete the certification, the grading has to be done accordingly.

End Semester Theory Examination:	
1	Question paper will be of 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.

VIVEKANAND EDUCATION SOCIETY'S

Institute of Technology

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Department of Electronics and Telecommunication

Mobile App Development

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/PR	Tut	Total
NOE505	Mobile App Development	03	01	---	03	01	---	04

Mobile App Development (Theory)

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/PR	Tut	Total
NOE505	Mobile App Development	03	01	---	03	01	---	04

Examination Scheme							
Course Code	Course Name	Theory			Term Work	Practical & Oral	Total
		Internal Assessment		End Sem Exam			
		Mid Term Test	Continuous Assessment				
NOE505	Mobile App Development (Theory)	20	20	60	-	---	100

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Department of Electronics and Telecommunication

Course Prerequisite: Knowledge of any programming language.	
Course Objectives:	
1	Learn the basics of the Flutter framework.
2	Develop the App UI by incorporating widgets, layouts, gestures, and animation
3	Create a production ready Flutter App by including files and Firebase backend service.
4	To equip learners with skills to implement effective unit, widget, and integration testing in Flutter applications, ensuring code reliability and maintainability.
5	To provide hands-on knowledge of deploying Flutter apps to Android and iOS platforms, configuring CI/CD pipelines, and managing post-deployment analytics.
6	To introduce Flutter Web development, focusing on responsive UI, state management, performance optimization, and deployment on modern hosting platforms.
Course Outcomes: After successful completion of the course students will be able to:	
1	Understand cross platform mobile application development using Flutter framework
2	Design and Develop interactive Flutter App by using widgets, layouts, gestures and animation
3	Analyze and Build production ready Flutter App by incorporating backend services and deploying on Android / iOS
4	Learners will be able to design, write, and automate Flutter tests across various levels, analyze failures, and improve code quality using modern testing tools and practices.
5	Learners will be capable of preparing production-ready Flutter apps, deploying them to app stores, automating releases with CI/CD tools, and handling real-time user feedback.
6	Learners will gain the ability to build and deploy responsive, performant Flutter web applications with PWA features, API integrations, and SEO considerations.

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Institute of Technology

(An Autonomous Institute Affiliated to University of Mumbai, Approved by A.I.C.T.E & Recognized by Govt. of Maharashtra)

Department of Electronics and Telecommunication

Module	Contents	Hrs
1	**Cross-Platform Development:** **Understanding Flutter:** Introduction of Flutter, Understanding Widget Lifecycle Events, Dart Basics, Widget Tree and Element Tree, Basics of Flutter installation, Flutter Hello World App. **Dart Programming:** main() function, Dart Variables, Dart Data Types, Dart Conditional Operators, Control Flow & Loops. Dart Functions - Functions, Function Structure, creating a Function, Function Returning Expression. Object-Oriented Programming (OOP) - Creating a Class, Adding Methods to Classes, Class — Getters and Setters, Class Inheritance, Abstract Class.	7
2	**Developing Flutter UI: Widgets, Layouts, Gestures, Animation:** USING COMMON WIDGETS: Safe Area, Appbar, Column, Row, Container, Buttons, Text , Richtext, Form ,Images and Icon. BUILDING LAYOUTS : high level view of layouts, Creating the layout, Types of layout widgets APPLYING GESTURES: Setting Up Gesture Detector, Implementing the Draggable and Drag target Widgets, Using the Gesture Detector for Moving and Scaling ADDING ANIMATION TO AN APP :Using Animated Container, Using Animated Cross Fade, Using Animated Opacity, Using Animation Controller, Using Staggered Animation CREATING AN APP'S NAVIGATION: Using the Navigator, Using the Named Navigator Route, Using the Bottom Navigation Bar, Using the Tab Bar and Tab Bar View	7

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Institute of Technology
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Department of Electronics and Telecommunication

3	**Creating Production Ready Apps:** Working with files : Including libraries in your Flutter app, Including a file with your app, Reading/Writing to files, Using JSON. Using Firebase with Flutter: Adding the Firebase and Firestore Backend, Configuring the Firebase Project, Adding a Cloud Fire store Database and Implementing Security Testing and Deploying of Flutter Application: Widget testing, Deploying Flutter Apps on Android / iOS	6
4	**Flutter Testing: Introduction to Testing in Flutter:** Importance of Testing in App Development,Types of Testing: Unit, Widget, and Integration,Setting Up Flutter Testing Environment **Unit Testing:** Writing Unit Tests for Dart Functions and Classes,Using test package,Mocking Dependencies using mockito,Best Practices in Unit Testing **Widget Testing:** Testing Widgets in Isolation,Using flutter_test Package,Simulating User Interactions,Golden Tests for UI validation **Integration Testing:**Setting Up Integration Tests,Using integration_test Package,Running Tests on Emulators and Real Devices,Automating Tests with CI/CD Pipelines (GitHub Actions/GitLab CI) **Debugging and Coverage:** Analyzing Test Failures,Improving Test Coverage,Using Code Coverage Tools like lcov and flutter_coverage	5
5	**Flutter Deployment:** **Preparing for Deployment:** Preparing for Deployment, App Versioning and Build Flavors, Managing Secrets & Environment Variables, Generating Keystore for Android, Setting up iOS Certificates and Profiles **Android Deployment:**Building APKs and AABs, Signing & Obfuscating Builds, Uploading to Google Play Store, Using Play Console Features (Testing Tracks, Release Management) **iOS Deployment:**Building and Signing iOS Apps, Using Xcode for Archive and Distribution, Uploading to App Store using Transporter or Xcode, TestFlight for Beta Testing **CI/CD for Flutter Deployment**: Automating Build and Release (Codemagic, GitHub Actions, Bitrise), Integrating Fastlane for Flutter Projects **Post-Deployment:** Crash Reporting & Analytics (Firebase Crashlytics), In-App Updates, Feedback Collection	7

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Institute of Technology

(An Autonomous Institute Affiliated to University of Mumbai, Approved by A.I.C.T.E & Recognized by Govt. of Maharashtra)

Department of Electronics and Telecommunication

6	**Flutter for Web:** **Introduction to Flutter Web**: Flutter Web Architecture,Differences from Mobile Development, Setting up for Web Development **Building Web UI:** Responsive Design with Flutter, Navigation with go_router or Navigator 2.0, Web-specific Widgets and Customizations, **State Management:** Choosing the Right State Management for Web (Provider, Riverpod, Bloc), Web Performance Optimization Techniques **Web Deployment:** Building for Web (flutter build web), Hosting on Firebase Hosting, GitHub Pages, Netlify, Vercel, SEO Considerations for Flutter Web **Advanced Topics, Progressive Web App (PWA) with Flutter:** Offline Support and Caching, Integrating REST APIs and WebSockets	7
	Total	**39**

Textbooks:	
1	Beginning Flutter a Hands-on Guide to App Development, Marco L. Napoli, Wiley, 2020.
2	Beginning App Development with Flutter: Create Cross-Platform Mobile Apps, By Rap Payne, 2019
Reference Books:	
1	Google Flutter Mobile Development Quick Start Guide.Packt,2019
Access to software and virtual labs:	
1	Google Cloud Labs & Qwiklabs: Access to Android Studio, Firebase, TensorFlow Lite via cloud-based labs.
2	AWS Educate/AWS Academy : Free credits for AWS Amplify, Lambda, and IoT integrations.
Industry articles and case studies :	

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Department of Electronics and Telecommunication

1	Article: Rise of Flutter in FinTech – Insights on why Flutter is chosen for fast MVP development and lower maintenance in financial startups.
2	Trends Report – Mobile App Development Trends (e.g., Flutter vs. React Native, Kotlin Multiplatform Mobile).
Any other (Access to AI tools / Data driven insights (if applicable) or any other):	
1	AI-powered Mobile App Features: Hands-on modules using Google ML Kit for image labeling, text recognition, barcode scanning, and language translation in Android apps.
2	Chatbot Integration Labs: Building intelligent chatbots using Dialog Flow and integrating with Android/Flutter frontends.
3	Analytics with Firebase and Google Analytics: Gain data-driven insights on user engagement, retention, crash reports, and app performance.
4	Recommendation Engines: Introduction to building simple recommendation models in apps (e.g., product or content recommendations).
5	AI Tools: Exposure to tools like OpenAI APIs for generating text-based content within apps or integrating natural language features.

Internal Assessment:

1) Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks.

2) Mid Term test is to be conducted when approx. 50% syllabus is completed.

3) The duration of the midterm test shall be one hour.

Continuous Assessment:

Continuous Assessment is of 20 marks. The Continuous Assessment marks would be assigned by the subject teacher based on the practical's done by the student.

End Semester Theory Examination:	
1	Question paper will be of 60 marks
2	Question paper will have a total of five questions

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Department of Electronics and Telecommunication

3	All questions have equal weightage and carry 20 marks each
4	Any three questions out of five need to be solved.

Mobile App Development (Lab)

Suggested Experiments: Students are required to complete at least 10 experiments.

Star (*) marked experiments are compulsory.

Sr. No.	Name of the Experiment	Hrs
1*	To install and configure the Flutter Environment	01
2*	To design Flutter UI by including common widgets.	01
3*	To include icons, images, fonts in Flutter app	01
4	To create an interactive Form using form widget	01
5*	To apply navigation, routing and gestures in Flutter App	01
6*	To Connect Flutter UI with fireBase database	01
7	Write and execute unit and widget tests for a simple Flutter app to validate business logic and UI behavior	01
8*	Perform integration testing on a multi-screen Flutter app by automating navigation and simulating user interactions.	01
9*	Build, sign, and upload a Flutter Android app to the Google Play Console for internal testing.	01
10	Build and deploy a Flutter Web app using Firebase Hosting to make it	02

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Institute of Technology
(An Autonomous Institute Affiliated to University of Mumbai, Approved by A.I.C.T.E & Recognized by Govt. of Maharashtra)

Department of Electronics and Telecommunication

	accessible online.	
11*	Develop a responsive Progressive Web App (PWA) using Flutter Web and validate it with Lighthouse.	02
	Total	**13**

Note: Suggested List of Experiments is indicative. However, flexibility lies with individual course instructors to design and introduce new, innovative and challenging experiments, (limited to maximum 30% variation to the suggested list) from within the curriculum, so that the fundamentals and applications can be explored to give greater clarity to the students and they can be motivated to think differently

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Department of Electronics and Telecommunication

Semester VI
Syllabus

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Department of Electronics and Telecommunication

Semester VI Scheme								
Course Type	**Course Name**	**Teaching scheme (Contact Hours)**			**Credits Assigned**			
		Th	Pr	Tut	Th	Pr	Tut	Total
Programme Core Course (PCC)	Digital VLSI	3	2	-	3	1	-	4
Programme Core Course (PCC)	Microwave Engineering	3	2	-	3	1	-	4
Programme Elective(PE)	Program Elective Course-II	4	-	-	4	-	-	4
Programme Elective(PE)	Program Elective Course-III	4	-	-	4	-	-	4
Multidisciplinary Minor (MDM)	MDM Course -IV	-	4	-	-	2	-	2
Vocational and Skill Enhancement Course (VSEC)	Skill Lab-II: Embedded Programming for Telecommunication	-	2+2*	-	-	2	-	2
Project	Major Project -1	-	4	-	-	2	-	2
Total Credits					14	08	-	**22**

* Tutorial for complete class

Program Elective Course -II

Course Code	Name Of The Subject
NETPE611	EMI & EMC
NETPE612	IoT & Industry 4.0
NETPE613	Sensor Technology

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(An Autonomous Institute Affiliated to University of Mumbai, Approved by A.I.C.T.E & Recognized by Govt. of Maharashtra)

Department of Electronics and Telecommunication

Program Elective Course -III

Course Code	Name Of The Subject
NETPE621	Big Data Analytics
NETPE622	Neural Network & Fuzzy Logic
NETPE622	Image Processing

Multidisciplinary Minor (MDM Course IV)

Course Code	Name Of The Subject
NETMML61	Vulnerability Assessment and Penetration Testing Lab

Semester VI Marks Scheme							
Course Type	Course Name	TH	MT	CA	TW	PR/OR	Total
Programme Core Course (PCC)	Digital VLSI	60	20	20	25	25	150
Programme Core Course (PCC)	Microwave Engineering	60	20	20	25	25	150
Programme Elective	Program Elective Course-II	60	20	20	-	-	100
Programme Elective	Program Elective Course-III	60	20	20	-	-	100
Multidisciplinary Minor (MD M)	MDM Course -IV	-	-	-	25	25	50
Vocational and Skill Enhancement Course (VSEC)	Skill Lab-II: Embedded Programming for Telecommunication	-	-	-	25	25	50
Project	Major Project-1	-	-	-	50	50	100
Total Marks							700

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Department of Electronics and Telecommunication

COURSE NAME: DIGITAL VLSI

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/ PR	Tut	Total
NETPC61	Digital VLSI	03	02	---	03	01	---	04

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Institute of Technology
(An Autonomous Institute Affiliated to University of Mumbai, Approved by A.I.C.T.E & Recognized by Govt. of Maharashtra)

Department of Electronics and Telecommunication

Digital VLSI (Theory)

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/PR	Tut	Total
NETPC61	Digital VLSI (Theory)	03	---	---	03	--	---	03

Course Code	Course Name	Examination Scheme					
		Theory			Term Work	Practical & Oral	Total
		Internal Assessment		End Sem Exam			
		Mid-Term Test	CA				
NETPC61	Digital VLSI (Theory)	20	20	60	--	--	100

Course Prerequisite: Electronic Devices and Circuits, Digital System Design , Linear Integrated Circuits.	
Course Objectives:	
1	To introduce the process flow of VLSI Design.
2	To understand MOSFET operation and layout design techniques
3	To learn VLSI design performance metric and various trade-offs.
4	To design, implement and verify combinational and sequential logic circuits using various MOS design styles.
5	To provide an exposure to RTL design and programming.
Course Outcomes:	
After successful completion of the course students will be able :	

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(An Autonomous Institute Affiliated to University of Mumbai, Approved by A.I.C.T.E & Recognized by Govt. of Maharashtra)

Department of Electronics and Telecommunication

1	Use various tools and processes used in VLSI Design.
2	Design various CMOS combinational and sequential circuits used in VLSI Design.
3	Analyse the performance parameters of basic building blocks like CMOS inverter.
4	Design memories and layouts using CMOS
5	Evaluate timing requirements of sequential and combinational circuits
6	Design RTL for various combinational and sequential circuits for given specifications.

Digital VLSI (Theory)

Module		Content	Hrs
1		**Review of MOSFET operation and Fabrication**	**4**
	1.1	Overview of VLSI Design Flow, Review of MOSFET operation, MOSFET Capacitances, MOSFET scaling, short channel effects	
	1.2	Fabrication process flow of NMOS and PMOS, Lambda based design rules, stick diagrams.	
2		**Combinational CMOS Logic Circuits**	**4**
	2.1	CMOS inverter operation, Voltage Transfer characteristics (VTC), Noise Margins, Propagation Delay, Power Dissipation, Design of CMOS Inverter, Layout of CMOS Inverter.	
	2.2	Realization of CMOS NAND gate, NOR gate, Complex CMOS Logic Circuits, Layout of CMOS NAND, NOR and complex CMOS circuits.	
3		**MOS Design Logic Styles**	**10**
	3.1	Static CMOS, Pass Transistor Logic, Transmission Gate, Pseudo NMOS, Dynamic Logic, Domino Logic, NORA, Zipper, C2MOS .	
	3.2	Setup time, Hold time, clocked CMOS SR Latch, CMOS JK Latch, MS –JK Flip Flop, Edge triggered D-Flip Flop and realization using design styles .	
	3.3	Realization of Shift Register, MUX.	
4		**Semiconductor Memories**	**7**

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Institute of Technology

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Department of Electronics and Telecommunication

	4.1	ROM array, 6T-SRAM (operation, design strategy, leakage currents, sense amplifier), layout of SRAM	
	4.2	Operation of 1T and 3T DRAM Cell, NAND and NOR flash memory	
5		**Data path and system design issues**	**8**
	5.1	1-bit full adder , Ripple carry adder, CLA adder, carry save adder, carry select adder, carry skip adder, Array Multiplier , barrel shifter.	
	5.2	On chip clock generation and distribution, Static timing analysis.	
6		**RTL Design**	**6**
	6.1	High Level state machines, RTL design process	
	6.2	RTL design of Soda dispenser machine, FIR Filter, Sum of absolute differences, Laser Distance measure.	
		Total	**39**

Textbooks:	
1	Sung-Mo Kang and Yusuf Leblebici, "*CMOS Digital Integrated Circuits Analysis and Design*", Tata McGraw Hill, 3rd Edition, 2012.
2	Jan M. Rabaey, Anantha Chandrakasan and Borivoje Nikolic, "*Digital Integrated Circuits: A Design Perspective*", Pearson Education, 2nd Edition.
3	Frank Vahid, "Digital Design with RTL design, VHDL and VERILOG", John Wiley and Sons Publisher 2011.
Reference Books:	
1	Neil H. E. Weste, David Harris and Ayan Banerjee, ―*CMOS VLSI Design: A Circuits and Systems Perspective*, Pearson Education, 3rd Edition.
2	John P. Uyemura, "*Introduction to VLSI Circuits and Systems*", Wiley, Student Edition, 2013.
3	R. Jacob Baker, "*CMOS Circuit Design, Layout and Simulation*", Wiley, 2nd Edition, 2013
NPTEL/Swayam Courses:	
	https://nptel.ac.in/courses/117/101/117101058/
	https://nptel.ac.in/courses/108/107/108107129/

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Department of Electronics and Telecommunication

Internal Assessment:

1) Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks.
2) Mid Term test is to be conducted when approx. 50% syllabus is completed.
3) Duration of the midterm test shall be one hour.
4)

Continuous Assessment:

Continuous Assessment is of **20 marks**. The rubrics for assessment will be considered on approval by the subject teachers. The rubrics can be any 2 or max 4 of the following:

Sr. No	Rubrics	Marks
1	*Certificate course for 4 weeks or more: NPTEL/ Coursera/ Udemy/any MOOC	10 marks
2	Wins in the event/competition/hackathon	10 marks
3	Content beyond syllabus presentation	10 marks
4	Creating Proof of concept	10 marks
5	Mini Project / Extra Experiments/ Virtual Lab	10 marks
6	GATE Based Assignment test/Tutorials etc	10 marks
7	Participation in event/workshop/talk / competition followed by small report and certificate of participation relevant to the subject (in other institutes)	05 marks
8.	Multiple Choice Questions (Quiz)	05 marks
*For sr.no.1, the date of the certification exam should be within the term and in case a student is unable to complete the certification , the grading has to be done accordingly.		

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Institute of Technology

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Department of Electronics and Telecommunication

End Semester Theory Examination:	
1	Question paper will be of 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.

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Department of Electronics and Telecommunication

COURSE NAME: DIGITAL VLSI LAB

</div>

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/PR	Tut	Total
NETPCL61	Digital VLSI Lab	---	02	---	---	01	---	01

Course Code	Course Name	Examination Scheme					
		Theory			Term Work	Practical & Oral	Total
		Internal Assessment		End Sem Exam			
		Mid-Term Test	CA				
NETPCL61	Digital VLSI Lab	--	---	--	25	25	50

Course Prerequisite: Digital Design, Electronic devices and circuits	
Course Objectives:	
1	To become familiar with professional tools like AMD Xilinx Vivado, Cadence, Microwind etc.
2	To perform various type of analysis of combinational and sequential CMOS circuits
3	To evaluate performance of given combinational and sequential CMOS circuits
4	To design, implement and verify combinational and sequential CMOS circuits using industrial VLSI design tools.
Course Outcomes: After successful completion of the course students will be able :	
1	Write spice/verilog code for given combinational and sequential CMOS circuits.
2	Perform various analysis like operating point, dc, transient etc of given CMSO circuits.

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Institute of Technology
(An Autonomous Institute Affiliated to University of Mumbai, Approved by A.I.C.T.E & Recognized by Govt. of Maharashtra)

Department of Electronics and Telecommunication

3	Evaluate performance of given CMOS circuits.
4	Draw layout of given CMOS circuit and also able extract various parasitic using layout tools like Microwind, Cadence, Mentor Graphics.
5	Design, simulate, and verify RTL design using AMD Xilinx Vivado Tool.

Suggested Experiments: Students are required to complete at least 10 experiments.	
Sr. No.	**Name of the Experiment**
1.	Constant Voltage and Constant field MOSFET scaling
2.	Layout of MOSFET and extraction of parasitic capacitances
3.	Voltage transfer characteristics of CMOS inverter and calculation of Noise Margin and static power
4.	Design of CMOS inverter for given specifications
5.	Layout of CMOS inverter and comparison of pre layout and post layout performance.
6.	Voltage transfer characteristics of 2 input NAND/NOR gate and calculation of noise margins and validation using equivalent inverter approach.
7.	Layout of 2 input CMOS NAND/NOR gate and comparison of pre layout and post layout performance.
8.	Static and transient analysis of Complex CMOS gate.
9.	Layout of complex CMOS gate using Euler path.
10.	Implementation of various combinational and sequential circuits using different design styles.
11.	Design and implementation of NAND based and NOR based ROM array.
12.	Performance analysis of 6T-SRAM Cell
13.	Design of 6T SRAM cell robust read and write operation.

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Department of Electronics and Telecommunication

14.	Performance analysis of 1T and 3T DRAM Cell
15.	RTL design of Soda dispenser machine
16.	RTL design of FIR Filter
17.	RTL design of sum of absolute differences
18.	RTL design of Laser based distance measure

Term Work:	
1	Term work should consist of 8 to 10 experiments.
2	Journal may include assignments.
3	The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
4	Total 25 Marks (Experiments: 15-marks, Attendance Theory & Practical: 05-marks, Assignments/Quiz/mock viva/activity: 05-marks)

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Institute of Technology

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Department of Electronics and Telecommunication

COURSE NAME: Microwave Engineering

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned			
		Theory	Practical	Theory	Practical	Tut.	Total
NETPC62	Microwave Engineering	03	02	03	01	--	04

Department of Electronics and Telecommunication

Microwave Engineering(Theory)

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned			
		Theory	Practical	Theory	Practical	Tut.	Total
NETPC62	Microwave Engineering	3	--	3	--	--	3

Course Code	Course Name	Examination Scheme						
		Theory				Term Work	Pract & Oral	Total
		Internal Assessment		End Sem Exam	Exam Duration(in Hrs)			
		Mid Term Test (MT)	Continuous Assessment (CA)					
NETPC62	Microwave Engineering	20	20	60	2	--	--	100

Course Code:	Course Title	Credit
NETPC62	Microwave Engineering	3
Prerequisite: Knowledge of Electromagnetic Engineering		
Course Objectives:		
1	Perceive the concepts of waveguides and analyze the field components in different types of Waveguides.	
2	Categorize different types of microwave components based on their applications.	
3	Imbibe knowledge to use microwave oscillators & amplifiers in microwave communication and compare their characteristics.	

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Institute of Technology

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Department of Electronics and Telecommunication

4	Demonstrate the ability to measure different microwave parameters using microwave bench setup.
Course Outcomes:	
1	Describe the types of waveguides, rectangular waveguides and field equations.
2	Understand the coupling mechanisms in waveguides and analyze the waveguide multiport junctions.
3	Explore the microwave linear tubes and analyze with microwave cross field tubes.
4	Understand the microwave solid state devices and avalanche transit time devices.
5	Demonstrate the microwave bench set up and conducting measurements of different parameters

Module		Content	Hrs
1		**Planar transmission lines and lumped impedance Matching**	
	1.1	Planar transmission lines: micro strip line, strip line and coplanar lines analysis and design.	**08**
	1.2	matching network design using distributed line elements and lumped elements	
2		**Waveguides,Planar Lines & Resonators**	**04**
	2.1	Types of waveguides, rectangular waveguides, field equations in rectangular and circular waveguides, modes of TM and TE waves in rectangular and circular waveguides, cut off frequency , Wave impedance in waveguides:, Dominant mode and degenerate modes, mode characteristics of phase velocity, group velocity, wavelength and impedance relations; Illustrative problems.	
	2.2	Cavity resonators: Types of cavity resonators; Rectangular and cylindrical cavity resonator: Dominant modes and resonant frequencies, illustrative problems.	
3		**Waveguide Components**	

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Institute of Technology

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Department of Electronics and Telecommunication

	3.1	Coupling mechanisms: Probe, loop, coupling to a cavity resonator, waveguide discontinuities, waveguide irises, tuning screws and posts, matched loads; Waveguide attenuators and phase shifters	**07**
	3.2	Multiport junctions: E plane Tee, H plane Tee, Magic Tee, applications of Magic Tee, hybrid ring; Ferrites, Faraday rotation principle, gyrator, isolator, circulator	
4		**Microwave Tubes**	**10**
	4.1	Microwave linear beam tubes (O type): Limitations of conventional tubes at microwave frequencies; Klystron: Velocity modulation process, bunching process, output power and beam loading. Reflex Klystron: Velocity modulation, power output and efficiency. Helix Traveling Wave tube: Slow wave structures, amplification process, modes of operation of TWT	
	4.2	Microwave cross field tubes (M type): Introduction of cross field devices Magnetrons: Different types, 8-cavity cylindrical travelling wave Magnetron, Hull cut-off and Hartree conditions, modes of resonance and PI-mode operation Backward wave oscillator	
5		**Microwave Semiconductor Devices**	**06**
	5.1	Microwave solid-state devices: Transferred electron devices Gunn- effect diodes, RWH theory, modes of operations, Avalanche transit time devices: IMPATT diode, TRAPATT diode, BARITT diode,	
6		**Microwave Measurements**	04

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Institute of Technology

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Department of Electronics and Telecommunication

	6.1	Description of microwave bench: Different blocks and their features, precautions Microwave power measurement for low medium and high microwave power Measurement of attenuation; Frequency standing wave measurements: measurement of low and high VSWR; Cavity Q; Impedance measurements.	
		Total	**39**

Textbooks:	
1	Microwave Devices and Circuits by SAMUEL Y. LIAO(1905-06-29), Pearson
2	Microwave Engineering: Theory and Techniques, 4ed, An Indian Adaptation, David M Pozar,Wiely
3	Microwave Engineering, 4th Edition, Annapurna Das and Sisir K Das, McGraw Hill, 2020
Reference Books:	
1	R.E. Collin —Foundations for Microwave Engineering, IEEE Press, John Wiley

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Department of Electronics and Telecommunication

Internal Assessment:

Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks. Mid Term test is to be conducted when approx. 50% syllabus is completed Duration of the midterm test shall be one hour.

Continuous Assessment: -

Continuous Assessment is of **20 marks**. The assessment tools for the continuous assessment will be considered on approval by the subject teachers. The assessment tools can be any 2 or max 4 of the following: -

Sr.no	Assessment Tools	Marks
1.	*Certificate course for 4 weeks or more: - NPTEL/ Coursera/ Udemy/any MOOC	10 mark
2.	Wins in the event/competition/hackathon	10 marks
3.	Content beyond syllabus presentation	10 marks
4.	Creating Proof of concept	10 marks
5.	Mini Project / Extra Experiments/ Virtual Lab	10 marks
6.	GATE Based Assignment test/Tutorials etc	10 marks
7.	Participation in event/workshop/talk/competition followed by small report and certificate of participation relevant to the subject (in other institutes)	5marks
8.	Multiple Choice Questions (Quiz)	5 marks

*For sr.no.1, the date of certification exam should be within the term and in case a student is unable to complete the certification, the grading has to be done accordingly.

VIVEKANAND EDUCATION SOCIETY'S
Institute of Technology

(An Autonomous Institute Affiliated to University of Mumbai, Approved by A.I.C.T.E & Recognized by Govt. of Maharashtra)

Department of Electronics and Telecommunication

	End Semester Theory Examination:
1	Question paper will be of 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 needs to be solved.

VIVEKANAND EDUCATION SOCIETY'S
Institute of Technology

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Department of Electronics and Telecommunication

COURSE NAME: Microwave Engineering Lab

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned			
		Theory	Pract.	Theory	Pract.	Tut.	Total
NETPCL62	Microwave Engineering Laboratory	--	2	--	1	--	1

Course Code	Course Name	Examination Scheme						
		Theory				Practical		
		Internal Assessment		End Sem. Exam	Exam Duration (in Hrs)	Term Work	Pract & Oral	Total
		Mid Test (MT)	Continuous Assessment (CA)					
NETPCL62	Microwave Engineering Laboratory	--	--	--	--	25	25	50

	Lab Name	Credit
	Microwave Engineering Laboratory	1
Prerequisite:		
Lab Objectives:		
1	To become familiar working with rectangular waveguides and doing microwave bench set up.	
2	To determine the characteristics of various microwave components	

VIVEKANAND EDUCATION SOCIETY'S

Institute of Technology

(An Autonomous Institute Affiliated to University of Mumbai, Approved by A.I.C.T.E & Recognized by Govt. of Maharashtra)

Department of Electronics and Telecommunication

3	To be able to measure wave parameters like impedance, frequency, wavelength using microwave bench and VSWR/power meter
4	To study characteristics and behaviour of various microwave semiconductor devices.

Lab Outcomes:

1	Able to handle microwave equipment
2	Able to understand microwave measurements and test the characteristics of microwave components
3	Able to understand Waveguide and transmission line measurements
4	Demonstrate working of microwave semiconductor devices
5	Demonstrate the microwave bench set up and conducting measurements of different parameters

Suggested Experiments: Students are required to complete at least 8 to 10 experiments.

Sr. No.	Name of the Experiment
1	Measurement of microwave frequency using direct and indirect method.
2	Measurement of guide wavelength
3	Measurement of VSWR of unknown load
4	Measurement of impedance of unknown load.
5	Study of field patterns of various modes inside a rectangular waveguide cavity using Virtual lab

VIVEKANAND EDUCATION SOCIETY'S

Institute of Technology

(An Autonomous Institute Affiliated to University of Mumbai, Approved by A.I.C.T.E & Recognized by Govt. of Maharashtra)

Department of Electronics and Telecommunication

6	Study of field patterns of various modes inside a rectangular waveguide using Virtual lab
7	Find the change in characteristics impedance and reflection coefficients of the transmission line by changing the dielectric properties of materials Embedded between two conductors. using Virtual lab
8	Determination of VI characteristics of Gunn diode using microwave test bench.
9	Measurement of attenuation
10	Measurement of microwave power
11	Characterization of E plane TEE, H plane TEE and Magic TEE
12	Measurement of reflection coefficient using transmission line bench

Term Work:

1	Term work should consist of 8 to 10 experiments.
2	Journal must include at least 2 assignments.
3	The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
4	Total 25 Marks (Experiments: 15-marks, Attendance Theory & Practical: 05-marks, Assignments: 05-marks)

VIVEKANAND EDUCATION SOCIETY'S
Institute of Technology

(An Autonomous Institute Affiliated to University of Mumbai, Approved by A.I.C.T.E & Recognized by Govt. of Maharashtra)

Department of Electronics and Telecommunication

COURSE NAME: EMI & EMC

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/ PR	Tut	Total
NETPE611	EMI & EMC (Theory)	04	---	---	04	---	---	04

EMI & EMC (Theory)

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/ PR	Tut	Total
NETPE611	EMI & EMC (Theory)	04	---	---	04	---	---	04

Course Code	Course Name	Examination Scheme					
		Theory			Term Work	Practical & Oral	Total
		Internal Assessment		End Sem Exam			
		Mid-Term Test	CA				
NETPE611	EMI & EMC (Theory)	20	20	60	---	---	100

Course Prerequisite: Basic knowledge of electronic components, circuits, electromagnetic fields and Transmission lines, Power Electronics and Power systems.	
Course Objectives:	
1	To understand EMI problems in subsystem and system level design.
2	To introduce the concepts of electromagnetic interference and electromagnetic compatibility

VIVEKANAND EDUCATION SOCIETY'S
Institute of Technology

(An Autonomous Institute Affiliated to University of Mumbai, Approved by A.I.C.T.E & Recognized by Govt. of Maharashtra)

Department of Electronics and Telecommunication

3	To measure the emission. immunity level from different systems to couple with the prescribed EMC standards
4	To discuss electromagnetic interference measurements and standards

Course Outcomes:
After successful completion of the course students will be able to:

1	Understand various source of Electromagnetic interference
2	Would gain knowledge to understand the concept of Shielding grounding related to product design
3	Design PCBs which are electromagnetically compatible
4	Find solution to EMI Sources, EMI problems in PCB level / Subsystem and system level design
5	To measure emission immunity level from different systems to couple with the prescribed EMC standards

EMI & EMC (Theory)

Module		Content	Hrs
1		**Concept of EMI and EMC and Definitions**, **Natural and Nuclear Sources of EMI**	**8**
	1.1	Practical Experiences and Concerns Transmission Lines, Mains Power Supply, Switches and Relays, Telephone Equipment, Radio Astronomy, Biological Effects, Aircraft Navigation, Military Equipment, Secure Communications, Integrated Circuits	
	1.2	Introduction, Celestial Electromagnetic Noise. Lightning Discharge Cloud-to Ground Discharge, Cloud-to-Cloud Discharge, EM Fields Produced by Lightning, Effects of Lightning Discharge on Transmission Lines Electrostatic Discharge	
	1.3	Charge Accumulation and Discharge, Model ESD Waveform, ESD Equivalent Circuit, Radiated Field from ESD Electromagnetic Pulse EMP from Surface Burst, High Attitude Burst, EMP Induced Voltage, EMP Coupling Through Cable Shields	
2		**EMI From Apparatus and Circuits**	**8**

VIVEKANAND EDUCATION SOCIETY'S

Institute of Technology

(An Autonomous Institute Affiliated to University of Mumbai, Approved by A.I.C.T.E & Recognized by Govt. of Maharashtra)

Department of Electronics and Telecommunication

	2.1	Introduction Electromagnetic Emissions Systems, Appliances, Noise from Relays and Switches Circuit Model, Noise Characteristics, Effects of Interference. Nonlinearities in Circuits Amplifier Nonlinearity, Modulation, Intermodulation, Cross Modulation, Passive Intermodulation	
	2.2	Cros- Talk in Transmission Lines Multiconductor Line, Illustrative Example- Three Conductor Line, Transients in Power Supply Lines Calculation of Induced Voltages and Currents, Surges on Mains Power Supply. Electromagnetic Interference Radiation Coupling, Conduction Coupling, Combination of Radiation and Conduction	
3		**Radiated Interference Measurements**	**10**
	3.1	Introduction Anechoic Chamber, Measurements Using an Anechoic Chamber, Sources of Inaccuracies in Measurement,Transverse Electromagnetic Cell TEM Cell. Measurements Using TEM Cell, Sources of Inaccuracies. Reverberating Chamber Reverberating Chamber, Measurements Using a Reverberating Chamber. Giga-Hertz TEM Cell GTEM Cell, EMC Evaluation Using a GTEM Cell, EMC Evaluation Using a GTEM Cell Comparison of Test Facilities Anechoic Chambers, TEM Cells, Reverberating Chambers, GTEM Cells, Measurement Uncertainties	
	3.2	Conducted Interference measurements, Characterization of Conduction Currents/Voltages Common -Mode and Differential- Mode Interferences, Examples of CM and DM Interferences, Conducted EMI Noise on Power supply Lines Transient on Power Supply Lines, Propagation of Surges in Low Voltage AC Lines, Conducted EMI in Ships and Aircrafts. Conducted EMI From Equipment Instrumentation for Measuring Conducted EMI, Experimental Setup for Measuring Conducted EMI, Measurement of CM and DM Interferences, Immunity to Conducted EMI Detectors and measurement.	
4		**Grounding, Shielding, and Bonding EMC Technology**	**10**
	4.1	Principles and Practice of Earthing, Precautions in Earthing, Measurement of Ground Resistance, System Grounding for EMC, Cable Shield Grounding, Design Example, Additional Practical Examples. Shielding, Shielding Theory and Shielding Effectiveness, Shielding Materials.	
	4.2	Shielding Integrity at Discontinuities, Conductive Coatings, Cable Shielding, Shielding Effectiveness Measurements, Some Practical Examples	

VIVEKANAND EDUCATION SOCIETY'S
Institute of Technology
(An Autonomous Institute Affiliated to University of Mumbai, Approved by A.I.C.T.E & Recognized by Govt. of Maharashtra)

Department of Electronics and Telecommunication

		Electrical Bonding Shape and Material for Bond Strap, General Guidelines for Good Bonds.	
5		**EMI Filters**	7
	5.1	Introduction, Characteristics of Filters Impedance Mismatch Effects, Lumped Element Low-Pass Filters, High-Pass Filters, Band-Pass Filters, Band-Reject Filters, Insertion-LOss Filter Design. Power Line Filter Design.	
	5.2	Common-Mode Filter, Differential-Mode Filter, Combined CM and DM Filter, Inductor Design, Leakage Inductance of CM Choke, Reduction of Leakage Inductance, Power Line Filter Design Example. Filter Installation. Filter Evaluation.	
6		**Standards and Regulations**	9
	6.1	Need for Standards, Generic/General Standards for Residential and Industrial environment, Basic Standards, Product Standards, National and International EMI Standardizing Organizations; IEC, ANSI, FCC, AS/NZS, CISPR, BSI, CENELEC, ACEC. Electro Magnetic Emission and susceptibility standards and specifications, MIL461E Standards	
	6.2	**EMI Test Methods and Instrumentation** Fundamental considerations, EMI Shielding effectiveness tests, Open field test, TEM cell for immunity test, shielded chamber, shielded anechoic chamber, EMI test receivers, Spectrum analyser, EMI test wave simulators, EMI coupling networks, Line impedance stabilization networks, Feed through capacitors, Antennas, Current probes, MIL -STD test methods, Civilian STD test methods.	
		Total	**52**

Textbooks:	
1	V Prasad Kodali, "Engineering Electromagnetic Compatibility", IEEE Press, Newyork, 2017.
2	Clayton Paul, "Introduction to Electromagnetic Compatibility", Wiley Interscience, 2006

VIVEKANAND EDUCATION SOCIETY'S
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Department of Electronics and Telecommunication

	Reference Books:	
1	Henry W. Ott, "Electromagnetic Compatibility Engineering", John Wiley & Sons Inc, Newyork, 2009	
2	Daryl Gerke and William Kimmel, "EDN"s Designer"s Guide to Electromagnetic Compatibility", Elsevier Science & Technology Books, 2002	
3	W Scott Bennett, "Control and Measurement of Unintentional Electromagnetic Radiation", John Wiley & Sons Inc., (Wiley Interscience Series) 1997.	
4	Dr Kenneth L Kaiser, "The Electromagnetic Compatibility Handbook", CRC Press 2005	
Access to software and virtual labs:		
	https://onlinecourses.nptel.ac.in/noc24_ee67/preview	
Any other (Access to AI tools / Data driven insights (if applicable) or any other):		

Internal Assessment:
1) Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks.
2) Mid Term test is to be conducted when approx. 50% syllabus is completed.
3) Duration of the midterm test shall be one hour.

Continuous Assessment:

Continuous Assessment is of **20 marks**. The rubrics for assessment will be considered on approval by the subject teachers. The rubrics can be any 2 or max 4 of the following:

Sr. No	Rubrics	Marks
1	Certificate course for 4 weeks or more: NPTEL/ Coursera/ Udemy/any MOOC	10 marks
2	Wins in the event/competition/hackathon	10 marks
3	Content beyond syllabus presentation	10 marks
4	Creating Proof of concept	10 marks
5	Mini Project / Extra Experiments/ Virtual Lab	10 marks
6	GATE Based Assignment test/Tutorials etc	10 marks

VIVEKANAND EDUCATION SOCIETY'S
Institute of Technology

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Department of Electronics and Telecommunication

7	Participation in event/workshop/talk / competition followed by small report and certificate of participation relevant to the subject (in other institutes)	05 marks
8.	Multiple Choice Questions (Quiz)	05 marks
9.	Peer Review and participation in the class	05 Marks

End Semester Theory Examination:	
1	Question paper will be of 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.

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Department of Electronics and Telecommunication

COURSE NAME: IoT & Industry 4.0

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/ PR	Tut	Total
NETP E612	IoT & Industry 4.0 (Theory)	04	---	---	04	---	---	04

IoT & Industry 4.0 (Theory)

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/ PR	Tut	Total
NETP E612	IoT & Industry 4.0 (Theory)	04	---	---	04	---	---	04

Course Code	Course Name	Examination Scheme					
		Theory			Term Work	Practical & Oral	Total
		Internal Assessment		End Sem Exam			
		Mid-Term Test	CA				
NETPE612	IoT & Industry 4.0 (Theory)	20	20	60	---	---	100

Course Prerequisite: Mini Project(Microcontrollers/Embedded System), Skill based Lab Course	
Course Objectives:	
1	To provide the introduction to Internet of Things
2	To illustrate the protocols of Internet of Things (IoT)

VIVEKANAND EDUCATION SOCIETY'S

Institute of Technology

(An Autonomous Institute Affiliated to University of Mumbai, Approved by A.I.C.T.E & Recognized by Govt. of Maharashtra)

Department of Electronics and Telecommunication

3	To provide the concepts of data management and data analytics in IoT
4	To provide the introduction to Industry 4.0 standard
5	To provide the introduction to IIoT and Applications
6	To overview the applications of Industry 4.0

Course Outcomes:
After successful completion of the course students will be able to:

1	To discuss case studies and use cases of IoT design
2	To compare various communication protocols for IoT
3	To understand various methods for data handling in IoT-based applications
4	To understand the various frameworks and concepts for industry 4.0 standards.
5	To understand case studies on applications of IIoT.
6	To understand advanced technologies and applications of Industry 4.0

IoT & Industry 4.0 (Theory)

Module		Content	Hrs
1		**Introduction to IoT**	**05**
	1.1	Introduction :- Defining IoT, Characteristics of IoT, Physical design of IoT, Logical design of IoT Communication models, M2M, Difference between IoT and M2M.	
	1.2	Components (Things) in IoT :- Introduction - Sensors, Characteristics and categories, Introduction - Actuators *Exemplary Device (Self study by Students):- R–Pi and its Interfaces, PCDuino, BeagleBone*	
2		**Design Principles & Connectivity**	**08**
	2.1	Design Principles & Web Connectivity :- Web Communication Protocols for connected devices, Web connectivity using Gateway, SOAP, REST, HTTP, RESTful and Web Sockets (Publish—Subscribe), MQTT, AMQP, CoAP Protocols	

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Department of Electronics and Telecommunication

		Internet Connectivity : - Internet connectivity, Internet based communication	
3		**Data Handling in IoT and Design Methodology**	**12**
	3.1	Data Handling in IoT :- Data Acquiring and Storage, Organizing the Data, Transactions and Business Processes, Analytics Data Collection, Storage and Computing Using Cloud Platform, Introduction to Cloud Computing, Virtualization, Cloud Models, Cloud Services	
	3.2	Design Methodology :- Purpose & requirements, process, domain model, information model, service, IoT level, Functional view, Operational view, Device and Component Integration, Application Development	
	3.3	IoT Case :- Case Studies: Home Automation (Smart lighting, home intrusion detection), Cities (Smart Parking), Environment (Weather monitoring, weather reporting Bot.	
4		**Introduction to Industry 4.0**	**10**
	4.1	Industry 4.0:- Introduction - Industrial Revolution, LEAN Production Systems, Smart and Connected Business Perspective, Smart Factories	
	4.2	Cyber Physical Systems and Next Generation Sensors, Collaborative Platform and Product Lifecycle Management, Augmented Reality and Virtual Reality	
5		**Introduction to Industrial IoT (IIoT) Protocols and Security**	**10**
	5.1	IIoT Protocols :- Introduction - Profibus, HART, DeviceNet, LORA, LORAWAN	
	5.2	Security and Fog Computing :- Fog Computing in IIoT, Security in IIoT-Part I, Part II Industrial IoT Application Domains :- Factories and Assembly Line, Food Industry.	
6		**Industry 4.0 Technologies and Applications**	**07**
	6.1	Inventory management, Supply Chain management, Plant Safety and Security	

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Institute of Technology

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Department of Electronics and Telecommunication

	6.2	Industrial IoT Application domains: Healthcare, Smart Cities, Manufacturing Industries	
		Total	**52**

Textbooks:	
1	ArshdeepBahga and Vijay Madisetti, "Internet of Things: A Hands-on Approach, Universities Press.
2	Raj Kamal, Internet of Things: Architecture and Design Principles", McGraw Hill Education, First edition
3	Sudip Misra, Chandana Roy and Anandarup Mukherjee, 'Introduction to Industrial Internet of Things and Industry 4.0', CRC Press, Edition 2020.
4	Andrew Minteer," Analytics for the Internet of Things(IoT)",Kindle Edition
5	Alasdair Gilchrist, "Industry 4.0: The Industrial Internet of Things", Apress
6	Sabina Jeschke, Christian Brecher, Houbing Song, Danda B. Rawat, "Industrial Internet of Things: Cybermanufacturing Systems", Springer
Reference Books:	
1	Alp Ustundag Emre Cevikcan," Industry 4.0: Managing The Digital Transformation", Springer Series in Advanced Manufacturing
2	G. R. Kanagachidambaresan, R. Anand, E. Balasubramanian, V. Mahima, Internet of Things for Industry 4.0. EAI/Springer Innovations in Communication and Computing
3	The Internet of Things (Connecting objects to the web) by Hakima Chaouchi (Wiley Publications)
4	The Internet of Things (MIT Press) by Samuel Greengard
5	Adrian McEwen, Hakim Cassimally,: Designing the Internet of Things", Paperback, First Edition

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Department of Electronics and Telecommunication

Suggested reference material	
1.	https://onlinecourses.nptel.ac.in/noc20_cs69/preview
2.	Self-Learning: Recommended list of tools for self-learning 1. Node Red - https://nodered.org/ 2. M2MLabs Mainspring - http://www.m2mlabs.com/ 3. Tensor Flow - https://www.tensorflow.org/ 4. Things Speak - https://thingspeak.com/

Internal Assessment:
1) Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks.
2) Mid Term test is to be conducted when approx. 50% syllabus is completed.
3) Duration of the midterm test shall be one hour

Continuous Assessment:
Continuous Assessment is of **20 marks**. The rubrics for assessment will be considered on approval by the subject teachers. The rubrics can be any 2 or max 4 of the following:

Sr. No	Rubrics	Marks
1	Certificate course for 4 weeks or more: NPTEL/ Coursera/ Udemy/any MOOC	10 marks
2	Wins in the event/competition/hackathon	10 marks
3	Content beyond syllabus presentation	10 marks
4	Creating Proof of concept	10 marks
5	Mini Project / Extra Experiments/ Virtual Lab	10 marks
6	GATE Based Assignment test/Tutorials etc	10 marks
7	Participation in event/workshop/talk / competition followed by small report and certificate of participation relevant to the subject (in other institutes)	05 marks

VIVEKANAND EDUCATION SOCIETY'S

Institute of Technology

(An Autonomous Institute Affiliated to University of Mumbai, Approved by A.I.C.T.E & Recognized by Govt. of Maharashtra)

Department of Electronics and Telecommunication

8.	Multiple Choice Questions (Quiz)	05 marks
9.	Peer Review and participation in the class	05 Marks

End Semester Theory Examination:	
1	Question paper will be of 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.

VIVEKANAND EDUCATION SOCIETY'S
Institute of Technology

(An Autonomous Institute Affiliated to University of Mumbai, Approved by A.I.C.T.E & Recognized by Govt. of Maharashtra)

Department of Electronics and Telecommunication

COURSE NAME-Sensor Technologies and Applications

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/ PR	Tut	Total
NETP E613	Sensor Technologies and Applications	04	---	---	04	---	---	04

Sensor Technologies and Applications (Theory)

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/ PR	Tut	Total
NETP E613	Sensor Technologies and Applications (Theory)	04	---	---	04	---	---	04

Course Code	Course Name	Examination Scheme					
		Theory			Term Work	Practical & Oral	Total
		Internal Assessment		End Sem Exam			
		Mid-Term Test	CA				
NETPE613	Sensor Technology (Theory)	20	20	60	---	---	100

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Department of Electronics and Telecommunication

Course Code:	Course Title	Credit
NETPE613	Sensor Technologies and Applications	4

Prerequisite:
  1. Engineering Physics-II
  2. Electronic Devices & Circuits
  3. Linear Integrated Circuits
  4. Engineering Mathematics

Course Objectives:

1	To understand various physical parameters and its sensing techniques.
2	To discuss working of different types of transducers and sensors.
3	To familiarize about MEMS sensors and Actuators.
4	To introduce wireless sensing technologies.
5	To develop understanding about signal conditioning using ADC and DAC.
6	To provide insight into various sensor applications.

Course Outcomes:

1	Comprehend the transduction principle of various sensors.
2	Select sensors suitable for required application.
3	Analyse wireless sensing techniques.
4	Design the data acquisition system.

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Department of Electronics and Telecommunication

5	Identify signal conditioning method for particular application.
6	Create an application using various sensor technologies.

Module		Content	Hrs
1		**Introduction**	**9**
	1.1	**Overview of sensors and their role in modern systems.**	
	1.2	**Classification of Sensors:** **Primary physical quantity sensed**: Temperature, pressure, force, displacement, light, sound, etc. **Transduction principle**: Resistive, capacitive, inductive, piezoelectric, optical, etc. **Material and technology used**: MEMS, nano-sensors, fiber optic sensors. **Application domain**: Biomedical, automotive, industrial automation, aerospace, environmental monitoring. The sensors are classified with criteria like primary physical quantity to be sensed, transduction principle, material and technology used and application.	
	1.3	**Criteria to choose a Sensor:** Accuracy, Environmental condition, Range, Calibration, Resolution, Cost and Repeatability.	
	1.4	**Digital sensors:** Principle of digital sensing, sampling, quantization, and digital output. **Comparison with analog sensors:** Signal integrity, Ease of interface with digital systems. Noise resistance.	
	1.5	**Smart Sensors:** Definition and key features, Built-in signal processing, Communication capabilities, Low power, consumption, Self-diagnostic and self-calibration features.	

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Department of Electronics and Telecommunication

	1.6	**Overview of sensors in IoT applications, AI-integrated sensors, Predictive sensing.**	
2		**Types of Sensors**	**10**
	2.1	**Temperature Sensors :** RTD, Thermocouple PT100, and Thermistors sensor, Semiconductor PN junction sensors-LM35, Thermopile.	
	2.2	**Proximity Sensors :** Inductive (LVDT), Capacitive, Photoelectric and Ultrasonic sensors.	
	2.3	**Chemical Sensors :** Gas , Smoke, Conductivity and pH sensor.	
	2.4	**Other Sensors :** Optical, Infrared (IR), Sound, Motion, Pressure , Level , Moisture, Humidity, Laser , Image and GPS sensor.	
3		**MEMS Sensors and Actuators**	**7**
	3.1	**MEMS SENSORS:** miniaturized devices that integrate mechanical and electrical components for sensing applications. General design methodology, techniques for sensing, Pressure sensor, Mass Flow sensor, Acceleration sensor, Angular Rate sensor and Gyroscopes, Micro machined microphones, Chemical sensors, Taguchi Gas sensor, and Combustible Gas sensors.	
	3.2	**MEMS ACTUATORS:** Techniques for actuation, Digital Micro mirror Device, Micro Machined Valves.	
4		**Wireless Sensing Technologies**	**6**
	4.1	**Bluetooth:** Concepts of Pico net, Scatter net, Link types, Network connection establishments.	
	4.2	**ZigBee:** components, architecture, network topologies.	
	4.3	**Ultra Wide Band (UWB),** Near Field Communication (NFC) and RFID: technical requirements, components and characteristics.	

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Department of Electronics and Telecommunication

	4.4	**WLAN and ISA Standards:** Equipment, WLAN topologies. ISA100.11a standard (Wireless Networking Standard for Industrial Automation)	
	4.5	**WirelessHART:** Wireless Highway Addressable Remote Transducer protocol.	
5		**Data Acquisition and Signal Conditioning**	8
	5.1	**Fundamentals of Data Acquisition:** Analog and Digital data acquisition system with different configurations, Data loggers, Noise and interference which affect accuracy and signal integrity.	
	5.2	**Signal Conditioning:** Wheatstone Bridge, Flash ADC, R2R DAC.	
	5.3	Utilization of Signal conditioning circuits for Temperature, Pressure, Optical, Strain gauges, Displacement and piezoelectric Transducers.	
6		**Sensor Applications**	12
	6.1	Automobile sensors, Tire Pressure Monitoring System for Preventive Safety in Cars.	
	6.2	Smart Agriculture and Environmental Monitoring.	
	6.3	Radio sensors for industrial applications, Ground Penetrating Radars, Underwater sensing.	
	6.4	LIDAR in Autonomous Vehicles: Object detection, distance calculation, Enabling 360° environmental perception and safety enhancement.	
	6.5	Biomedical Sensing Applications-Biomedical Wearables	
		Total	52

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Department of Electronics and Telecommunication

Textbooks:	
1	D.V. S. Murthy, "Transducers and Instrumentation", PHI Learning, 2nd Edition, 2013.
2	D. Patranabis – Sensor and Transducers (2e) Prentice Hall, New Delhi, 2003.
3	Antti V. Raisanen, Arto Lehto, "Radio Engineering for Wireless Communication and Sensor Applications", Artech House mobile communications series, USA, 2003.
4	Ramon Pallas Areny, John G. Webster, Sensors and Signal Conditioning, 2nd edition, John Wiley and Sons, 2000.
5	Vijay K. Garg, "Wireless Communication and Networking", Morgan -Kaufmann Series in Networking, Elsevier, 2010.
6	James J. Allen, Micro Electro Mechanical System Design, Taylor and Francis, 2005
Reference Books:	
1	Nadim Maluf, Kirt Williams, An Introduction to Microelectromechanical Systems Engineering, Artech House, 2004.
2	A.K. Sawhney, A Course in Electrical and Electronic Measurements and Instrumentation, Dhanpatrai & Co., 19th Edition, 2011.
3	Nathan Ida, Sensors, Actuators and their Interfaces: A Multidisciplinary Introduction, Second Edition, IET Control, Robotics and Sensors Series 127, 2020
4	C.S. Rangan, G.R. Sarma, V.S. Mani, Instrumentation Devices and System, TMH, 1997.
5	Jacob Fraden Handbook of Modern Sensors Physics, Designs, and Applications, Fourth Edition, Springer, 2010
6	Richard Zurawski, Industrial Communication Technology Handbook, CRC press, 2nd Edition, 2014.

For Module-6 and advanced topics also refer to IEEE, Elsevier, Springer journal papers and magazines related to the specific topics.

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Department of Electronics and Telecommunication

NPTEL Course:

1 Sensors and Actuators, Prof. Hardik J. Pandya, IISc Bangalore, :
   https://nptel.ac.in/courses/108/108/108108147/

2 Aditya K. Jagnnatham, IIT Kanpur, LTE, WLAN, Bluetooth and Future, :
   https://www.youtube.com/watch?v=vjhp0zTXEsc

Internal Assessment:

Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks. Mid Term test is to be conducted when approx. 50% syllabus is completed Duration of the midterm test shall be one hour.

Continuous Assessment:-

Continuous Assessment **is of 20 marks.** The rubrics for assessment will be considered on approval by the subject teachers. The rubrics can be any 2 or max 4 of the following:-

Sr.no	Rubrics	Marks
1.	*Certificate course for 4 weeks or more:- NPTEL/ Coursera/ Udemy/any MOOC	10 marks
2.	Wins in the event/competition/hackathon	10 marks
3.	Content beyond syllabus presentation	10 marks
4.	Creating Proof of concept	10 marks
5.	Mini Project / Extra Experiments/ Virtual Lab	10 marks
6.	GATE Based Assignment test/Tutorials etc	10 marks
7.	Participation in event/workshop/talk / competition followed by small report and certificate of participation relevant to the subject(in other institutes)	5 marks

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Department of Electronics and Telecommunication

8.	Multiple Choice Questions (Quiz)	5 marks

End Semester Theory Examination:	
1	Question paper will be of 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 needs to be solved.

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Department of Electronics and Telecommunication

COURSE NAME: Big Data Analytics

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/ PR	Tut	Total
NETPE 621	Big Data Analytics	04	---	---	04	---	---	04

Big Data Analytics

Course Code	Course Name	Examination Scheme					
		Theory			Term Work	Practical & Oral	Total
		Internal Assessment		End Sem Exam			
		Mid-Term Test	CA				
NETPE621	Big Data Analytics	20	20	60	---	---	100

Course Prerequisite: Basic knowledge of Database Management System

Course Objectives:

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Department of Electronics and Telecommunication

1.	To Provide an Overview of an exciting growing field of Big Data Analytics.
2.	To introduce the tools required to manage and analyze big data like Hadoop, NoSql, Map Reduce.
3.	To teach the fundamental techniques in achieving big data analytics with scalability and streaming capability.

Course Outcomes:
After successful completion of the course students will be able to:

1.	Understand the key issues in big data management and its associated applications in intelligent business and scientific computing.
2.	Understand the building blocks of Big Data Analytics.
3.	Acquire fundamental enabling techniques like Hadoop, MapReduce and NoSQL in solving real world problems.
4.	Apply advanced techniques for emerging applications like stream analytics, link analysis, finding similar and frequent items.
5.	Achieve adequate perspectives of big data analytics in various applications like recommender systems, social media applications etc

Big Data Analytics

Module		Content	Hrs
1		**Introduction to Big Data Analytics**	**6**
	1.1	Introduction to Big Data, Big Data characteristics, Types of Big Data, Traditional vs. Big Data a business approach	
	1.2	Technologies Available for Big Data, Infrastructure for Big Data, Big Data Challenges, Case Study of Big Data Solutions.	
2		**Hadoop**	**8**
	2.1	Introduction to Hadoop, Core Hadoop Components, Physical Architecture, Hadoop limitations.	

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Department of Electronics and Telecommunication

	2.2	Hadoop Ecosystem-Apache HBase, Hive, HCatalog, Pig, Mahout, Oozie, Zookeeper, Sqoop etc.	
3		**MapReduce**	**8**
	3.1	MapReduce and The New Software Stack: Distributed File Systems, Physical Organization of Compute Nodes, The Map Tasks, Grouping by Key, The Reduce Tasks, Combiners, MapReduce Execution,	
	3.2	Relational-Algebra Operations such as Selections, Projections, Union, Intersection, and Difference by MapReduce.	
4		**NoSQL**	**8**
	4.1	Introduction to NoSQL, NoSQL business drivers, NoSQL data architecture patterns: Key-value stores, Graph stores, Column family	
	4.2	Analyzing big data with a shared-nothing architecture; Choosing distribution models: master-slave versus peer-to-peer; Four ways that NoSQL systems handle big data problems	
5		**Techniques for Big Data Analytics**	**15**
	5.1	**Finding Similar Item:** Nearest Neighbor Search, Similarity of Documents, Distance Measures: Euclidean, Jaccard , Cosine, Edit and Hamming Distance with its Examples	
	5.2	**Mining Data Streams:** Data Stream Management Systems, Data Stream Model, Examples of Data Stream Applications: Sensor Networks, Network Traffic Analysis, Filtering streams: The Blooms filter.	
	5.3	**Link Analysis:** Page Rank Definition, Structure of the web, dead ends, Using Page rank in a search engine, Efficient computation of Page Rank.	
	5.4	**Frequent Itemset Mining:** Market-Basket Model, Apriori Algorithm, Algorithm of ParkChen-Yu.	

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Department of Electronics and Telecommunication

		Big Data Analytics Applications	
6	6.1	**Recommendation Systems:** Introduction, A Model for Recommendation Systems: Collaborative-Filtering System, Content based system and its Examples.	7
	6.2	**Mining Social-Network Graphs:** Social Networks as Graphs, Types of Social-Network. Clustering of Social Graphs: Applying Standard Clustering Techniques	
		Total	52

Textbooks:	
1	Radha Shankarmani and M Vijayalakshmi ―Big Data Analytics‖, Wiley
2	Alex Holmes ―Hadoop in Practice‖, Manning Press, Dreamtech Press
3	Dan Mcary and Ann Kelly ―Making Sense of NoSQL‖ – A guide for managers and the res of us, Manning Press.
Reference Books:	
1	Bill Franks ―Taming The Big Data Tidal Wave: Finding Opportunities in Huge Data Streams with Advanced Analytics‖, Wiley
2	Chuck Lam ―Hadoop in Action‖, Dreamtech Press
Access to software	
	https://www.cloudera.com/products/stream-processing.html
Any other (Access to AI tools / Data driven insights (if applicable) or any other):	
	https://www.analyticsvidhya.com/blog/2014/05/hadoop-simplified
	https://www.analyticsvidhya.com/blog/2014/05/introduction-mapreduce/
	https://www.pdfdrive.com/big-data-analytics-a-hands-on-approach-e158549112.html
	https://www.pdfdrive.com/data-science-and-big-data-analytics-e58447171.html
	https://nptel.ac.in/courses/106104189

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Department of Electronics and Telecommunication

https://www.coursera.org/specializations/big-data#courses	
https://www.digimat.in/nptel/courses/video/106106169/L01.html	
https://www.coursera.org/learn/nosql-databases#syllabus	

Internal Assessment:
1) Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks.
2) Mid Term test is to be conducted when approx. 50% syllabus is completed.
3) Duration of the midterm test shall be one hour

Continuous Assessment:

Continuous Assessment is of **20 marks**. The rubrics for assessment will be considered on approval by the subject teachers. The rubrics can be any 2 or max 4 of the following:

Sr. No	Rubrics	Marks
1	Certificate course for 4 weeks or more: NPTEL/ Coursera/ Udemy/any MOOC	10 marks
2	Wins in the event/competition/hackathon	10 marks
3	Content beyond syllabus presentation	10 marks
4	Creating Proof of concept	10 marks
5	Mini Project / Extra Experiments/ Virtual Lab	10 marks
6	GATE Based Assignment test/Tutorials etc	10 marks
7	Participation in event/workshop/talk / competition followed by small report and certificate of participation relevant to the subject (in other institutes)	05 marks
8.	Multiple Choice Questions (Quiz)	05 marks
9.	Peer Review and participation in the class	05 Marks

VIVEKANAND EDUCATION SOCIETY'S

Institute of Technology

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Department of Electronics and Telecommunication

End Semester Theory Examination:	
1	Question paper will be of 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.

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Department of Electronics and Telecommunication

COURSE NAME: NEURAL NETWORKS AND FUZZY LOGIC

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/ PR	Tut	Total
NETPE622	Neural Networks and Fuzzy Logic	04	---	---	04	---	---	04

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/ PR	Tut	Total
NETPE622	Neural Networks and Fuzzy Logic	04	---	---	04	---	---	04

Course Code	Course Name	Examination Scheme					
		Theory					
		Internal Assessment		End Sem Exam	Term Work	Practical & Oral	Total
		Mid-Term Test	CA				

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Institute of Technology

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Department of Electronics and Telecommunication

NETPE622	Neural Networks and Fuzzy Logic	20	20	60	---	---	100

Prerequisite: Computer Networks and Operating Systems.	
Course Objectives:	
1	To introduce the concepts and understanding of artificial neural networks
2	To provide adequate knowledge about supervised and unsupervised neural networks
3	To expose neural networks based methods to solve real world complex problems
4	To study Machine Learning, Deep Learning and Applications
5	To introduce fuzzy logic and fuzzy inference systems
6	To provide knowledge about applications of Fuzzy Logic.
Course Outcomes:	
1	Comprehend the concepts of biological neurons and artificial neurons
2	Analyse the feed-forward and feedback neural networks and their learning algorithms.
3	Comprehend the neural network training and design concepts.
4	Comprehend the concept of SVM and CNN.
5	Comprehend the concept of fuzzy logic and fuzzy systems.
6	Analyse the application of neural networks and fuzzy logic to real world problems.

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Institute of Technology

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Department of Electronics and Telecommunication

Module		Content	Hrs
1		**Introduction to Neural Networks and their Basic Concepts**	8
	1.1	Biological neuron and Artificial neuron,	
	1.2	McCulloch-Pitts Model, Activation Function, various types of Activation Functions and types of Neural Network Architectures.	
	1.3	Prerequisites for Training of Neural Networks. Linearly Separable and Linearly Non-Separable Systems with examples, Concepts of Supervised Learning, Unsupervised Learning, and Reinforcement Learning.	
	1.4	Brief survey of applications of Neural Networks.	
2		**Supervised Learning Neural Networks**	8
	2.1	Perceptron - Single Layer Perceptron, Multilayer Perceptron and their Architecture.	
	2.2	Error Functions: Mean Square Error and Sum Squared Error. Gradient Descent, Generalized delta rule, Error back propagation, LMS Algorithm, Stopping Criterions for Training.	
3		**Unsupervised Learning Neural Networks**	8
	3.1	Competitive Learning Network – Kohonen Self-Organizing Networks – Architecture, Training Algorithm.	
	3.2	Discrete Hopfield Network- Hopfield Matrix, Testing Algorithm, K-Means Clustering Algorithm.	

VIVEKANAND EDUCATION SOCIETY'S

Institute of Technology

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Department of Electronics and Telecommunication

4		**Machine Learning and Deep Learning**	
	4.1	Basic concept of Machine Learning, Support Vector Machine (SVM) - Introduction and SVM based Binary Classifier.	**6**
	4.2	Basic concept of Deep Learning, Convolution Operation, Overview of CNN Architecture, Input layer, Convolution layers, Pooling layers, Padding, Strided Convolutions. Rectified Linear Unit (ReLU), One Layer of a Convolutional Network, Fully Connected Layers, Complex Image Classification using CNN.	
5		**Fundamentals of Fuzzy logic and Fuzzification**	
	5.1	Fundamentals of Fuzzy Logic, Fuzzy Rules, Properties of Fuzzy Sets. Fuzzy Set Operations, - Union, Intersection, complement Difference; Fuzzy relations: Cartesian product of relation, Classical Relation, Cardinality of fuzzy relations, Operations on Fuzzy relations, Properties of Fuzzy, Fuzzy relations composition.	**14**
	5.2	Membership Functions, Fuzzification - Membership Value Assignments using Intuition Method.	
6		**Methods of Defuzzification, Fuzzy Inference System**	
	6.1	Defuzzification Methods -- Mean of Maxima and Centroid (Centre of Area) Methods, Fuzzy Inference System with reference to Mamdani Model, Lambda-Cuts for Fuzzy Sets.	**8**
	6.2	Brief Review of Applications of Fuzzy Logic to Speed Control of DC Motor, Train Break, and Washing Machine.	
		Total	**52**

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Department of Electronics and Telecommunication

Textbooks:	
1.	S. N. Sivanandam and S. N. Deepa, Introduction to Soft Computing, Wiley India Publications, 3rd Edition.
2.	Simon Haykin, Neural Networks and Learning Machines, Pearson Prentice Hall, 3rd Edition
3.	S. Rajasekaran and G. A. Vijayalakshmi Pai, Neural Networks, Fuzzy Logic, and Genetic Algorithms, PHI Learning Pvt. Ltd, 2003.
4.	Mohit Sewak, Md. Rezaul Karim, Pradeep Pujari, Practical Convolutional Neural Networks by , Packt Publishing, 2018.
5.	Timothy J. Ross, Fuzzy Logic with Engineering Applications, Wiley India Publications, 3rd Edition.
Reference Books:	
1.	Hagan, Demuth, and Beale, Neural Network Design, Thomson Learning, 2nd Edition.
2.	Simon Haykin, Neural Network- A Comprehensive Foundation, Pearson Education, 2nd Edition.
3.	Christopher M. Bishop, Neural Networks for Pattern Recognition, Oxford University Press, 2005.
4.	William W. Hsieh, Machine Learning Methods in the Environmental Sciences: Neural Network and Kernels, Cambridge University Press, 2009.
5.	Ian Goodfellow, Yoshua Bengio, Aaron Courville, Deep Learning, MIT Press, 2016
6.	S. N. Sivanandam, S. Sumathi, and S. N. Deepa, Introduction to Neural Network using Matlab, Tata McGraw-Hill Publications, 2006.

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Department of Electronics and Telecommunication

7.	Mehrotra Kishan, Mohan C. K. Ranka Sanjay, Elements of Artificial Neural Networks, Penram International Publishing Pvt. Ltd, 2nd Edition.
8.	J. M. Zurada, Introduction to Artificial Neural Systems, Jaico Publishers, 2006.
9.	Bart Kosko, Neural Networks and Fuzzy Systems, Pearson Education, 2007.

Access to software and virtual labs:
1.	**Artificial Neural Networks Lab by IIIT Hyderabad**: This virtual lab provides hands-on experience in understanding the basics of ANN models and the pattern recognition tasks they perform. cse22-iiith.vlabs.ac.in
2.	**Soft Computing Tools in Engineering Lab by IIT Kharagpur**: This lab offers an introduction to neural networks and includes a perceptron example to help understand the fundamentals. scte-iitkgp.vlabs.ac.in
Any other (Access to AI tools / Data driven insights (if applicable) or any other):
1	**Fuzzy Logic and Neural Networks by IIT Kharagpur** https://onlinecourses.nptel.ac.in/noc25_ge15/preview

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Institute of Technology
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Department of Electronics and Telecommunication

Internal Assessment:

Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks.

Mid Term test is to be conducted when approx. 50% syllabus is completed Duration of the midterm test shall be one hour.

Continuous Assessment:-

Continuous Assessment **is of 20 marks.** The assessment tools for the continuous assessment will be considered on approval by the subject teachers. The assessment tools can be any 2 or max 4 of the following:-

Sr.no	Assessment Tools	Marks
1.	*Certificate course for 4 weeks or more:- NPTEL/ Coursera/ Udemy/any MOOC	10 marks
2.	Wins in the event/competition/hackathon	10 marks
3.	Content beyond syllabus presentation	10 marks
4.	Creating Proof of concept	10 marks
5.	Mini Project / Extra Experiments/ Virtual Lab	10 marks
6.	GATE Based Assignment test/Tutorials etc	10 marks
7.	Participation in event/workshop/talk / competition followed by small report and certificate of	5 marks

VIVEKANAND EDUCATION SOCIETY'S
Institute of Technology

(An Autonomous Institute Affiliated to University of Mumbai, Approved by A.I.C.T.E & Recognized by Govt. of Maharashtra)

Department of Electronics and Telecommunication

	participation relevant to the subject(in other institutes)	
8.	Multiple Choice Questions (Quiz)	5 marks

End Semester Theory Examination:	
1	Question paper will be of 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 needs to be solved.

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Department of Electronics and Telecommunication

COURSE NAME: IMAGE PROCESSING AND MACHINE VISION

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/PR	Tut	Total
NETPE 623	Image Processing and Machine Vision	04	---	---	04	---	---	04

IMAGE PROCESSING AND MACHINE VISION (Theory)

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW / PR	Tut	Total
NETPE 623	Image Processing and Machine Vision (Theory)	04	---	---	04	--	---	04

Course Code	Course Name	Examination Scheme					
		Theory			Term Work	Practical & Oral	Total
		Internal Assessment		End Sem Exam			
		Mid-Term Test	CA				
NETPE623	Image Processing and Machine Vision (Theory)	20	20	60	--	--	100

VIVEKANAND EDUCATION SOCIETY'S
Institute of Technology

(An Autonomous Institute Affiliated to University of Mumbai, Approved by A.I.C.T.E & Recognized by Govt. of Maharashtra)

Department of Electronics and Telecommunication

Course Prerequisite: Signals and Systems , Discrete Time Signal Processing , Python Programming Skill Lab

Course Objectives:	
1	To teach the fundamentals and mathematical models in digital image processing and Machine Vision
2	To teach quality enhancement of image through filtering operations
3	To teach the students image morphology and restoration techniques
4	To expose the students to segmentation techniques in image processing and Machine Vision
5	To teach the techniques of extracting image attributes like regions and shapes
6	To learn classification and recognition algorithms for machine vision

Course Outcomes: After successful completion of the course students will be able to:	
1	Understand fundamentals of image processing and machine vision.
2	Enhance the quality of image using spatial and frequency domain techniques for image enhancement
3	Learn image morphology and restoration techniques
4	Learn image segmentation techniques based on principle of discontinuity and similarity using various algorithms
5	Represent boundaries and shapes using standard techniques
6	Classify the object using different classification methods

VIVEKANAND EDUCATION SOCIETY'S
Institute of Technology

(An Autonomous Institute Affiliated to University of Mumbai, Approved by A.I.C.T.E & Recognized by Govt. of Maharashtra)

Department of Electronics and Telecommunication

IMAGE PROCESSING AND MACHINE VISION (Theory)

Module		Content	Hrs
1		**DIGITAL IMAGE FUNDAMENTALS AND POINT PROCESSING**	**4**
	1.1	Introduction –Steps in Digital Image Processing, concept of spatial and intensity resolution, Relationships between pixels	
	1.2	Point Processing: Image Negative, Log Transform, Power Law transform, Bit plane slicing, Contrast stretching, Histogram equalization and Histogram Specification	
2		**IMAGE ENHANCEMENT**	**12**
	2.1	Spatial Domain filtering: The Mechanics of Spatial Filtering, Smoothing Spatial Filters-Linear Filters-Averaging filter, Order-Statistic Filters- Median filter, Application of Median filtering for Noise removal Sharpening Spatial Filters- The Laplacian, Unsharp Masking and High boost Filtering, Using First-Order Derivatives —The Gradient- Sobel, Prewitt and Roberts	
	2.2	Frequency Domain Filtering: Introduction to 2-D DFT and its application in frequency domain filtering, Wavelet transform, Haar transform	
	2.3	Frequency Domain Filtering Fundamentals, Fourier Spectrum and Phase angle, Steps for Filtering in the Frequency Domain, Correspondence Between Filtering in the Spatial and Frequency Domains, Frequency domain Image Smoothing and sharpening filter - Ideal, Butterworth, Gaussian	
3		**IMAGE MORPHOLOGY AND RESTORATION**	**8**
	3.1	Morphology: Erosion and Dilation, Opening and Closing, The Hit-or-Miss Transformation, Boundary extraction, Hole filling, Thinning and thickening	
	3.2	Restoration: A Model of the Image Degradation/Restoration Process, Noise models, Removal periodic noise, Principle of Inverse filtering.	
4		**IMAGE SEGMENTATION**	**10**

VIVEKANAND EDUCATION SOCIETY'S
Institute of Technology

(An Autonomous Institute Affiliated to University of Mumbai, Approved by A.I.C.T.E & Recognized by Govt. of Maharashtra)

Department of Electronics and Telecommunication

	4.1	Point, Line, and Edge Detection: Detection of Isolated Points, Line detection, edge models, Canny's edge detection algorithm, Edge linking: Local processing and boundary detection using regional processing (polygonal fitting).	
	4.2	Thresholding: Foundation, Role of illumination and reflectance, Basic global thresholding.	
		Region Based segmentation: Region Growing, Region Splitting and merging.	
5		**INTRODUCTION TO IMAGE DESCRIPTORS**	**8**
	5.1	Introduction to Texture, Co-occurrence matrix, Chain code.	
	5.2	Image Feature Selection, Best Features and Their Properties, Feature Variance, Feature Correlation, Dimension Reduction.	
6		**MACHINE VISION ALGORITHMS**	**10**
	6.1	Knowledge representation, Object detection using Template Matching, Artificial Neural Networks for Image Classification, Feed-Forward Error Back Propagation based Classifier Learning, Class Separation Distance, Confusion Matrix.	
	6.2	K-means clustering algorithm, Support Vector Machine for binary classification case; Support Vectors and Hyperplane.	
		Total	**52**

Textbooks:	
1	Milan Sonka , Vaclav Hlavac, Roger Boyle, "Image Processing, Analysis, and Machine Vision" Cengage Engineering, 3rd Edition, 2013
2	Gonzales and Woods, "Digital Image Processing", Pearson Education, India, Third Edition,
3	R. O. Duda and P. E. hart, Pattern classification and scene analysis, Wiley Interscience publication
4	Christopher M. Bishop; Pattern Recognition and Machine Learning, Springer, 2006
5	Kenneth R. Castleman, Digital Image Processing, Pearson Publications, 2012.

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Institute of Technology
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Department of Electronics and Telecommunication

Reference Books:	
1	Anil K. Jain, "Fundamentals of Image Processing", Prentice Hall of India, First Edition, 1989.
2	W Pratt, "Digital Image Processing", Wiley Publication, 3rd Edition, 2002
3	Forsyth and Ponce, Computer vision: A modern approach, PHI
4	Frank Y Shish, Image Processing and Pattern Recognition: Fundamentals and Techniques, Wiley Wiley-IEEE Press, 2010

Internal Assessment:

1) Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks.
2) Mid Term test is to be conducted when approx. 50% syllabus is completed.
3) Duration of the midterm test shall be one hour.

Continuous Assessment:

Continuous Assessment is of **20 marks**. The rubrics for assessment will be considered on approval by the subject teachers. The rubrics can be any 2 or max 4 of the following:

Sr. No	Rubrics	Marks
1	*Certificate course for 4 weeks or more: NPTEL/ Coursera/ Udemy/any MOOC	10 marks
2	Wins in the event/competition/hackathon	10 marks
3	Content beyond syllabus presentation	10 marks
4	Creating Proof of concept	10 marks
5	Mini Project / Extra Experiments/ Virtual Lab	10 marks
6	GATE Based Assignment test/Tutorials etc	10 marks
7	Participation in event/workshop/talk / competition followed by small report and certificate of participation relevant to the subject (in other institutes)	05 marks
8.	Multiple Choice Questions (Quiz)	05 marks

VIVEKANAND EDUCATION SOCIETY'S
Institute of Technology

(An Autonomous Institute Affiliated to University of Mumbai, Approved by A.I.C.T.E & Recognized by Govt. of Maharashtra)

Department of Electronics and Telecommunication

*For sr.no.1, the date of the certification exam should be within the term and in case a student is unable to complete the certification , the grading has to be done accordingly.

End Semester Theory Examination:	
1	Question paper will be of 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.

VIVEKANAND EDUCATION SOCIETY'S
Institute of Technology

(An Autonomous Institute Affiliated to University of Mumbai, Approved by A.I.C.T.E & Recognized by Govt. of Maharashtra)

Department of Electronics and Telecommunication

COURSE NAME: VULNERABILITY ASSESSMENT AND PENETRATION TESTING LAB

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/ PR	Tut	Total
NETM ML61	Vulnerability Assessment and Penetration Testing Lab	--	04	---	--	02	---	02

Course Code	Course Name	Examination Scheme					
		Theory			Term Work	Practical & Oral	Total
		Internal Assessment		End Sem Exam			
		Mid-Term Test	CA				
NETMM L61	Vulnerability Assessment and Penetration Testing Lab	--	--	--	25	25	50

Lab Prerequisite: C programming, Python programming, Computer networks, Basics of Network Security, Ethical Hacking & Digital Forensics	
Lab Objectives:	
1	To identify security vulnerabilities and weaknesses in the target applications
2	To discover potential vulnerabilities which are present in the system in network using vulnerability assessment tools.
3	To identify threats by exploiting them using penetration test attempt by utilizing the vulnerabilities in a system

VIVEKANAND EDUCATION SOCIETY'S
Institute of Technology
(An Autonomous Institute Affiliated to University of Mumbai, Approved by A.I.C.T.E & Recognized by Govt. of Maharashtra)

Department of Electronics and Telecommunication

4	To recognize how security controls can be improved to prevent hackers gaining access controls to database
5	To test and exploit systems using various tools and understands the impact in system logs
6	To write a report with a full understanding of current security posture and what work is necessary to both fix the potential threat and to mitigate the same source of vulnerabilities in the future

Lab Outcomes:

After successful completion of the course students will be able to:

1	Understand the structure where vulnerability assessment is to be performed.
2	Apply assessment tools to identify vulnerabilities present in the system in network.
3	Evaluate attacks by executing penetration tests on the system or network
4	Analyse a secure environment by improving security controls and applying prevention mechanisms for unauthorised access to database.
5	Create security by testing and exploit systems using various tools and remove the impact of hacking in system
6	Formation of documents as per applying the steps of vulnerabilities of assessment and penetration testing

VIVEKANAND EDUCATION SOCIETY'S
Institute of Technology

(An Autonomous Institute Affiliated to University of Mumbai, Approved by A.I.C.T.E & Recognized by Govt. of Maharashtra)

Department of Electronics and Telecommunication

VULNERABILITY ASSESSMENT AND PENETRATION TESTING LAB

Hardware & Software Requirements:

Hardware Requirements	Software Requirements	Other Requirements
PC With Following Configuration 1. Intel PIV Processor 2. 4 GB RAM 3. 500 GB Harddisk 4. Network interface card	1. Windows or Linux Desktop OS 2. Security Software and tools	1. Internet Connection

Module		Content	Hrs
		Pre-requisites: Computer networks, Basics of Network Security, Ethical Hacking & Digital Forensics	**2**
1		**Human Security (Social Engineering) Assessment**	**8**
	1.1	**Visibility Audit:** Collecting information through social media and internet. Collecting contact details (like phone number, email ID, What's App ID, etc)	
	1.2	**Active Detection Verification:** Test if the phone number, email id etc are real by test message. Test whether the information is filtered at point of reception. Test if operator / another person assistance can be obtained	
	1.3	**Device Information:** IP Address, Port details, Accessibility, Permissions, Role in business **Trust Verification:** Test whether the information can be planted in form of note / email / Message (Phishing)	
	1.4	**Test Subjects:** College Staff, Reception, PA to Director / Principal. To	

VIVEKANAND EDUCATION SOCIETY'S
Institute of Technology
(An Autonomous Institute Affiliated to University of Mumbai, Approved by A.I.C.T.E & Recognized by Govt. of Maharashtra)

Department of Electronics and Telecommunication

		conduct information gathering to conduct social engineering audit on various sections in your college. **Self-Learning Topics:** Networking Commands	
2		**Network & Wireless Security Assessment**	**8**
	2.1	**Network Discovery:** Using various tools to discover the various connected devices, to get device name, IP Address, relation of the device in network, Detection of Active port, OS Fingerprinting, Network port and active service discovery **Tools:** IP Scanner, Nmap etc	
	2.2	**Network Packet Sniffing:** Packet Sniffing to detect the traffic pattern, Packet capturing to detect protocol specific traffic pattern, Packet capturing to reassemble packet to reveal unencrypted password **Tools:** Wireshark **Self-Learning Topics:** Learning the CVE database for vulnerabilities detected	
3		**Setting up Pentester lab**	**9**
	3.1	Including an attacker machine preferably Kali and in the same subnet victim machines either DVWA/ SEEDlabs/ multiple VULNHUB machines as and when required. Understanding Categories of pentest and legalities/ ethics.	
	3.2	Installed Kali machine on VM environment with some VULNHUB machines and we can find out vulnerability of Level 1-VULNHUB machine like deleted system files, permissions of files. **Self learning Topics:** Vulnerability exploitation for acquire root access of the Kioptrx machine	
4		**Database and Access Control Security Assessment**	**9**
	4.1	**Database Password Audit:** Tool based audit has to be performed for strength of password and hashes. **Tools:** DBPw Audit	

VIVEKANAND EDUCATION SOCIETY'S
Institute of Technology
(An Autonomous Institute Affiliated to University of Mumbai, Approved by A.I.C.T.E & Recognized by Govt. of Maharashtra)

Department of Electronics and Telecommunication

	4.2	**Blind SQL Injection:** Test the security of the Database for SQL Injection **Tools:** BSQL Hacker	
	4.3	**Password Audit:** Perform the password audit on the Linux / Windows based system **Tools:** Cain & Able, John the ripper, LCP Password Auditing tools for Windows	
	4.4	**Active Directory and Privileges Audit:** Conduct a review of the Active Directory and the Group Policy to assess the level of access privileges allocated. **Tools:** SolarWinds **Self-Learning Topics:** Federated Database security challenges and solutions	
5		**Log Analysis**	**6**
	5.1	Conduct a log analysis on Server Event Log / Firewall Logs / Server Security Log to review and obtain insights Tools: graylog, Open Audit Module. **Self-Learning Topics:** Python and R-Programming scripts	
6		**Compliance and Observation Reporting**	**10**
	6.1	**License Inventory Compliance:** Identify the number of licenses and its deployment in your organization. Tools: Belarc Advisor, Open Audit	
	6.2	Report Writing: NESSUS tool Report should contain: a. Vulnerability discovered b. The date of discovery c. Common Vulnerabilities and Exposure (CVE) database reference and score; those vulnerabilities found with a medium or high CVE score should be addressed immediately d. A list of systems and devices found vulnerable	

VIVEKANAND EDUCATION SOCIETY'S

Institute of Technology

(An Autonomous Institute Affiliated to University of Mumbai, Approved by A.I.C.T.E & Recognized by Govt. of Maharashtra)

Department of Electronics and Telecommunication

		e. Detailed steps to correct the vulnerability, which can include patching and/or reconfiguration of operating systems or applications f. Mitigation steps (like putting automatic OS updates in place) to keep the same type of issue from happening again	
	6.3	**Purpose of Reporting:** Reporting provides an organization with a full understanding of their current security posture and what work is necessary to both fix the potential threat and to mitigate the same source of vulnerabilities in the future. **Self-Learning Topics:** Study of OpenVAS, Nikto, etc	
		Total	**52**

	Textbooks:
1	The Web Application Hacker's Handbook: Finding and Exploiting Security Flaws Paperback – Illustrated, 7 October 2011 by Dafydd Stuttard
2	Hacking: The Art of Exploitation, 2nd Edition 2nd Edition by Jon Erickson
3	Important links of Vulnhub: Vulnhub Kioptrix Download Link: https://www.vulnhub.com/entry/basic-pentesting-1,216/ https://www.vulnhub.com/entry/kioptrix-level-1-1,22/ Installation Video: https://youtu.be/JupQRHtfZmw Walkthrough/solutions Video: https://youtu.be/Qn2cKYZ6kBI
	Useful links:
1	www.leetcode.com
2	www.hackerrank.com
3	www.cs.usfca.edu/~galles/visualization/Algorithms.html
4	www.codechef.com

Term Work:

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Institute of Technology

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Department of Electronics and Telecommunication

1) Term work should consist of assessment for minimum 10 experiments.
2) Journal must include at least 2 assignments
3) Total 50 marks **(Split up)**

Department of Electronics and Telecommunication

COURSE NAME: SKILL LAB -II : EMBEDDED PROGRAMMING FOR TELECOMMUNICATION

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/ PR	Tut	Total
NETV S61	Skill Lab -II : Embedded Programming for Telecommunication	---	2+2*	---	---	02	---	02

Skill Lab -II : Embedded Programming for Telecommunication

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/ PR	Tut	Total
NETV S61	Skill Lab -II : Embedded Programming for Telecommunication	--	2+2*	---	--	02	---	02

*2 Hours Tutorial + Project work[Not necessarily classroom teaching]

Course Code	Course Name	Examination Scheme					
		Theory			Term Work	Practical & Oral	Total
		Internal Assessment		End Sem Exam			
		Mid-Term Test	CA				
NETVS61	Skill Lab -II : Embedded Programming for Telecommunication	--	--	--	50	50	100

VIVEKANAND EDUCATION SOCIETY'S

Institute of Technology

(An Autonomous Institute Affiliated to University of Mumbai, Approved by A.I.C.T.E & Recognized by Govt. of Maharashtra)

Department of Electronics and Telecommunication

Course Prerequisite: Microprocessor and Microcontrollers, Digital VLSI, Skill Lab -1: Telecommunication software Tools lab	
Course Objectives:	
1	Provide hands-on experience with Raspberry Pi and Xilinx FPGA boards.
2	Teach embedded programming, FPGA design, and sensor interfacing.
3	Enable students to develop real-world applications using embedded systems.
4	Foster teamwork and problem-solving skills through a capstone project.
Course Outcomes: After successful completion of the course students will be able :	
1	Design and implement embedded systems using Raspberry Pi and Xilinx SDK with FPGA boards.
2	Interface sensors and peripherals using communication protocols like I2C, SPI, and UART.
3	Develop FPGA-based systems using the MicroBlaze soft-core processor.
4	Build real-time embedded applications integrating hardware and software.
5	Complete a capstone project demonstrating end-to-end embedded system design and development.
6	Design and implement embedded systems using Raspberry Pi and Xilinx SDK kit with FPGA boards.

Skill Lab -II : Embedded Programming for Telecommunication

Module		Content	Hrs
1		**Introduction to Embedded Systems and Tools:** **Objective:** Familiarize students with embedded systems concepts, tools, and development environments.	6

	1.1	I. Overview of embedded systems and their applications. Introduction to Raspberry Pi and Xilinx SDK with Boolean FPGA boards.
		    a. Setting up development environments:
		    b. Raspberry Pi: Raspbian OS, Python, and C programming.
		 II. Xilinx SDK: Vivado IDE, FPGA programming flow.	

VIVEKANAND EDUCATION SOCIETY'S

Institute of Technology

(An Autonomous Institute Affiliated to University of Mumbai, Approved by A.I.C.T.E & Recognized by Govt. of Maharashtra)

Department of Electronics and Telecommunication

		III. Basic GPIO interfacing on Raspberry Pi and Boolean FPGA boards. IV. Introduction to communication protocols: UART, I2C, SPI.	

	1.2	**LAB 1: 5 Marks**
		1. Install and configure Raspbian OS on Raspberry Pi.
		2. Write a simple LED blink program on Raspberry Pi and Boolean FPGA boards.
		3. SDK Experiment:
		    a) Create a Vivado project and use IP Integrator to develop a basic embedded system for a target board.
		    b) Adding Peripherals in Programmable Logic
		    c) Writing Basic Software Applications: Write a basic C application to access the peripherals.
		    d) Software Debugging Using SDK
		Reference **:**
		https://www.amd.com/en/corporate/university-program/vivado/vivado-workshops/vivado-embedded-design-flow-zynq.html	

2		**Embedded Programming with Raspberry Pi** **Objective:** Develop proficiency in programming and interfacing sensors/ actuators using Raspberry Pi.	**6**
	2.1	I. Python and C programming for embedded systems. II. Interfacing sensors (e.g., temperature, humidity, motion) with Raspberry Pi. III. PWM and motor control using Raspberry Pi. IV. Introduction to Linux-based embedded systems.	
	2.2	**LAB 2 : 5 Marks** 1. Interface a temperature sensor (e.g., DHT11) and display readings. 2. Control a DC motor using PWM signals. 3. Develop a simple web server on Raspberry Pi to display sensor data.	
3		**FPGA MicroBlaze Interfacing with I2C and SPI Protocols** **Objective:** Learn to design and implement FPGA-based systems using the MicroBlaze soft-core processor and interface it with I2C and SPI-based sensors.	**8**
	3.1	I. Introduction to MicroBlaze soft-core processor.	

VIVEKANAND EDUCATION SOCIETY'S

Institute of Technology

(An Autonomous Institute Affiliated to University of Mumbai, Approved by A.I.C.T.E & Recognized by Govt. of Maharashtra)

Department of Electronics and Telecommunication

		II. I2C protocol and interfacing with accelerometer and temperature sensors. III. SPI protocol and interfacing with moisture sensors. IV. Sensor data processing and display using MicroBlaze.	
	3.2	**LAB 3: 5 Marks[Perform at least 3 Labs of SDK from below]** 1. Set up MicroBlaze in Vivado and Xilinx SDK. 2. Interface an I2C-based accelerometer (e.g., MPU6050) and read data. 3. Interface an SPI-based moisture sensor and read data. 4. Interface an I2C-based temperature sensor and read data. 5. Integrate and UART based datalogger system for display sensor data on a serial terminal or LCD.	
4		**Communication Protocols and Interfacing** **Objective**: Explore communication protocols and their implementation in embedded systems.	7
	4.1	I. Deep dive into UART, I2C, and SPI protocols. II. Interfacing sensors and peripherals using communication protocols. III. Wireless communication: Bluetooth and Wi-Fi with Raspberry Pi. IV. Implementing custom communication protocols on Boolean FPGA boards.	

	4.2	**LAB 4: 5 Marks [Perform at least 2 labs of Raspberry pi and 3 Labs of SDK below]**
		1. Interface an I2C-based accelerometer with Raspberry Pi.
		2. Establish SPI communication for Raspberry Pi
		3. Develop a Bluetooth-controlled LED system using Raspberry Pi.
		4. Using SDK
		   1. Create a SoC-Based System using Programmable Logic
		   2. Debugging using Vivado Logic Analyzer cores
		   3. Extending Memory Space with Block RAM
		   4. Direct Memory Access using CDMA
		   5. Configuration and Booting
		   6. Profiling and Performance Tuning
		Reference **:**
		https://www.amd.com/en/corporate/university-program/vivado/vivado-workshops/vivado-adv-embedded-design-zynq.html	

VIVEKANAND EDUCATION SOCIETY'S
Institute of Technology
(An Autonomous Institute Affiliated to University of Mumbai, Approved by A.I.C.T.E & Recognized by Govt. of Maharashtra)

Department of Electronics and Telecommunication

5	**Raspberry Pi with OpenCV and IoT Camera Applications** **Objective:** Learn to implement computer vision and IoT applications using Raspberry Pi and OpenCV with a camera module.		**6**
	5.1	I. Introduction to OpenCV and its applications in embedded systems. II. Setting up OpenCV on Raspberry Pi. III. Capturing and processing images/videos using Raspberry Pi camera. IV. IoT integration: Streaming video over the internet. V. Object detection and face recognition using OpenCV.	
	5.2	**LAB 5: 5 Marks [Perform at least 3 labs from below]** 1. Install OpenCV on Raspberry Pi and set up the camera module. 2. Capture and display live video feed using OpenCV. 3. Implement motion detection using OpenCV. 4. Stream video over a local network using Flask or MQTT. 5. Develop a simple face recognition system using OpenCV.	
6		**Capstone Project: (25 Marks)**	**15**
	6.1	**Project Guidelines:** I. Students will work in teams to design an embedded system using Raspberry Pi or Xilinx SDK with Boolean FPGA boards. II. The project should integrate hardware, software, and communication protocols.	
	6.2	**Project Activities:** 1. Project planning and requirement analysis. 2. Hardware and software design. 3. Integration and testing. 4. Final presentation and demonstration.	
		Total	**48**

Reference Books:	
1	"Embedded Systems with ARM Cortex-M Microcontrollers in Assembly Language and C" by Yifeng Zhu – For embedded programming concepts.

VIVEKANAND EDUCATION SOCIETY'S

Institute of Technology

(An Autonomous Institute Affiliated to University of Mumbai, Approved by A.I.C.T.E & Recognized by Govt. of Maharashtra)

Department of Electronics and Telecommunication

2	"FPGA Prototyping by Verilog Examples" by Pong P. Chu – For FPGA design and Verilog programming.
3	"Raspberry Pi Cookbook" by Simon Monk – For Raspberry Pi-based projects.
4	"Learning OpenCV 4 Computer Vision with Python" by Joseph Howse – For OpenCV and computer vision applications.
5	"Designing Embedded Systems with 32-Bit PIC Microcontrollers and MikroC" by Dogan Ibrahim – For embedded system design principles.
Useful Links	
1.	https://www.amd.com/en/corporate/university-program/workshops.html
2.	https://learn.circuit.rocks/introduction-to-opencv-using-the-raspberry-pi

Internal Assessment:

1. **Term Work Consists of**
   - I. 5 Labs mentioned in syllabus &
   - II. Capstone Project
2. Total (50 Marks) = 5 Labs (25 Marks) + Capstone Project (25 Marks).

3. **Lab Reports and Activities** : 25 Marks
   - I. LAB 1 to LAB 5 each carry 5 Marks
   - II. It includes LAB performance and Journal Submission.
4. **Capstone Project** : 25 Marks
   1. Implementation of Project : 10 Marks
      - I. Defining specification and selecting sensors : 2 Mark
      - II. Literature survey, block diagram/architecture : 2 Marks
      - III. Implementing of hardware : 6 Marks
   2. Validation and Testing : 4 Marks
   3. PCB design : 4 Marks
   4. Making Model using 3 D Printing : 4 Marks
   5. Idea pitching of working Prototype : 3 Marks

VIVEKANAND EDUCATION SOCIETY'S
Institute of Technology
(An Autonomous Institute Affiliated to University of Mumbai, Approved by A.I.C.T.E & Recognized by Govt. of Maharashtra)

Department of Electronics and Telecommunication

Suggested Project List

Sr. No	Projects	Description	Components Needed
FPGA Based Projects			

1. Magnetometer-based Digital Compass
   a. Use an HMC5883L magnetometer to build a digital compass.
2. Clap Switch
   a. Use a Sound sensor to turn on and off LEDs
3. Weather Station
   a. Collects and displays environmental data on a PC via UART or an LCD screen.
4. Smart Fan Using BMP280
   a. Automatically controls a fan based on temperature using the BMP280 sensor
5. Water Level Detection
   a. The Ultrasonic sensor detects the level of water in a tank.
6. Weighing Machine
   a. Measuring Weight using HX711 ADC Module and Load Cells
7. FPGA-based digital audio processor with IoT integration
8. FPGA-Based Temperature Monitoring System
   a. Read temperature data via I2C sensor.
   b. Display temperature on LCD and trigger alerts.
9. MicroBlaze-Based Real-Time Data Logger
   a. Store sensor data in FPGA memory.
   b. Send logged data via UART to a PC for analysis.
10. MicroBlaze-Based Real-Time Data Logger
    a. Store sensor data in FPGA memory.
    b. Send logged data via UART to a PC for analysis.
11. MicroBlaze-Based Custom CPU Implementation
    a. Implement a basic RISC processor using MicroBlaze.
    b. Run simple embedded C programs on the soft core.
12. MicroBlaze-Based Motor Control System
    a. Control a stepper motor using PWM signals.
    b. Implement speed variation using FPGA logic.
13. MicroBlaze & FPGA-Based Voice Recognition System

VIVEKANAND EDUCATION SOCIETY'S
Institute of Technology

(An Autonomous Institute Affiliated to University of Mumbai, Approved by A.I.C.T.E & Recognized by Govt. of Maharashtra)

Department of Electronics and Telecommunication

a. Process voice commands and control an LED or motor.
b. Use DSP functions within MicroBlaze for analysis.
14. MicroBlaze-Based VGA Display Controller
a. Generate graphical output on a VGA screen.
b. Implement a basic GUI for FPGA-based applications.

Raspberry Pi Based Project

1. Smart home automation system with IoT camera.
   a. Control lights, fans, and appliances via web or mobile.
   b. Use MQTT/Google Assistant integration.
2. IoT-based weather monitoring station with video streaming.
3. Autonomous robot with sensor fusion and computer vision.
4. Smart Security Camera with Motion Detection
   a. Detect motion and capture intruder images.
   b. Send alerts via email or SMS.
5. Face Recognition-Based Door Lock
   a. Train a model to recognize faces and unlock doors.
   b. Use OpenCV and dlib for face recognition.
6. Smart Attendance System
   a. Recognize faces and mark attendance automatically.
   b. Store attendance logs in a CSV file or cloud database.
7. License Plate Recognition System
   a. Capture and recognize vehicle number plates.
   b. Use OCR (Tesseract) to extract text from images.
8. Hand Gesture Recognition
   a. Detect different hand gestures for controlling devices.
   b. Use OpenCV with Mediapipe for gesture tracking.
9. Face Detection System
   a. Detect human faces in a live video feed.
   b. Use Haar cascades or DNN-based face detection.
10. Object Tracking System
    a. Track a moving object using color-based tracking.
    b. Use OpenCV's MeanShift or CamShift algorithms.
11. Edge Detection using Canny Algorithm
    a. Capture real-time video and apply edge detection.
    b. Useful for applications like lane detection in self-driving cars.

VIVEKANAND EDUCATION SOCIETY'S

Institute of Technology

(An Autonomous Institute Affiliated to University of Mumbai, Approved by A.I.C.T.E & Recognized by Govt. of Maharashtra)

Department of Electronics and Telecommunication

12. Motion Detection and Alert System
    a. Detect movement using frame difference method.
    b. Send an alert when significant motion is detected.
13. Smart Traffic Monitoring System
    a. Detect and count vehicles using OpenCV.
    b. Send real-time traffic data to a cloud dashboard.
14. AI-Powered Smart Mirror
    a. Recognize user faces and display personalized content (weather, news).
    b. Use OpenCV, IoT, and voice assistants.
15. Live Streaming & Remote Monitoring System
    a. Stream live video from Raspberry Pi camera to a remote PC or mobile.
    b. Use Flask for web-based video streaming.
16. Smart Farming with Plant Disease Detection
    a. Capture plant images and detect diseases using image processing.
    b. Send alerts via an IoT-based system.
17. Blind Assistance System
    a. Identify objects and read out their names using OpenCV and text-to-speech.
    b. Implement OCR to read signs and books aloud.
18. Autonomous Line Following Robot
    a. Use IR sensors and OpenCV to follow a path.
    b. Implement PID control for accuracy.
19. Raspberry Pi as a WiFi Router
    a. Convert Pi into a wireless access point.
20. SPI/I2C Communication Between Raspberry Pi & FPGA
21. Implement real-time data exchange between FPGA & Pi.

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Department of Electronics and Telecommunication

Major Project I

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/ PR	Tut	Total
NETM P61	Major Project I	-	08	-	-	04	-	04

Course Code	Course Name	Examination Scheme					
		Theory			Term Work	Presentation & Oral	Total
		Internal Assessment		End Sem Exam			
		Mid-Term Test	CA				
NETM P61	Major Project I	--	--	--	50	100	150

Course Prerequisite: Basics of subjects learned in previous semesters
Course Objectives:
1. To enable the students to develop the required skills and knowledge gained during the programme by applying them for the analysis of a social real life problem or an issue, and mapped with 17 sustainable development goals (SDGs) to transform our world via a substantial piece of work which is to be carried out over an extended period.

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2.	To enable the students to demonstrate to proficiency in the design of a research project, application of appropriate research methods, collection and analysis of data and presentation of results.

Course Outcomes:
This course is designed to equip students with fundamental research methodology skills. By the end of the course, students will be able to:

1.	To undertake problem identification, formulation and design engineering solutions to social problems following a systematic approach.
2.	To demonstrate a sound technical knowledge of selected problem/ issue.
3.	To demonstrate the knowledge, skills and attitudes of a professional engineer.
4.	Develop and test a working prototype or simulation, demonstrate real-world application of the selected problem/issue in a forum/ community involving poster presentations etc.

Guidelines for Major Project I: The following guidelines are to be adhered to for the Major Project I

1. **Selection of Topic**
   - Choosing the right project topic is crucial. It should aim to solve a real-life problem within the available time frame.

2. **Scope of the Project**
   - Projects must address issues relevant to the **Electronics and Telecommunication** domain.
   - Topics should aim to contribute toward solving real-world problems and must be **aligned with one or more of the 17 Sustainable Development Goals (SDGs)** listed at the end of this document.

3. **Type of Project**
   - Both practical and theoretical **Research and Development (R&D)** projects are encouraged.
   - Projects should demonstrate innovation, relevance, and technical depth.

4. **Team Composition**
   - Each project must be completed by a group of **2 to 3 students**.

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- Projects must be **original**, although students may take inspiration from external sources like **society, NGOs, companies, or surveys**. However, the final implementation must reflect a **unique and customized approach**.

5. **Project Location and Industry Involvement**
   - Projects may be undertaken in collaboration with **research institutes, companies, or other organizations**, with proper consultation and approval from the **internal guide and Head of Department (HoD)**.
   - If the project is conducted outside the institute, the internal guide must **visit the site once a month** to monitor progress.
   - The **final working prototype or project must be demonstrated within the institute** during evaluation.

6. **Project Topic Approval**
   - Students must consult both the **internal guide** and, if applicable, the **external guide** for topic selection.
   - Final approval of project topics will be granted by the **HoD and senior faculty members**.

7. **Progress Monitoring**
   - Students are required to submit a **weekly progress report** to the internal guide.
   - The internal guide will monitor progress regularly and maintain an **attendance and progress record**, which will be considered for **term work evaluation**.

8. **Evaluation Criteria:**
   The following aspects will be assessed during the presentation of the project.
   - **Quality of Literature Review and Novelty of the Topic:**
     Depth of research and originality in the topic selection.
   - **Relevance to Specialization:**
     How well the topic aligns with the student's field of study.
   - **Understanding and Clarity of Problem Definition:**
     Demonstrated understanding of the topic and clear articulation of the research problem.
   - **Prototype/Simulation Development and Result Significance:**
     Quality of the prototype or simulation, and the importance of the results achieved.
   - **Quality of Written and Oral Presentation:**
     Overall presentation skills, including clarity, structure, and communication of ideas.

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Final Year Project Report Format (To be prepared in LaTeX)

Each group must submit a well-structured project report at the end of the semester. The report should include, at a minimum, the following sections:

Abstract

- A concise summary of the project, highlighting the problem addressed, methodology, key innovations, and expected outcomes.
- Limit to 200–300 words.

Introduction

- Brief background of the project topic.
- Relevance and motivation for selecting the topic.
- Real-world application and expected impact.

Literature Survey

a) Review of Existing Systems/Approaches: Summary of current technologies, methods, or systems related to the problem domain.

b) Research Gap / Limitations of Existing Systems: Identify shortcomings, challenges, or gaps in the current approaches.

c) Problem Statement and Objectives: Clearly define the problem to be solved. List specific objectives your project aims to achieve.

d) Scope of the Project: Define boundaries and focus of the project. State what the project will and will not cover.

Proposed System / Solution

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a) System Analysis / Conceptual Framework / Algorithm: Explain the theoretical or conceptual approach. Include block diagrams or system architecture if applicable.

b) Hardware and Software Requirements: List components and tools with specifications.

c) System Design Details: Include flowcharts, circuit diagrams, UML diagrams, or other design models as relevant.

d) Methodology: Describe the step-by-step approach for problem-solving.. Include justifications for methods chosen.

Implementation Plan for Next Semester: Detailed roadmap for completion in the following semester. Include milestones, Gantt chart or timeline, and division of responsibilities among team members.

Conclusion: Summarize key findings so far and potential outcomes.Highlight the technical contributions and real-world implications.

References

- List all cited work in a **standard citation format (IEEE, APA, or ACM)**.
- Use BibTeX for LaTeX integration and maintain academic integrity.

List of 17 Sustainable Development Goals (SDGs)

No Poverty
Zero Hunger
Good Health and Well-being
Quality Education
Gender Equality
Clean Water and Sanitation
Affordable and Clean Energy
Decent Work and Economic Growth
Industry, Innovation and Infrastructure
Reduced Inequality

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Sustainable Cities and Communities
Responsible Consumption and Production
Climate Action
Life Below Water
Life on Land
Peace, Justice and Strong Institutions
Partnerships for the Goals