

SU 24

B.Tech

Electronics & Communication Engineering

B.Tech. Degree Programs for students admitted from the Academic Year 2024-25

(Detailed Syllabus upto Semester V)

Velagapudi Ramakrishna
Siddhartha School of Engineering
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SIDDHARTHA ACADEMY OF HIGHER EDUCATION

(Deemed to be University)

SCHEME OF INSTRUCTIONS [SU24]

B.Tech. Degree Program for students admitted from the

Academic Year 2025-26

VELAGAPUDI RAMAKRISHNA

SIDDHARTHA SCHOOL OF ENGINEERING

Kanuru, Vijayawada -520 007, Andhra Pradesh

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SIDDHARTHA ACADEMY OF HIGHER EDUCATION

(Deemed to be University)

V R SCHOOL OF ENGINEERING

SCHEME OF INSTRUCTION FOR FIRST YEAR UG PROGRAMME [SU24]

(ECE)

SEMESTER I **CONTACT HOURS: 29**

S.No	Course Code	Category	Course Name	L	T	P	Credits
1	24MA101	BS	Mathematics – I (Linear Algebra, Series and Calculus)	3	0	2	**4**
2	24CY102	BS	Engineering Chemistry	3	0	0	**3**
3	24BY101	BS	Biology for Engineers	3	0	0	**3**
4	24CS102	ES	Programming using 'C'(2025-26)	3	0	0	**3**
5	24CS181	ES	Programming using 'C' Lab(2025-26)	0	0	3	**1.5**
6	24ME181	ES	Engineering Graphics	1	0	3	**2.5**
7	24CY181	BS	Chemistry lab	0	0	2	**1**
8	24ME182	ES	Workshop Practice	0	0	3	**1.5**
9	24UC183	MC	Sports & Yoga / NSS/NCC	0	0	3	**0**
	UC- University Common		**Total**	**13**	**0**	**16**	**19.5**

BS- Basic Science HS- Humanities & Social Sciences ES- Engineering Science
MC- Mandatory Course

SEMESTER II **CONTACT HOURS: 29**

S.No	Course Code	Category	Course Name	L	T	P	Credits
1	24MA102	BS	Mathematics – II (Differential Equations and Numerical Methods)	3	0	2	**4**
2	24PH102	BS	Engineering Physics	3	0	0	**3**
3	24EN101	HS	Communicative English	3	0	3	**4.5**
4	24EE101	ES	Electrical Network Analysis	3	0	0	**3**
5	24IT103	ES	Problem Solving with Python (2025-26)	2	0	2	**3**
6	24UC181	ES	Design Thinking	0	0	2	**1**
7	24PH181	BS	Physics Lab	0	0	2	**1**
8	24UC182	ES	AI Tools and Applications	0	0	2	**1**
9	24UC101	MC	Essence of Indian Knowledge Tradition	2	0	0	**0**
	UC- University Common		**Total**	**16**	**0**	**13**	**20.5**

BS- Basic Science HS- Humanities & Social Sciences ES- Engineering Science
MC- Mandatory Course

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VELAGAPUDI RAMAKRISHNA
SIDDHARTHA SCHOOL OF ENGINEERING

SCHEME OF INSTRUCTION

Semester-III

CONTACT HOURS: 28

S No	Course Code	Category	Course Name	L	T	P	Credits
1	24MA202	BS	Mathematics – III : Complex Analysis, Transform Techniques & Statistics	4	0	0	4
2	24CS211	ES	Data Structures using C	3	0	0	3
3	24EC201	PC1	Analog Circuits – I	3	0	0	3
4	24EC202	PC2	Digital Circuit Design	3	0	0	3
5	24EC203	PC3	Signals & Systems	3	0	0	3
6	24EC281	PL	Analog Circuits – I Laboratory	0	0	3	1.5
7	24EC282	PL	Digital Circuit Design Laboratory	0	0	3	1.5
8	24EC285	ES	Data Structures using C Laboratory	0	0	3	1.5
9	24UC201	HS	Universal Human Values - II	3	0	0	3
			Total	**18**	**0**	**11**	**23.5**

24MA101 **Linear Algebra, Series and Calculus**

Category: Basic Sciences (BS) **3L 0T 2P 4C**

Pre-requisite: 10+2 Mathematics

Course Description:

An overview of the fundamental concepts of linear algebra, infinite series, differential calculus, multiple integrals and vector calculus, with a focus on the applications in solving engineering problems

Course Aims and Objectives:

- Introduce techniques for solving systems of linear equations, determining eigenvalues and eigenvectors, and performing matrix diagonalization
- Explain methods to analyze the convergence and divergence of an infinite series and to expand functions using Taylor's or Maclaurin's series
- Familiarize differentiation rules and theorems to solve problems related to rates of change and optimization
- Explain the concept of double and triple integrals to calculate areas and volumes for two-dimensional and three-dimensional objects
- Teach operations on vector-valued functions, including line and surface integrals, as well as the concepts of curl and divergence, and their applications in engineering

Course Outcomes:

At the end of the course, the student will be able to…

- CO 1: solve the systems of equations and analyze engineering problems using linear algebra techniques [K3]
- CO 2: apply the convergence tests of an infinite series to solve engineering problems [K3]
- CO 3: use differential calculus to solve optimization problems and analyze rates of change in engineering applications [K3]
- CO 4: calculate areas and volumes using double and triple integrals[K3]
- CO 5: apply vector calculus concepts to solve problems involving work done by force fields and analyze related physical phenomena [K3]

Course Structure:

Unit 1: Linear Algebra

- **Contents**
  Rank of a matrix (Echelon form), Finding the inverse by Gauss-Jordan method, System of linear equations: Homogeneous and Non-Homogeneous, Linear transformations,

Orthogonal transformation, Eigenvalues and Eigenvectors, Reduction to Diagonal form

- **Description:** This unit familiarizes the students, the concept of linear algebra, which is essential for solving system of equations, analyzing data, modeling engineering problems
- **Exercises/Projects**:
  - Find the inverse of a matrix by Gauss-Jordan method
  - Solve a system of linear equations
  - Find the eigenvalues and eigenvectors of a given matrix
  - Diagonalization of a square matrix
- **Examples/Applications/Case Studies:**
  - Solve the system of linear equations representing currents in an electrical network to determine the voltage at each node
  - Diagonalize a symmetric matrix representing a physical system to simplify calculations of its behavior
  - Transforming a quadratic form into a canonical form for retrieval of shapes
- **Learning Outcomes:**
  - Find the rank of a matrix and use it to test for consistency of linear systems
  - Find eigenvalues and eigenvectors of a given matrix and perform diagonalization
- **Specific Resources:**
  - MIT OpenCourseWare: Linear Algebra https://ocw.mit.edu/courses/18-06-linear-algebra-spring-2010/
  - NPTEL: Linear Algebra https://archive.nptel.ac.in/courses/111/104/111104137/

Unit 2: Infinite Series

- **Contents**

  Infinite Sequence (Definition), Infinite Series, Comparison Tests, Integral Test, Ratio and Root Test, Alternating Series, Absolute and Conditional convergence
- **Description:** This unit covers infinite series, their convergence/ divergence, and applications in various engineering fields
- **Exercises/Projects:**
  - Finding the convergence/divergence of a given infinite series using appropriate tests
- **Examples/Applications/Case Studies:**
  - A ball is dropped from a height of 4m. Each time it strikes the pavement after falling from a height of h meters it rebounds to a height of 0.5h meters. Find the total distance the ball travels up and down
  - Define the sequence of partial sums $s_k = \sum_{n=1}^{n=k} \frac{1}{(sin^2 n)\, n^3}$. What happens, when

you try to find the limit of s_k as $k \to \infty$

- Apply the concept of series, to model periodic phenomena

- **Learning Outcomes:**
  - Apply various tests to determine the convergence/divergence of an infinite series
- **Specific Resources:**
  - Khan Academy: Infinite Series
    https://www.khanacademy.org/math/ap-calculus-bc/bc-series-new
  - NPTEL : Real Analysis I
    http://archive.nptel.ac.in/courses/111/106/111106142/

Unit 3: Differential Calculus

- **Contents**

  Mean value theorems: Rolle's theorem (without proof), Lagrange's mean value theorem (without proof), Taylor's and Maclaurin's theorems with Lagrange's form of remainder (without proof), Expansions of functions: Taylor's and Maclaurin's series

  Functions of Several Variables: Maxima and Minima of functions of two variables, Lagrange's method of undetermined multipliers
- **Description:** This unit focuses on expansion of functions as Taylor's and Maclaurin's series and finding extreme values of multi-variable functions with and without constraints
- **Exercises/Projects**:
  - Verification of mean value theorems
  - Taylor's and Maclaurin's series expansions of single variable functions
  - Examine the extreme values of a function
- **Examples/Applications/Case Studies:**
  - It took 14sec for a mercury thermometer to rise from -19^{0}C to 100^{0}C, when it was taken from a freezer and placed in boiling water. Show that somewhere along the way the mercury was rising at the rate of 8.5^{0}C per second.
  - On our moon, the acceleration of gravity is 1.6m/sec^2.If a rock is dropped into a crevasse, how fast will it be going just before it hits bottom 30sec later.
  - Show that the maximum value of $a^2b^2c^2$ on a sphere of radius r centered at the origin of Cartesian 'abc' coordinate system is $\left(\frac{r^2}{3}\right)^3$.
  - Show that for non-negative numbers a, b, c the geometric mean is less than or equal to their arithmetic mean.
- **Learning Outcomes**:
  - Apply the mean value theorems and find extreme values of multivariable functions

- **Specific Resources:**
  - MIT OpenCourseWare: Multivariable Calculus
    https://ocw.mit.edu/courses/18-02sc-multivariable-calculus-fall-2010/
  - NPTEL: Engineering Mathematics-I
    https://archive.nptel.ac.in/courses/111/105/111105121/

Unit 4: Multiple Integrals

- **Contents**

  Double integrals (Cartesian coordinates), Change of order of integration, Triple integrals, Change of variables to polar, cylindrical and spherical coordinates, Areas as double integration and Volumes as triple integration
- **Description:** This unit introduces double and triple integrals, which are essential for calculating areas and volumes of objects in two and three dimensions
- **Exercises/Projects:**
  - Evaluate a double integral to find the area enclosed by a region.
  - Evaluate a triple integral to find the volume of a solid
- **Examples/Applications/Case Studies:**
  - Calculating the center of mass using multiple integrals
- **Learning Outcomes:**
  - Evaluate double and triple integrals
  - Apply double and triple integrals to solve engineering problems involving areas and volumes
- **Specific Resources:**
  - MIT OpenCourseWare: Multivariable Calculus
    https://ocw.mit.edu/courses/18-02sc-multivariable-calculus-fall-2010/

Unit 5: Vector Calculus

- **Contents**

  Introduction to Gradient of a scalar field, Divergence and Curl of a vector field, Line integral, Green's theorem in the plane (without proof), Surface integrals, Stoke's theorem (without proof) and Gauss divergence theorem (without proof)
- **Description:** This unit covers vector-valued functions, curl and divergence, line integrals and surface integrals, which are used to analyze various physical phenomena in engineering
- **Exercises/Projects:**
  - Find gradient, divergence and curl of a point functions
  - Verification of Greens, Stokes and Gauss divergence theorems
- **Examples/Applications/Case Studies:**
  - Calculate work done by a force field using line integral.
  - Calculate total flux across the surface using surface integral

- **Learning Outcomes:**
  - Perform operations on vector-valued functions
  - Apply Green's theorem, Stoke's theorem, and the Divergence theorem to convert line integrals to area integrals and surface integrals to volume integrals for solving engineering problems
- **Specific Resources:**
  - MIT OpenCourseWare: Multivariable Calculus
    https://ocw.mit.edu/courses/18-02sc-multivariable-calculus-fall-2010/

Textbook(s) / Reference(s)

Text book:

1. Weir Maurice D., Hass Joel & Giodano Frank R. (2013). *Thomas' Calculus.* (11th Edition). Pearson Education,inc..
2. Grewal B. S. (2017). *Higher Engineering Mathematics.* (44th Edition). Khanna Publishers.

References:

1. Kreyszig Erwin. (2013). *Advanced Engineering Mathematics.*(9th Edition).Wiley Publishers.
2. Ramana B.V.(2007). *Higher Engineering Mathematics.*Tata Mc.Graw Hill

Mapping of Course Outcomes to Program Outcomes:

PO / CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO1	M	M	-	-	L	-	-	-	-	-	-	-
CO2	M	M	-	-	L	-	-	-	-	-	-	
CO3	M	M	-	-	L	-	-	-	-	-	-	-
CO4	M	M	-	-	L	-	-	-	-	-	-	-
CO5	M	M	-	-	L	-	-	-	-	-	-	-

Key:

- M: Moderate emphasis
- L: Low emphasis
- H: High emphasis
- '-': Not applicable

24CY102 **Engineering Chemistry**

(EEE, ECE, EIE branches only)

Category: Basic Sciences (BS) **3L 0T 0P 3C**

***Pre-requisite*: 10+2 Chemistry**

Course Description:

The course is designed for B.Tech. Electrical, Electronics and Communications and Instrumentation Engineering students, providing essential and applied knowledge of Chemistry relevant to their fields. Understanding the specific application of materials based on their characteristic properties, which are determined by their structural and bonding aspects, is crucial for appropriate utilization. With this focus, the course covers the working of electrodes, sensors, batteries, fuel cells and super capacitors which are application of principles of electrochemistry. Also, the course enlightens the students on mechanistic aspects of corrosion and its control, chemical aspects of materials useful in electrical and electronics engineering. Further, it focuses on the principles and instrumentation of various instrumental techniques.

Course Aims and Objectives:

1. Impart knowledge on the functioning of electrodes, potentiometric and conductometric sensors.
2. Discuss construction and working of different types of batteries, fuel cells and super capacitors based on the principles of electrochemistry.
3. Analyse various corrosion processes and propose control methods depending on the principles of corrosion.
4. Explore the chemical aspects of various materials used in electrical, electronics and communications engineering.
5. Explain the principles, instrumentation of different instrumental techniques and their applications.

Course Outcomes:

At the end of the course, the student will be able to...

CO1: apply the principles of electrochemistry to analyse working of electrodes and sensors **[K3]**.

CO2: analyse various electrochemical energy systems for their application in engineering **[K4]**.

CO3: assess the challenges arising due to corrosion of electronic devices **[K4]**.

CO4: demonstrate the knowledge of materials for their use in manufacture of electrical and electronic devices **[K3]**.

CO5: compare different analytical techniques and their instrumentation for their application in qualitative and quantitative analysis **[K4]**.

Course Structure:

Unit 1: Electrochemistry

Contents

- Electrodes, electrode potentials and electrochemical cells
- The Nernst equation with numerical problems for calculating electrode potential and emf
- Reference electrodes – Calomel and Ag/AgCl electrodes, Ion-selective electrodes, glass electrode - construction, working, advantages, and disadvantages
- Potentiometry – redox titrations
- Conductometry (acid-base reactions)
- Electrochemical sensors – principle and applications

Description:

This unit covers the fundamentals of various electrodes and sensors, and deals with their working and applications.

Examples/Applications/Case Studies:

- Determination of pH using glass electrode
- Applications of electrodes and sensors in water quality analysis

Exercises/Projects:

- Numerical problems based on calculation of emf of cells uisng Nernst equation
- Conductometric titrations with examples of acid-base reactions
- Potentiometric titrations of redox reactions

Learning Outcomes:

- Understand the working mechanisms of various electrodes and the chemical reactions involved
- Explore the electrochemical principles underlying the operation of sensors
- Select appropriate electrodes and sensors for specific applications in their respective fields

Specific Resources:

- https://www.sciencedirect.com/topics/chemistry/electrochemistry
- https://wme-z1.pwr.edu.pl/wp-content/uploads/2017/05/Basics-of-Electrochemistry.pdf

Unit 2: Electrochemical Energy Systems

Contents

- Types of electrochemical energy systems – charging vs. discharging
- Primary vs. secondary batteries
- Lithium-ion batteries – Lithium iron phosphate and lithium cobalt oxide – construction and working of the batteries including cell reactions
- Fuel cells – hydrogen-oxygen fuel cell and polymer electrolyte membrane fuel cell
- Super capacitors – principle, classification and applications
- Chemistry of fast charging EVs

Description:

This unit provides the knowledge of different electrochemical energy systems including batteries, fuel cells and super capacitors useful in the domains of electrical, electronics, communications and instrumentation engineering.

Examples/Applications/Case Studies:

- Study of the working of lead-acid battery and effect of concentration of electrolyte on the working of battery
- Identification of applications of commercially available batteries and correlating with the properties of the batteries.

Exercises/Projects:

- Preparation of a comparative report on different batteries with reference to their efficiency, cycle life, self discharge and other characteristics.
- Correlating the characteristics of batteries and their applications.

Learning Outcomes:

- Understand the working and chemistry involved in different batteries and fuel cells
- Explore the advantages and disadvantages of different electrochemical energy systems
- Predict the suitable energy system that can be employed for a particular application in electrical and electronics domains.

Specific Resources:

- https://ocw.mit.edu/courses/10-626-electrochemical-energy-systems-spring-2014/pages/lecture-notes/
- https://pressbooks.online.ucf.edu/chemistryfundamentals/chapter/batteries-and-fuel-cells-2/

Unit 3: Corrosion and Its Control

Contents

- Introduction to corrosion, causes and examples
- Electrochemical corrosion: hydrogen evolution and oxygen absorption corrosion
- Differential aeration corrosion
- Galvanic corrosion and its control, including the galvanic series
- Corrosion in microelectronic devices
- Factors influencing corrosion
- Electroplating and electroless plating

Description:

This unit introduces the fundamentals of corrosion, its mechanisms, and various forms. It also covers methods for controlling corrosion through surface coatings.

Examples/Applications/Case Studies:

- Corrosion of metals in acidic medium
- Water drop experiment
- Corrosion of bolts and nuts fitted to wooden structures
- Practical examples of corrosion in electronic and electrical devices

Exercises/Projects:

- Identify practical corrosion processes, determine their forms, and propose appropriate control methods
- Determine corrosion rates of different metal in any specific corrosive medium

Learning Outcomes:

- Describe the principles and various forms of corrosion
- Explore the mechanistic aspects of corrosion processes
- Predict the probable causes of corrosion and identify suitable methods to minimize it

Specific Resources:

- https://pesjournal.net/journal/v3-n1/2.pdf
- https://www.researchgate.net/publication/275028997_Corrosion_and_Corrosion_Control

Unit 4: Chemistry of Electrical and Electronic Materials

Contents

- Conducting polymers: Types of conducting polymers, mechanisms of conduction in undoped, doped polyacetylene and engineering applications of conducting polymers.
- Other materials of conduction: Production of electronic grade silicon from quartz and its applications, metal compounds as semiconductors, applications of carbon nanotubes and graphene in electrical and electronic industry.

Description:

This unit focuses on the chemistry of electrical and electronic materials with reference to their structural changes during conduction. It also includes applications of silicon, metal compounds and nanomaterials in electrical and electronic engineering.

Examples/Applications/Case Studies:

- Practical examples of conducting polymers and their applications
- Illustrations of application of conducting polymers in electrical and electronic applications.

Exercises/Projects:

- Comparison of conductivities of different types of materials such as polymers, pure elements, and nano materials.
- Preparation of a report on the conduction performance of solid conducting materials

Learning Outcomes:

- Understand the chemical structural changes in materials that lead to variation of conductivity.
- Explore different steps involved in the production of silicon from quartz
- Select appropriate materials for specific applications in electrical and electronic industry.

Specific Resources:

- https://pubs.rsc.org/en/content/articlehtml/2021/ra/d0ra07800j
- https://nanografi.com/blog/application-areas-of-nanotechnology-in-display-and-communication-technology/

Unit 5: Analytical Instrumentation Techniques

Contents

- Electromagnetic spectrum, Interaction of radiation with matter.
- UV-Visible spectroscopy: principle, electronic transitions, various shifts in UV-Visible spectroscopy, Lambert-Beer's law, Instrumentation, qualitative and quantitative applications of UV-Visible spectroscopy.
- Infrared spectroscopy: principle, types of vibrations, selection rule for vibrations in diatomic molecules, Instrumentation, qualitative and quantitative applications of IR spectroscopy.

Description:

This unit explores the principles, instrumentation and applications of spectroscopic techniques such as UV-Visible spectroscopy and Infrared spectroscopy.

Examples/Applications/Case Studies:

- Practical applications of Lambert-Beer's law
- Comparison of the two instrumental techniques namely UV-Visible and IR spectroscopy with reference to their principles and applications.

Exercises/Projects:

- Verification of the Lambert-Beer's law with different solutions
- Determination of wavelength (max) of different organic compounds using UV-Visible spectrophotometer, and comparing the values with literature reported values.
- Determination of wavelength (max) of different coloured compounds using colorimeter, and comparing the values with literature reported values.

Learning Outcomes:

- Understand the principles of spectroscopic techniques and instrumentation involved in each technique
- Explore the role of each component in the instrumentation of the selected analytical techniques
- Apply the knowledge of principles and instrumentation of the analytical techniques for their suitable applications

Specific Resources:

- https://personal.utdallas.edu/~goeckner/plasma_tech_class/AgilentSpectroPub4.pdf
- https://personal.utdallas.edu/~scortes/ochem/OChem_Lab1/recit_notes/ir_presentation.pdf

Textbook(s) / Reference(s):

Textbooks:

1. Ramesh, S. (2013). *Engineering chemistry* (2nd ed.). Wiley India.
2. Shikha Agarwal, (2015). *Engineering chemistry: fundamentals and applications* (1st ed.). Cambridge University Press.
3. Jain, P.C. (2018). *Engineering chemistry* (17th ed.). Dhanpat Rai.

References:

1. Prasantha Rath, & Aruna Kumari, S. (2023). *Engineering chemistry* (1st ed.). Cengage.
2. Arun Bahl, Bahl, B. S., & Tuli, G. D. (2020). *Essentials of physical chemistry* (28th ed.). S. Chand.
3. Haghi, A. K., Mercader, A. G., Balkoese, D., & Mukbaniani, O. V. (2021). *Applied chemistry and chemical engineering*, (1st ed.). CRC Press, Taylor & Francis Group.
4. Skoog, D. A., West, D. M., Holler, F. J., & Crouch, S. R. (2022). *Fundamentals of analytical chemistry* (10th ed.). Cengage.
5. Fontana, M. G. (2017). *Corrosion engineering* (3rd ed.). McGraw-Hill Education.
6. Swaminathan, P. (2017). *Semiconductor materials, devices, and fabrication*. Wiley.
7. Banwell, C. N., & McCash, E. M. (2017). *Fundamentals of molecular spectroscopy* (4th ed.). McGraw-Hill Education.

Mapping of Course Outcomes to Program Outcomes:

(**H**=high; **M**=medium; **L**=low)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	H	L	M									
CO2	H		M		L							
CO3	H	M	L									
CO4	H		M		L							
CO5	H	M		L								

24BY101 **Biology for Engineers**

Category: Basic Sciences (BS) **3L 0T 0P 3C**

Pre-requisite: 10 + 2 Science

Course Outcomes: At the end of the course, the student will be able to

CO1: demonstrate a fundamental understanding of basic biological principles, such as cell biology, genetics, and physiology, and their application in engineering contexts.

CO2: analyse and evaluate biomaterials based on their mechanical properties and design biomedical devices using biomechanical principles.

CO3:apply bio-inspired design principles and synthetic biology techniques to propose innovative engineering solutions and understand their practical applications in biotechnology.

CO4: develop proficiency in using bioinformatics tools, constructing computational models, and applying systems biology approaches to study and interpret biological data and systems.

CO5: critically analyse and evaluate current research trends and innovations in advanced areas of biological engineering, demonstrating the ability to apply advanced concepts in real-world engineering scenarios.

COURSE CONTENTS:

Unit 1: Introduction to Biology for Engineers

- Overview of interdisciplinary nature and importance of biology for engineers
- Basic biological concepts relevant to engineering applications
- Introduction to engineering challenges addressed by biology-inspired solutions
- Introduction to the structure and functions of Biomolecules

Unit 2: Biomaterials and Biomechanics

- Properties and applications of biomaterials in engineering (e.g., tissue engineering, drug delivery systems)
- Biomechanical principles applied to engineering (e.g., mechanics of bones and joints, biomechanics of tissues)
- Case studies: Design and development of biomaterials for medical implants, prosthetics, and tissue engineering

Unit 3: Bio inspired Design, Synthetic Biology and Biotechnology

- Introduction to bioinspired design, biomimicry, synthetic biology and genetic engineering(Genetically modified Crops & Animals)
- Examples of biological systems inspiring engineering innovations (e.g., bird flight, gecko adhesion, shark skin, human eye camera)
- Applications of biotechnology in engineering (e.g., bioprocessing, bioremediation, biosensors)
- Case studies: Biomimetic design in robotics, materials science, architecture, Development of biofuels, bioplastics, and biopharmaceuticals

Unit 4: Bioinformatics and Systems Biology

- Introduction to bioinformatics tools and databases
- Engineering applications of bioinformatics (e.g., genome sequencing, protein structure prediction, drug discovery)
- Systems biology approaches to understanding complex biological systems and networks

- Case studies: Computational modelling of biological systems, personalized medicine, and synthetic biology

Unit 5:Advanced Topics in Biology for Engineers

- Emerging trends and cutting-edge research in biology for engineers
- Advanced applications and case studies in specific engineering fields (e.g., nanotechnology, energy, environmental engineering)
- Ethical considerations(Bio-Safety) and societal implications (Biopiracy & Biopatent)

Textbook(s) / Reference(s):

Textbooks:

1. Johnson, A. T. (2011). Biology for Engineers. CRC Press.

2. Renneberg, R. (2017). Biotechnology for Engineers: Biological Processes and Technologies (1st ed.). Elsevier.

3. Mount, D. W. (2004). Bioinformatics: Sequence and Genome Analysis (2nd ed.). Cold Spring Harbor Laboratory Press.

References:

1. Enderle, J., & Bronzino, J. (2011). Introduction to Biomedical Engineering (3rd ed.). Academic Press.

2. Ratner, B. D., Hoffman, A. S., Schoen, F. J., & Lemons, J. E. (2012). Biomaterials Science: An Introduction to Materials in Medicine (3rd ed.). Academic Press.

3. Benyus, J. M. (2002). Biomimicry: Innovation Inspired by Nature. Harper Perennial.

Gr. Indusree

S. Srinivas

COURSE CODE: 24CS102
PROGRAMMING USING C

Course Category:	Engineering Science (ES)	**Credits:**	3
Course Type:	Theory	**Lecture -Tutorial-Practice:**	3-0-0
Pre-requisites:		**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	40 60 100

Course Description

This course introduces foundational programming concepts, covering algorithms, flowcharts, and pseudo code. It explores the C language structure, data types, operators, control structures, loops, arrays, strings, and functions. Advanced topics include pointers, dynamic memory allocation, structures, unions, enumerations, and file handling. Students gain hands-on experience with inter-function communication, recursion, sorting/searching techniques, and memory management. The course emphasizes practical coding skills, problem-solving, and program design, providing a solid foundation for software development using the C language.

Course Objectives

- *To introduce students to the fundamentals of computer programming.*
- *To provide hands-on experience with coding and debugging.*
- *To foster logical thinking and problem-solving skills using programming.*
- *To familiarize students with programming concepts such as data types, control structures, functions, and arrays.*
- *To encourage collaborative learning and teamwork in coding projects.*
- *To evaluate and apply C programming techniques proficiently for searching and sorting.*

Course Outcomes

At the end of the course, the student will be able to

	Course Outcomes	BTL	POI
CO1	Understand fundamental programming concepts in C through algorithms, flowcharts, and selection statements.	K2	1.7.1,2.5.1, 2.5.2, 2.7.1
CO2	Develop efficient C programs using loops, arrays, and strings using control structures.	K3	1.7.1,2.5.1, 2.5.2, 2.6.3,3.5.1
CO3	Implement modular C programs using functions, pointers, and memory optimizations.	K3	1.7.1, 2.5.2, 2.6.3, 3.5.1, 5.4.1
CO4	Develop C programs using structures and unions for user defined data types.	K3	2.5.2, 2.6.3,3.5.1
CO5	Analyze the use of enumerations and file handling techniques in C to manage data efficiently and solve real-world programming problems.	K4	1.7.1,2.5.1, 2.5.2, 2.6.3,3.5.1

SIDDHARTHA ACADEMY OF HIGHER EDUCATION (DEEMED TO BE UNIVERSITY)

Contribution of Course Outcomes towards achievement of Program Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	3	2												
CO2	3	3	2										2	2
CO3	2	2	2		2								2	2
CO4	2	2	2										2	2
CO5	2	2	2										2	2

(1- Low, 2 - Medium, 3 – High)

Unit-I : Introduction to C & Problem solving

Introduction to the C Language: Introduction to Programming Languages, Basics of a Computer Program, Algorithms, flowcharts (Using Dia Tool), pseudo code. Introduction to Compilation and Execution, Background of C program, Identifiers, Types, Variables, Constants, Memory Layout, Input/Output, Programming Examples.

Structure of a C Program: Logical Data and Operators, Expressions, Precedence and Associatively, Evaluating Expressions, Type Conversion, Statements, Storage Class.

Selection: Two-way Selection, Multiway selection, More Standard Functions.

Unit-II: Repetition, Arrays & Strings

Repetition: Concept of Loops in C, Loop Examples, the Calculator Program.

Arrays: Array Concepts in C, Inter-Function Communication, Array Applications, One Dimensional Arrays, Linear Search and Binary Search Techniques, Selection Sort, Bubble Sort, Two Dimensional Arrays, Multidimensional Arrays.

Strings: String Concepts, C Strings, String Input/output Functions, Arrays of Strings, String Manipulation Functions, String- Data Conversion.

Unit-III: Functions, Pointers & Memory Allocations

Functions: Functions in C, User Defined Functions, Call by Value, Call Value Reference, Inter-Function Communication, Standard Functions, Scope, Recursion and advantages.

Pointers: Introduction to Pointers, Pointers for Inter-Function Communications, Pointers to Pointers, Compatibility, Lvalue and Rvlaue. Arrays and Pointers, Pointers Arithmetic and Arrays, Passing an Array to a Function, Array of Pointers.

Memory Allocation: Need of dynamic memory allocation, malloc(), calloc(), free(), realloc(), NULL, Stack vs. Heap Allocation.

Unit-IV: Structures & Unions

Structures: Structure Type Declaration, Initialization, Accessing Structures, Operations on Structures, Complex Structures, Structures and Functions, Sending the Whole Structure, Passing individual structure members, passing structure via pointer, nested structure.

Unions: Referencing Unions, Initializers, Unions and Structures, Internet Address, Programming Applications.

Unit-V: Enumerations & Files

Enumerations: The Type Definition (Typedef), Enumerated Types: Declaring an Enumerated Type, Operations on Enumerated Types, Enumeration Type Conversion, Initializing Enumerated Constants, Anonymous Enumeration: Constants, Input/Output Operators.

Files: introduction to the files, Uses of Files, Text files Vs. Binary files, Opening and closing FILE , Modes of FILE operation, Command line arguments, Standard Library Input /Output functions ,Character i/o functions, File Handling functions.

Text Books:

1. "The C Programming Language", Brian W. Kernighan and Dennis M. Ritchie, Prentice-Hall, 1988
2. Behrouz A. Forouzan and Richard F. Gilberg, "Computer Science A Structured Programming Approach Using C", CENGAGE Learning, Third Edition.
3. Schaum's Outline of Programming with C, Byron S Gottfried, McGraw-Hill Education, 1996

Reference Books:

1. Computing fundamentals and C Programming, Balagurusamy, E., McGraw-Hill Education, 2008.
2. Programming in C, Rema Theraja, Oxford, 2016, 2nd edition
3. C Programming, A Problem Solving Approach, Forouzan, Gilberg, Prasad, CENGAGE, 3rd edition
4. Horowitz Sahni and Anderson-Freed, "Fundamentals of Data Structures in C", 2nd edition, Universities Press, 2011

Web Resources:

1. NPTEL, "NOC: Introduction to Programming in C," [Online]. Available: https://nptel.ac.in/courses/106/104/106104128/. [Accessed: Feb. 25, 2025].
2. Coursera, "C for Everyone: Structured Programming," [Online]. Available: https://www.coursera.org/learn/c-structured-programming/. [Accessed: Feb. 25, 2025].
3. GeeksforGeeks, "Arrays, Pointers and Functions in C," [Online]. Available: https://www.geeksforgeeks.org/arrays-and-pointers-functions-in-c/. [Accessed: Feb. 25, 2025].
4. GeeksforGeeks, "C Enumerations," [Online]. Available: https://www.geeksforgeeks.org/enumeration-enum-c/. [Accessed: Feb. 25, 2025].

5. Codeforwin, "Understanding malloc, calloc, realloc, and free," [Online]. Available: https://codeforwin.org/2018/07/malloc-calloc-realloc-free-functions-c-programming.html. [Accessed: Feb. 25, 2025].
6. GeeksforGeeks, "Unions in C," [Online]. Available: https://www.geeksforgeeks.org/union-c/. [Accessed: Feb. 25, 2025].
7. Programiz, "Structures in C," [Online]. Available: https://www.programiz.com/c-programming/c-structures. [Accessed: Feb. 25, 2025].
8. TutorialsPoint, "Formatting Input/Output Functions and Character Input/Output Functions," [Online]. Available: https://www.tutorialspoint.com/cprogramming/c_file_io.htm. [Accessed: Feb. 25, 2025].
9. Programiz, "Command-Line Arguments," [Online]. Available: https://www.programiz.com/c-programming/c-command-line-arguments. [Accessed: Feb. 25, 2025].
10. W3Schools, "C Programming Language," [Online]. Available: https://www.w3schools.com/c/index.php. [Accessed: Feb. 25, 2025].

SIDDHARTHA ACADEMY OF HIGHER EDUCATION (CAIE)

COURSE CODE: 24CS181
PROGRAMMING USING 'C' LAB

Course Category:	Engineering Science (ES)	**Credits:**	1.5
Course Type:	Practical	**Lecture -Tutorial-Practice:**	0-0-3
Pre-requisites:		**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	60 40 100

Course Description

This hands-on course introduces students to the foundational principles of the C programming language, integrating essential Linux command-line skills and compiler tools such as GCC and Turbo C. The course emphasizes problem-solving, logical thinking, and algorithm development. Students will work through a structured progression from simple input/output to complex file operations and data structures, including practical projects and assignments.

Course Objectives

The primary objective of this C Programming Lab course is to provide hands-on practical experience in writing, debugging, and executing C programs. It aims to develop students' understanding of fundamental programming concepts such as input/output operations, control structures, arrays, strings, functions, and pointers through practical exercises. By the end of the course, students will be proficient in using essential C programming tools, developing logical problem-solving skills, and applying programming concepts to build efficient programs in a Linux environment using compilers like Turbo C and GCC.

Course Outcomes

At the end of the course, the student will be able to

	Course Outcomes	BTL	POI
CO1	Understand basic Linux shell commands to compile and run C programs using GCC.	K2	1.7.1,2.5.1, 2.5.2, 2.7.1
CO2	Select the right control structure for solving the problem.	K3	1.7.1, 2.5.1,2.5.2, 2.6.3,3.5.1
CO3	Develop C programs which utilize memory efficiently using programming constructs like pointers.	K3	1.7.1, 2.5.2, 2.6.3,3.5.1 5.4.1
CO4	Develop, Debug and Execute programs to demonstrate the applications of arrays, functions, basic concepts of pointers in C.	K3	2.5.2, 2.6.3,3.5.1
CO5	Analyze the use of enumerations and file handling techniques in C to manage data efficiently and solve real-world programming problems.	K4	1.7.1, 2.5.1,2.5.2, 2.6.3,3.5.1

Contribution of Course Outcomes towards achievement of Program Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	2	2												
CO2	3	2	3										2	2
CO3	3	2	3		2								2	2
CO4	3	2	3										2	2
CO5	2	3	3										2	2

(1- Low, 2 - Medium, 3 – High)

Course Content:

WEEK- 1

1. Basic Linux environment and its editors like Vi, Vim & Emacs etc.

2. Exposure to Turbo C, gcc

3. Write a C program to print the following output Input:

Enter a Character: *
Enter a Number: 1
Output:

```
* * * * * * *
*       1     *
*       1     *
*       1     *
*       1     *
*     1 1 1   *
* * * * * * *
```

4. Write a C program that takes two numbers and an arithmetic operator (+, -, *, or /) as input from the user using scanf(), performs the corresponding operation, and displays the result using printf().

5. Write a C program that reads two numbers from the user using `scanf()`, and then swaps their values using both methods:

1. With a third variable 2. Without using a third variable

Finally, display the swapped values using `printf()`.

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6. Declare three variables of integer data type. User has to input three valid numbers. Display Sum and average of user entered numbers.
Approach is to take three numbers and find their sum and average using the formula given below-

Sum: a+b+c
Average: (a+b+c)/3
Where a,b,c are the three numbers.
Sample Input:
Enter 3 Values: 10 20 30
Sample Output: Sum: 60 Average: 20

WEEK-2

1. Input the temperature in Fahrenheit and output the equivalent temperature in Celsius and Vice – Versa. Input two numbers. The first is for a Celsius value, and the second is for a Fahrenheit value. Input Celsius value, convert it to Fahrenheit. Use the formula F = C*9/5 + 32 for conversion. In case of decimals, show up to 1 decimal value.
Input the Fahrenheit value, convert it to Celsius.
Use the formula C= (F−32)×5/9 for conversion. In case of decimals, show up to 1 decimal value.
Sample Input: 0 100
Sample Output: 32 37.7

2. You can calculate a Simple Interest by just providing the Principle Amount, Rate of Interest and Time or Periods provided by the user input. We can calculate the Simple Interest by the using the below Formula.
Simple Interest = (Principal*Rate*Time)/100
Principal (P): The principal is the amount that was initially borrowed (loan) from the bank or invested.
Rate (R): It is the rate of interest at which the principal amount is given to someone for a certain time; the rate of interest can be 5%, 10%, or 13%, etc.
Time (T): Time is the duration for which the principal amount is given to someone.
Constraints: 1<=Principal<=10000 1<=Rate<=10
1<=T<=30
Sample Input: 100 3 10
Sample Output: 30

3. You are working on a program that tracks the daily sales of a small bookstore. The owner wants to calculate the total sales and average sales for three consecutive days to better understand business trends. Write a program that takes the sales figures for three days as input, calculates the total sales, and finds the average sales. How will you implement this in C?

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4. Write a C program to evaluate and display the result of the following expressions. Use the given variable declarations and initialize them with appropriate values. Also, print the results of each expression.

- A+B*C+(D*E) + F*G
- A/B*C-B+A*D/3
- A+++B---A
- J= (i++) + (++i)

5. Write a C program to calculate electricity bill according to the given condition:

For first 50 units Rs. 0.50/unit

For next 100 units Rs. 0.75/unit

For next 200 units Rs. 1.20/unit

For unit above 250 Rs. 1.50/unit

An additional surcharge of 20% is added to the bill.

WEEK- 3

1. To find factorial of the any given positive number. The factorial of a positive number n is given by: 1*2*3*4 ...Note: This program should take a positive integer from the user as the factorial of a negative number doesn't exist and, the factorial of 0 is 1. Compute the factorial using any loop. Since the factorial of a number
may be very large, the type of factorial variable is declared as unsigned long. If the user enters a negative number, the program should display a custom error message.

2. Input a number, check the given number is a prime or not. A prime number should be a natural number greater
than 1 that has no positive divisors other than 1 and itself.
Test Data and Output: Enter n: 5
Output: Prime
Enter n: 6
Output: Not Prime

3. Checking a number palindrome. Number should be a positive integer having more than one digit as all the single digits are palindromes.
Test Data and output:
Input : 2002 Input: 1234
Output: true Output: false

4. Construct a pyramid of numbers. A pyramid of numbers represents the number of individuals per unit area of various trophic areas where producers are kept at the base and the tip is occupied by top carnivores.

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The pyramid of numbers is mostly upright. The members of successive higher trophic levels are higher than the previous one.

1. A higher trophic level has fewer individuals than that of the lower trophic levels.

1

2 2 2

3 3 3 3 3

4 4 4 4 4 4 4

5 5 5 5 5 5 5 5 5

5.Develop a C program that takes an integer as input from the user and prints 'Yes' if the number is an Armstrong number, and 'No' otherwise.(This adds specific input/output requirements.)

WEEK- 4

1. Write a C program to delete all duplicate elements from an array.
The program should:

- Ask the user to enter the number of elements in the array.
- Accept the array elements from the user.
- Remove all duplicate values from the array.
- Display the new array with only unique elements.

2. Write a C program to insert an element into a specific position in an array.
The program should:

- Ask the user to enter the size of the array and its elements.
- Ask the user to enter the element to insert and the position at which it should be inserted.
- Insert the element at the specified position by shifting the existing elements.
- Display the updated array.

3. Find 2's complement of the given binary number.
To get 2's complement of a binary number, simply invert the given number and add 1 to the least significant bit (LSB) of given result.
Test Data and Output:
Find 2's complement of binary number 10101110.
Simply invert each bit of given binary number, which will be 01010001. Then add 1 to the LSB of this result, i.e., 01010001+1=01010010 which is answer.
Find 2's complement of binary number 10001.001.
Simply invert each bit of given binary number, which will be 01110.110 Then add 1 to the LSB of this result, i.e., 01110.110+1=01110.111 which is answer.

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4. Write a C program to sort array elements in ascending or descending order.

5. Given an array of integers **nums** and an integer **target,** return indices of the two numbers such that they add up to target. You may assume that each input would have exactly one solution and you may not use the same element twice. You can return the answer in any order.
Sample Input:
Enter the size of an array: 4
Enter array elements: 2 7 11 15
Enter target: 9
Output: [0,1]

WEEK- 5

1. A matrix can only be added to another matrix if the two matrices have the same dimensions. To add two matrices, just add the corresponding entries, and place this sum in the corresponding position in the matrix which results.
Input elements in 3x3 matrix1: 1 2 3
4 5 6
7 8 9
Input elements in 3x3 matrix2: 9 8 7
6 5 4
3 2 1
Sum of both matrix = 10 10 10
10 10 10
10 10 10

2. Matrix multiplication is a binary operation that produces a matrix from two matrices. For matrix multiplication, the number of columns in the first matrix must be equal to the number of rows in the second matrix. The resulting matrix, known as the **matrix product,** has the number of rows of the first and the number of columns of the second matrix. The product of matrices **A** and **B** is denoted as AB.

3. Concatenate two strings without using built-in functions
Note: User would be asked to enter two strings and then the program would concatenate them. For concatenation we have not used the standard library function strcat(), instead we have written a logic to append the second string at the end of first string.
Test Data and Output:
Str1: Good Str2: Morning Output: Good Morning

4. Reverse a string using built-in and without built-in string functions
Using built-in function: The function is used for reversing a string. The reversed string will be stored in the same string.

5. Input two strings **str1** in lowercase, **str2** in uppercase. Print the lower case string **str1** in uppercase and the uppercase string **str2** in lowercase.

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WEEK- 6

1. Write a C program using a user-defined function to find the biggest number given any three numbers.

2. Write a **C program** to calculate the **factorial of a given number** using recursion. The program should prompt the user to enter a number and then compute its factorial using a recursive function.

3. Write a **C program** to generate the **Fibonacci series up to N terms** using a recursive function. The program should prompt the user to enter a number **N**, then compute and display the first **N Fibonacci numbers**.

4. Write a **C program** to swap two numbers using **call by value and call by reference**. The program should demonstrate that changes made inside the function do not affect the original values in the main function.

5. How can recursion be used to calculate NCR? Write a C program to demonstrate this.

WEEK- 7

1. String is a sequence of characters. Input two strings str1 and str2. Copy the contents of str1 to str2 using functions and pointers. Define a function copystr() with two pointer arguments copystr(*str1,*str2) Approach :
1. Scan string str from 0 to length-1.
2. check one character at a time based on ASCII values
- if(str[i] >= 65 and str[i] <=90), then it is uppercase letter, .
- if(str[i] >= 97 and str[i] <=122), then it is lowercase letter,
- if(str[i] >= 48 and str[i] <=57), then it is number,
- else it is a special character

3. Print all the counters
Sample Input:
Enter a string: Programming
Sample Output:
String1: Programming
String2: Programming

2. Given a string, write a program to count the occurrence of Lowercase characters, Uppercase characters, Special characters, and Numeric values. Define a function to count.
Input : #CseAi01dOr@gAIml07
Output :
Upper case letters : 5
Lower case letters : 8
Numbers : 4

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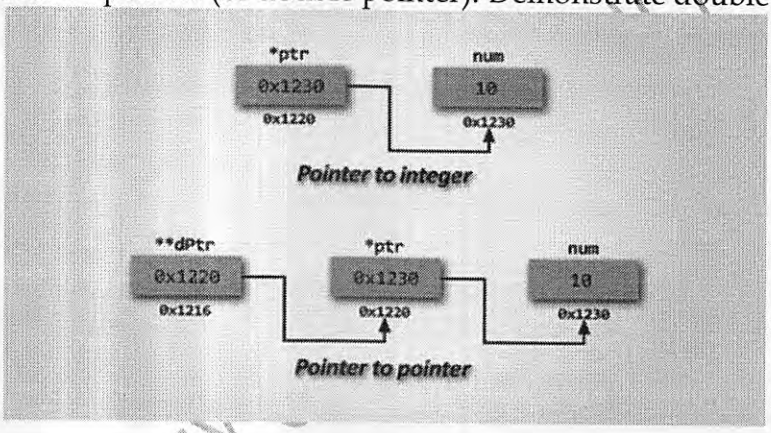
Special Characters : 2
Input : *AiMlC4AiDsS*
Output :
Upper case letters : 6
Lower case letters : 4
Numbers : 1
Special Characters : 2

3. Write a c program to perform simple pointer arithmetic operations in c.

4. Write a c program to find sum of array elements by using array of pointers in c

5. When a pointer holds the address of another pointer then such type of pointer is known as pointer-to-pointer or double pointer. ptr is a normal pointer that holds the address of an integer variable num. There is another pointer **dptr in the diagram that holds the address of another pointer ptr, the pointer dptr here is a pointer-to-pointer (or double pointer). Demonstrate double pointers using the following representation.



WEEK- 8

1. Write a C program to define a structure named Student that contains the following members:

- name (character array)
- rollNumber (integer)
- age (integer)

Using a structures concept, store and display the details of two students.

2. Write a C program to define a structure named Student with the following members:

- name (character array) - to store the student's name.
- rollNumber (integer) - to store the roll number.
- marks (array of 3 integers) - to store marks obtained in 3 subjects.

Using an array of structures, read the details of two students from the keyboard. Calculate and display:

- Name of the student
- Roll number

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- Marks in 3 subjects
- Total marks obtained

3. Write a C program to define a structure named Book with the following members:
- title (character array) – to store the book's title.
- author (character array) – to store the author's name.
- price (float) – to store the price of the book.

Using an array of structures, read the details of **five books** from the keyboard and display them in a formatted output.

4. Write a C program to define a structure **Student** that includes the following details:
- Name (character array)
- Roll Number (integer)
- Age (integer)
- Date of Birth (another structure with day, month, and year as integers)

Note: Student Details (with Date of Birth as a Nested Structure)

5. Write a C program to define a structure **Employee**, which contains the following details:
- **Employee Name** (character array)
- **Employee ID** (integer)
- **Salary** (float)

Additionally, the structure **Employee** should have a **nested structure Address**, which includes:
- **City** (character array)
- **State** (character array)
- **Pin Code** (integer)

The program should:
- Accept details of an employee, including their address.
- Display the entered details in a proper format.

Write the complete C program, including structure definition, input, and output statements.
Note: Employee Records (with Address as a Nested Structure)

WEEK- 9

1. Write a C program to demonstrate **passing individual structure members** to a function. Define a structure for a student with members: name, roll number, and marks. Pass individual members to a function to display the details.

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2. Explain the concept of **passing an entire structure** to a function in C. Write a program to define a structure for an Employee with members: name, ID, and salary. Pass the entire structure to a function to display the details.

3. Define a union Data with members: i (integer), f (float), str (string). Write a program to assign and print values to each member of the union one by one. Observe what happens to the values.

4. Explain the concept of **passing a structure through pointers** in C. Write a program to define a structure for a Student with members: name, roll number, and marks. Pass the address of the structure to a function and display the student details using pointers.

5. Write a C program to **add two complex numbers**.

- Define a **structure** Complex with two members: real (to store the real part)
- imag (to store the imaginary part)
- Take input for two complex numbers from the user.

Perform the addition of the two complex numbers: Add the **real parts** separately.

- Add the **imaginary parts** separately.
- Display the **sum** of the two complex numbers in the form **(a + bi)**.

Sample output:
Enter first complex number: 3 2
Enter second complex number: 1 7
Sum: 4 + 9i

WEEK- 10

1. Write a C program that defines an enumeration for different car brands and asks the user to enter a number. Display the corresponding car brand.

2. Create an enum for traffic signals (Red, Yellow, Green). Write a function that takes an enum value as input and prints its meaning (e.g., Red → Stop).

3. Write a C program to store and process student data using dynamic memory allocation with calloc(). The program should:

- Allow the user to enter the number of students (n).
- Dynamically allocate memory for n students using calloc().
- For each student, input details such as **roll number, name, and marks**.
- Display the list of students who have **failed** (consider marks less than 40 as failed).

4. Write a C program to print the corresponding weekday name for a given integer value (1 to 7) using enumeration constants. The program should define an enum for the weekdays, take an integer input from the user, and display the corresponding weekday name. If the input is out of range, display an appropriate error message.

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5. Write a C program to write and read text into a file.The program should prompt the user to enter a string and write it to a text file. Then, it should open the same file, read the content, and display it on the screen.

6. Write a C program to copy the contents of one file to another using command-line arguments. The program should accept the source filename and the destination filename as command-line arguments. It should read the contents from the source file and write them to the destination file. If the source file does not exist or an error occurs, display an appropriate error message.

Web Resources:

1. LinuxCommand.org, "Basic Linux Environment, Editors, Turbo C, GCC," [Online]. Available: https://linuxcommand.org/. [Accessed: Feb. 25, 2025].
2. Programiz, "Pattern Printing & Block Letters in C," [Online]. Available: https://www.programiz.com/c-programming/examples/pattern-printing. [Accessed: Feb. 25, 2025].
3. GeeksforGeeks, "Arithmetic Operations & Swapping Numbers," [Online]. Available: https://www.geeksforgeeks.org/swap-two-numbers-without-using-temporary-variable/. [Accessed: Feb. 25, 2025].
4. CodingCompiler, "Sum and Average of Numbers," [Online]. Available: https://codingcompiler.com/c-program-find-sum-average-three-numbers/. [Accessed: Feb. 25, 2025].
5. TutorialsPoint, "Reading and Printing Multiple Integers," [Online]. Available: https://www.tutorialspoint.com/cprogramming/c_arrays.htm. [Accessed: Feb. 25, 2025].
6. Programiz, "Mixed Data Types Input & Format Specifiers," [Online]. Available: https://www.programiz.com/c-programming/c-input-output. [Accessed: Feb. 25, 2025].
7. GeeksforGeeks, "Files in C," [Online]. Available: https://www.geeksforgeeks.org/basics-file-handling-c/. [Accessed: Feb. 25, 2025].

SIDDHARTHA ACADEMY OF HIGHER EDUCATION (SAHE)

24MA101 Linear Algebra, Series and Calculus (LAB)

Category: Basic Sciences (BS)

Pre-requisite: 10+2 Mathematics

Course Description:

An overview of the functions of MathWorks Symbolic Math Tool Box to solve problems in Matrix algebra, differential calculus, multiple integrals, vector calculus and to test the nature of series.

Course Objectives:

The objective of the lab course is to demonstrate built-in functions to

- find inverse, rank, eigen values, eigen vectors of a matrix and solution of system of linear equations.
- analyze the convergence and divergence of infinite series.
- find ordinary and partial derivatives
- expand functions as Taylor's and Maclaurin's series.
- determine extreme values of multi-variable function with and without constraints.
- Calculate areas and volumes using double and triple integrals.
- find gradient, divergent and curl.

Course Outcomes:

At the end of the course, the student will be able to…

- CO 1: find rank, solution of systems of equations and eigen values & eigen vectors of matrix [K3]
- CO 2: examine the convergence/divergence of infinite series. [K3]
- CO 3: use differential calculus to solve optimization problems. [K3]
- CO 4: calculate areas and volumes using double and triple integrals [K3]
- CO 5: find gradient, divergent and curl. [K3]

List of experiments:

Unit 1: CO 1 [K3]

1. inv() function to find inverse of a matrix
2. rank() function to find rank of a matrix
3. rref() function to solve system of linear equations
4. eig() function to find eigen values and eigen vectors of a matrix

- **Specific Resources:**
  MathWorks Linear Algebra Documentation
  Linear Algebra - MATLAB & Simulink - MathWorks India

Unit 2: CO 2 [K3]

1. vpa() function to evaluate numerically each term of series
2. symsum() function to test the nature of the series

- **Specific Resources:**
  MathWork Symbolic Calculus Tool Box
  Calculus - MATLAB & Simulink - MathWorks India

Unit 3: CO 3 [K3]

1. diff() function to find ordinary and partial derivatives
2. taylor() function to expand functions as Taylor's and Maclaurin's series
3. fmincon() function to find minimum of a function with constraints

- **Specific Resources:**
  MathWork Symbolic Math Tool Box
  Symbolic Math Toolbox Documentation - MathWorks India
  MathWork Optimization Tool Box
  Optimization Toolbox Documentation - MathWorks India

Unit 4: CO 4 [K3]

1. int() function to find double and triple integrals

- **Specific Resources:**
  MathWork Symbolic Calculus Tool Box
  Calculus - MATLAB & Simulink - MathWorks India

Unit 5: CO 5 [K3]

1. gradient() function to find gradient of a scalar point function
2. divergence() function to find divergence of a vector point function
3. curl() function to find curl of a vector point function

- **Specific Resources:**
  MathWork Symbolic Calculus Tool Box
  Calculus - MATLAB & Simulink - MathWorks India

24ME181 Engineering Graphics

Category: Engineering Sciences (ES) **1L 0T 3P 2.5C**

Pre-requisite: Nil

Course Description:

This course introduces students to the principles and practices of engineering graphics using Computer-Aided Design (CAD) tools. This course covers Plane and Descriptive geometry, orthographic and isometric projections. Students will learn to create, modify, and analyze 2D and 3D drawings, focusing on applications in engineering.

Course Aims and Objectives:

- To familiarize students with CAD software and its application in technical drawing.
- To make students proficient in creating and editing 2D and 3D engineering drawings.
- To teach the drawing of plane curves and their applications
- To explain the projection of points, lines, Planes, and solids.
- To enable students to visualize and represent 3D objects through orthographic projections, isometric views and development of surfaces.
- To cultivate skills in preparing engineering drawings following standard conventions and practices.

Course Outcomes:

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

1. construct plane curves and identify their applications.
2. draw orthographic projections of points, lines and planes
3. develop 2D drawings of solids and surfaces.
4. demonstrate proficiency in creating isometric projections.
5. identify the 3D objects through orthographic projections.

Course Outcomes:

Unit 1: Plane Curves

Contents

- Circles, ellipses, parabolas, hyperbolas,
- Involutes, cycloids,
- Helical and spirals.

Description

- This unit introduces the different types of plane curves and their construction using CAD tools.

Examples/Applications/Case-studies: Gear profiles, cam profiles, architectural curves.

Exercise/Project Problems: Drawing and dimensioning plane curves using CAD tools.

Learning Outcomes:

- Visualize different plane curves and their applications
- Construct and identify the usage of helical and spiral curves

Unit 2: Projection of Points, Lines, and Planes

Contents

- Orthographic projection fundamentals,
- Projections of points, lines and planes.

Description:

- This unit covers the principles of orthographic projection, projections of points, lines, and planes.

Examples/Applications/Case-studies: Projection of lines and planes in different orientations.

Exercise/Project Problems: Drawing projections of lines and plane surfaces.

Learning Outcomes:

- Represent the points and lines in 3-D space on a 2-D plane
- Identify the plan and elevation of planes in different orientations.

Unit 3: Projection of Solids and Development of Surfaces

Contents

- Projections and section of solids and development of surfaces.

Description:

- This unit provides the techniques for projecting 3D solids onto 2D planes and developing surfaces.

Examples/Applications/Case-studies: Projections of regular solids and their sections, Sheet metal development, pipe fittings.

Exercise/Project Problems: Creating projections and developments using CAD tools.

Learning Outcomes:

- Represent 3-D solids and their sections on a 2-D plane.
- Develop surfaces of complex solids on a 2-D plane.

Unit 4: Orthographic Projection

Contents

- Orthographic projection conventions, first and third angle projections.

Description:

- This unit covers the principles of orthographic projection and its application in engineering graphics.

Examples/Applications/Case-studies: Manufacturing drawings of engineering components.

Exercise/Project Problems: Creating orthographic projections of simple and complex objects using CAD tools.

Learning Outcomes:

- Represent machine parts in plan and elevation.
- Identify the details of drawings in first angle and third angle projections.

Unit 5: Isometric Projection

Contents

- Isometric projection principles, isometric views of objects.

Description:

- This unit focus on isometric projection and its application in engineering drawings.

Examples/Applications/Case-studies: Isometric views of engineering components.

Exercise/Project Problems: Drawing isometric views using CAD tools.

Learning Outcomes:

- Convert 2-D drawings into a pictorial drawing.

Text Books:

1. Kulkarni, D. M., Rastogi, A. P., & Sarkar, A. K. (2009). *Engineering graphics with AutoCAD* (revised ed.). PHI Learning Pvt. Ltd.

References/e-Resources:

1. Bethine. A. Fishel, Jay D. Helsel, (2014). *Engineering Graphics with AutoCAD*, Pearson Education.
2. CADFolks, (2023). *AutoCAD 2023 for Beginners*, CADFolks Publications.

24CY181 Chemistry Lab

Category: Basic Sciences (BS) 0L 0T 2P 1C

***Pre-requisite*: 10+2 Chemistry**

Course Description:

The course is designed for students of B.Tech., providing essential practical knowledge of Chemistry concepts relevant to their fields. This hands-on laboratory course provides the students with practical experience in applied chemical techniques and experiments. The course is useful for students to develop essential skills of proper handling of instruments and apparatus, accurate measurements and recording data, as well as interpretation of data to arrive at the correct conclusion. The course includes the experiments based on different instrumental techniques for the quantitative analysis of different solutions. Also, the course enlightens the students on preparation of polymers, and corrosion related experiments. Further, it focuses on the conventional method of quantitative determination of samples using volumetric method.

Course Aims and Objectives:

1. Enhance understanding of chemical principles involved in instrumental methods of chemical analysis.
2. Develop skills in handling analytical instruments that can measure various chemical parameters.
3. Promote critical thinking and problem-solving through the interpretation of data obtained from the instruments.
4. Familiarize students with advantages and limitations of instrumental methods of analysis compared to conventional volumetric analysis.
5. Explore the practical aspects of chemical processes involved in preparation of polymers, metallic coatings, etc.

Course Outcomes:

At the end of the course, the student will be able to...

CO1: demonstrate a comprehensive understanding of various instrumental methods of chemical analysis [**K3**].
CO2: analyse quantitatively different redox systems and neutralization systems using volumetric analysis [**K4**].
CO3: compare corrosion tendencies of different metals and their protection by surface coatings [**K4**].
CO4: apply theoretical knowledge and skills of preparation of polymers, complexes on substrates, adsorption processes, porosity, viscosity, etc. [**K3**].

Course Structure:

Contents

List of experiments: Following is the list of experiments common to all branches of engineering followed by the specific experiments proposed for different groups of branches:

Experiments common to all branches:

1. Determination of strength of acid in a lead-acid battery
2. Determination of strength of base using pH metric titration
3. Conductometric analysis of a base using a standard acid
4. Determination of ferrous iron by permanganometry
5. Comparison of corrosion rates of different metals/alloys
6. Preparation of Urea-formaldehyde resin
7. Determination of amount of iron in a solution by colorimetry
8. Chemistry of blueprinting
9. Adsorption of acetic acid on charcoal

Experiments for CE and ME branches:

10. Determination of total hardness of a water sample
11. Determination of calcium in Portland cement
12. Determination of porosity of a refractory material
13. Determination of viscosity of lubricating oil by Redwood viscometer

Experiments for ECE, EEE and EIE branches:

10. Determination of ferrous iron by dichrometry
11. Determination of ferrous iron by potentiometry
12. Verification of Lambert-Beer's law
13. Electroplating of copper on iron article

Experiments for CSE, AI and IT branches:

10. Determination of ferrous iron by dichrometry
11. Determination of ferrous iron by potentiometry
12. Conductometric analysis of mixture of acids
13. Preparation of conducting polyaniline from aniline

Textbook(s) / Reference(s):

Textbooks:

1. Mendham, J. (2009). *Vogel's Quantitative Chemical Analysis* (6th ed.). Pearson Education.
2. Theodore, J., & George Pope, F. (2021). *Elementary Practical Chemistry. Inorganic and Organic* (1st ed.). Legare Street Press.

References:

1. Akhil, N., Deepak, L., Atul, B., & Chaudari, P.B. (2023). *Practical Manual of Inorganic, Organic and Medicinal Chemistry* (1st ed.). IP Innovative.
2. Venkateswaran, V. (2012). *Basic Principles of Practical Chemistry* (2nd ed.). S. Chand & Sons.

E-Resources:

1. https://nitm.ac.in/ckfinder/userfiles/files/CY%20151_Labmanual%20Chemistry%20B_Tech%201st%20year.pdf
2. http://icv-au.vlabs.ac.in/inorganic-chemistry/Water_Analysis_Determination_of_Physical_Parameters/
3. http://pcv-au.vlabs.ac.in/physical-chemistry/EMF_Measurement/
4. http://pcv-au.vlabs.ac.in/physical-chemistry/Determination_of_Viscosity_of_Organic_Solvents/
5. http://vlabs.iitb.ac.in/vlabs-dev/labs/nitk_labs/Environmental_Engineering_1/experiments/determination-of-chloride-nitk/simulation.html
6. https://chemcollective.org/vlabs

Mapping of Course Outcomes to Program Outcomes:

(**H**=high; **M**=medium; **L**=low)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	M	H		M	H							
CO2	M	H		M		L						
CO3	M	H			M	L						
CO4	M	H			M							

24ME182 **Workshop Practice**

Category: Engineering Science (ES) **0L 0T 3P 1.5C**

Pre-requisite: 10+2 Physics

PART-1: Exercises common to all branches of engineering students

Course Description: (Part-1)

This part of the course provides first-year engineering students with comprehensive hands-on experience in electrical systems, electronics, and computer science fundamentals. The course covers practical exercises in electrical wiring and circuit design, electronics component handling, and computer hardware and software configuration. Students will engage in activities such as electrical switching circuits, distribution board assembly, electronic component identification, and basic IoT (Internet of Things) projects. The course is designed to equip students with essential skills for diagnosing and constructing electrical and electronic systems, as well as understanding computer hardware and IoT applications.

Course Outcomes: (Part-1)

At the end of this part of the course, the student will be able to...

CO1: design, assemble, and test various electrical circuits, including stair case, two-way, and fan connections, and accurately measure electrical parameters such as voltage, current, power, and energy using digital meters.

CO2: identify and use electronic components (resistors, capacitors, diodes, switches) to construct and test a simple calling bell circuit, demonstrating understanding of circuit design and component functionality.

CO3: install and configure peripheral devices on a desktop system and apply basic IoT principles using an Arduino board to measure and interpret environmental data such as temperature, humidity, and distance.

Course Contents: (Part-1)

1. **Electrical Workshop Practice Exercises: (3 hrs)**
    - Stair case/Two-way /Gowdown Switching/Fan connection
    - 3Φ Distribution board with fuse, MCB, two way switches, light indicator,4 switches, fan regulator
    - Measurement of voltage, current, power, Energy by using digital meters

2. **Electronics Workshop Practice Exercises: (1 hr)**
    - Familiarization of electronic components such as resistors, capacitors, diodes, and switches.
    - Preparation of a simple calling bell circuit board and and testing its operation.

3. **Computer science Workshop Practice Exercises: (2 hrs)**
    - Hardware components of a desktop system: Peripheral Installation: Install and configure peripheral devices such as printers, scanners, and external hard drives.
    - Basics of Internet of things (IOT):
    - Demonstration of different components and pin configuration of Arduino board
    - To measure Temperature, humidity and distance using Arduino board.

Modern Manufacturing methods:

- Demonstration of 3-D printing process.

PART-2: Exercises to Computers group students only (CSE/ AI&DS/ AI&ML/IT)

Course Description: (Part-2: CSE/ AI&DS/AI&ML/ IT)

This part of course provides first year CSE/AI&DS/AI&ML/IT students an in-depth exploration of the fundamental components and operations of modern computer systems. Through hands-on experience, students will gain practical knowledge in disassembling and reassembling computers, troubleshooting hardware issues, installing peripherals, setting up and configuring networks, interfacing sensors with microcontrollers, and implementing basic digital logic design. The course emphasizes real-world applications and problem-solving skills, enabling students to confidently manage and maintain computer hardware and network systems.

Course Outcomes: (Part-2: CSE/ AI&DS/AI&ML/ IT)

At the end of this course, students will be able to:

CO1: identify and explain the function of each major computer component by disassembling and reassembling a desktop computer, including the CPU, motherboard, RAM, HDD/SSD, and GPU.

CO2: examine and troubleshoot common hardware issues such as RAM failures and CPU overheating, using systematic problem-solving techniques.

CO3: demonstrate the installation of peripheral device software including printers, scanners, and external hard drives, ensuring full functionality within the system.

CO4: design and set up a network topology of a local area network (LAN)**,** including routers, switches, and computers, with proper IP addressing and network service configuration.

CO5: interface sensors with microcontrollers to acquire and display data using platforms like Arduino, demonstrating practical skills in sensor-based data acquisition.

CO6: illustrate basic digital logic operations using breadboards and logic Integrated Circuits (ICs), reinforcing foundational knowledge in digital logic design.

Course Contents: (Part-2: CSE/ AI&DS/ AI&ML/IT) (6 hrs)

1. Computer Components:

- Disassemble and reassemble a desktop computer to understand the role of each component (CPU, motherboard, RAM, HDD/SSD, GPU, etc.).

2. Hardware Troubleshooting & Peripheral Installation:

- Simulate common hardware issues (e.g., RAM failure, CPU overheating) and identify the procedures to resolving them.

3. Peripheral Installation:

- Install and configure peripheral devices such as printers, scanners, and external hard drives.

4. Network Setup and Configuration:

- Set up a small LAN network with routers, switches, and computers. Configure IP addresses, subnet masks, and basic network services.

5. Sensor Interfacing and Data Acquisition:

- Acquire the data by interfacing sensors (e.g., temperature, light, motion) through microcontrollers.
- Execute the program on Arduino IDE & display the measured values.

6. Digital Logic Design Basics:

- Implement basic digital logic gate (AND, OR, NOT) operations using breadboards and logic Integrated Circuits (ICs).

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Department of Electronics & Communication Engineering

SU 24 Scheme of Instructions

Fourth Semester

Course Structure

S.No.	Course Code	Course Category	Course Name	L	T	P	Credits
1	24EC204	ES	Random Variables and Stochastic Process	3	0	0	3
2	24EC205	PC	Analog Electronics – II	3	0	0	3
3	24EC206	PC	Analog & Digital Communications	3	0	0	3
4	24EC207	PC	Electromagnetic Waves and Transmission Lines	3	0	0	3
5	24EC208	PC	Microcontrollers and Interfacing	3	0	0	3
6	24EC283	PL	Analog Electronics – II Lab	0	0	3	1.5
7	24EC284	PC	Analog & Digital Communications Lab	0	0	3	1.5
8	24EC285	PC	Microcontrollers Lab	0	0	3	1.5
9	24EN281	HS	English for Professionals	0	0	2	1
10	24UC202	MC	Professional Ethics	2	0	0	0
			TOTAL				**20.5**

24EC204 : RANDOM VARIABLES AND STOCHASTIC PROCESS

Course Category:	**ES**	**Credits:**	**3**
Course Type:	**Theory**	**Lecture -Tutorial-Practice:**	**3-0-0**
Prerequisites:		**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	**40** **60** **100**

Course outcomes	Upon successful completion of the course, the student will be able to:	
	CO1	Apply the fundamental concepts of probability theory, including sample spaces, events, conditional probability, and Bayes' theorem.
	CO2	Explain the characteristics of random variables and analyze their probability distribution and density functions.
	CO3	Evaluate expectations, moments, and transformations associated with single and multiple random variables.
	CO4	Analyze the temporal and spectral characteristics of random processes, including autocorrelation and power spectral density.
	CO5	Examine the response of linear systems to random inputs and model noise behavior in communication systems.

		Program Outcomes (POs)											**Program Specific Outcomes (PSOs)**		
Contribution of Course Outcomes towards achievement of Program Outcomes (1 - Low, 2 - Medium, 3 - High)	**Course Outcomes**	1	2	3	4	5	6	7	8	9	10	11	1	2	3
	CO1	3	2	1	1	1	1	1	1	1	2	1	1	2	2
	CO2	3	3	1	1	1	1	1	1	1	2	1	1	2	2
	CO3	3	3	1	2	1	1	1	1	1	2	1	1	2	2
	CO4	3	3	2	2	1	1	1	1	1	3	1	1	3	2
	CO 5	3	3	3	3	1	1	1	1	1	3	1	1	3	2

Course Content	**UNIT-I** **Probability Theory:** Sample spaces, Events, Probability definition and Axioms, Mathematical model of experiments, Probability as relative frequency, Joint and conditional probability, Properties of joint probability and conditional probability, Total probability, Bayes' theorem, independent events. **(9 Hours)**

	UNIT-II **Random Variables and Operations on one random variable:** The Random Variable Concept, Distribution Function and Density function, The Gaussian Random Variable, Conditional Distribution and Density Functions. **Operations on One Random Variable** Expectation, Moments, Functions that give Moments, Monotonic and Non monotonic Transformations of a Random Variable.**(9 Hours)** **UNIT-III** **Multiple Random Variables:** Vector Random Variables, Joint Distribution and its Properties, Joint Density and its Properties, Conditional Distribution and Density, Statistical Independence, Distribution and Density of Sum of Random Variables **(9 Hours)** **UNIT-IV** **Random Processes – Temporal Characteristics**: The Random Process Concept, Stationary and Independence, Correlation Functions, Gaussian Random Process**.** **Random Processes – Spectral Characteristics**: Power Density Spectrum and its properties, Relationship between Power Spectrum and Auto Correlation Function **(9 Hours)** **UNIT-V** **Linear Systems with Random Inputs:** Random Signal Response of Linear Systems, Spectral characteristics of System response Noise Bandwidth, Modelling of Noise Sources, Modelling of Practical Noisy Networks **(9 Hours)**
Textbooks and Reference books	**Textbooks:** 1. Peyton Z. Peebles, "Probability, Random Variables & Random Signal Principles", 4th Edition, TMH, 2002. **Reference Books:** 1. Athanasios Papoulis, S. Unnikrishnan Pillai, "Probability, Random Variables and Stochastic Processes", 4rd Edition, TMHl, 2002. 2. Fundamentals of Applied Probability and Radom processes, Oliver Crib, Elsevier Publications, 2007.
E-resources and other digital material	1. http://nptel.ac.in/courses/117105085/ 2. https://www.stat.berkeley.edu/~aldous/134/gravner.pdf

Dr P Phani Kumar	Course Coordinator	
Dr P Phani Kumar	Program Coordinator	
Dr D Venkata Rao	Head of the Department	

24EC205 : ANALOG ELECTRONICS-II

Course Category:	Program Core	**Credits:**	3
Course Type:	Theory	**Lecture - Tutorial -Practice:**	3-0-0
Prerequisites:	24EC201:Analog Electronics-1	**Continuous Evaluation:**	30
		Semester end Evaluation:	70
		Total Marks:	100

Course Outcomes	Upon successful completion of the course, the student will be able to:	
	CO1	Understand basic operational amplifier circuits, including various modes of operation and characteristics.
	CO2	Understand various applications of op-amp.
	CO3	Analyze the performance of various data converter circuits.
	CO4	Analyze the operation of the 555 Timer integrated circuit in various configurations.
	CO5	Analyze the characteristics and performance of monolithic PLL ICs such as IC 565 and IC 566.

Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 Medium, 3 – High)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2
CO1	2	1	2	2	2	1	1	1	1	1	1	2	2
CO2	1	2	2	2	1	1	1	1	1	1	1	2	2
CO3	1	2	3	3	2	1	1	1	1	1	1	2	2
CO4	2	1	3	3	1	1	1	1	1	1	1	2	2

Course Content

UNIT-I

Operational Amplifier: Introduction of Operational Amplifier, Classification, Op-Amp parameters, Differential Amplifiers and its modes of operation, DC and AC Analysis, Op-Amp AC and DC Characteristics, CMRR improvement methods. **(9 Hours)**

UNIT-II

Basic Op-amp Applications, Op-Amp Half wave and Full wave rectifiers, Instrumentation Amplifier, Sample and Hold Circuits, Differentiator, Integrator, V-I and I-V Converters, Logarithmic Amplifier.**(9 Hours)**

UNIT-III

Data Converters - Introduction, Basic DAC techniques, Different types of

	DACs- Weighted resistor DAC, R-2R ladder DAC. Different Types of ADCs - Parallel Comparator Type ADC, Successive Approximation ADC and Dual Slope ADC, DAC, and ADC Specifications. **(9 Hours)** **UNIT-IV** **Applications of IC555:** Introduction to 555 Timer, Description of Functional Diagram, Monostable operation, Applications in Monostable mode, Astable Operation, Applications in Astable mode, Schmitt Trigger. **(9 Hours)** **UNIT-V** **Phase Locked Loops**: Introduction, Basic Principles, Phase Detector/Comparator, and Voltage Controlled Oscillator (566), Low Pass Filter, Monolithic PLL (565), PLL Applications. **(9 Hours)**
Text books and Reference books	**Text books:** 1. D. Roy Choudhary, Shail Jain, "Linear Integrated Circuits", 4th edition, New Age International Pvt. Ltd., 2010. 2. Ramakant A. Gayakwad "Op-Amps and Linear Integrated Circuits", Fourth Edition, 2015, Pearson. 3. Sedra and smith, "Microelectronic Circuits", Seventh Edition, Oxford University Press, 2014. **References:** 4. R.F.Coughlin & Fredrick Driscoll, "Operational Amplifiers & Linear Integrated Circuits" PHI, 6th Edition,2000. 5. David A Bell, "Operational Amplifiers & Linear ICs", Oxford Uni. Press, 3rd Edition,2011.
E- resources and other digital material	1. https://nptel.ac.in/courses/108108111

Mr G Hema Kumar	Course Coordinator	
Dr P Phani Kumar	Program Coordinator	
Dr D Venkata Rao	Head of the Department	

24EC206 : ANALOG AND DIGITAL COMMUNICATIONS

Course Category:	Programme Core	**Credits:**	3
Course Type:	Theory	**Lecture - Tutorial -Practice:**	3-0-0
Prerequisites:	Signals and Systems, Random Variables and Stochastic Process	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	40 60 100

Course outcomes	Upon successful completion of the course, the student will be able to:	
	CO1	Characterize amplitude modulation in time and frequency domains.
	CO2	Understand frequency modulation and its spectral characteristics.
	CO3	Apply pulse modulation techniques and baseband transmission principles in communication systems.
	CO4	Apply signal space concepts for coherent detection of signals in the presence of noise.
	CO5	Analyze digital passband modulation schemes in terms of bit error performance.

Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3 – High)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2
CO1	3	2	1	1			2	1			1	1	2
CO2	3	2	1	1			2	1			1	1	2
CO3	3	2	2	2			2	1			1	1	3
CO4	3	2	1	2			2	1			1	1	3
CO5	3	2	2	2			2	1			1	1	3

Course Content

UNIT I

Amplitude Modulation: AM: Time and Frequency Domain Description, Generation of AM waves, Detection of AM waves, Double Side Band-Suppressed Carrier Modulation: Time and Frequency Domain Description, Generation of DSBSC waves, Coherent detection of DSBSC Modulated Waves. **(9 Hours)**

UNIT II

Angle Modulation: Basic Concepts, Frequency Modulation- Single Tone, Spectrum Analysis of Sinusoidal FM Wave: Narrow Band FM, Wideband FM, Average Power, Transmission Bandwidth of FM. **(9 Hours)**

	UNIT III **Pulse Modulation:** Quantization Process, Pulse Code Modulation, Delta Modulation. **Baseband Pulse Transmission:** Matched filter, Properties of Matched filters, Intersymbol Interference **(9 Hours)** **UNIT IV:** **Signal Space Analysis:** Introduction, Geometric Representation of Signals, Gram-Schmidt Orthogonalization Procedure, Likelihood Functions, Coherent Detection of Signals in Noise - Maximum Likelihood Decoding, Correlation Receiver. **(9 Hours)** **UNIT V:** **Passband Digital Transmission:** Introduction, Passband Transmission Model, Coherent Phase Shift Keying – BPSK, QPSK, and Coherent Frequency Shift Keying - Binary FSK, Comparison of Digital Modulation Schemes Using a Single Carrier. **(9 Hours)**
Text books and Reference books	**Text Books:** 1. Simon Haykin, "An Introduction to Analog and Digital Communications", John Wiley and Sons, 1989. (Units – I, II) 2. Simon Haykin, "Communication Systems", John Wiley & Sons, 4th edition, 2001. (Units - III, IV & V) **Reference Books:** 1. Abhay Gandhi, "Analog and Digital Communications – Theory and Lab work", 1st edition, Cengage Learning, 2014. 2. Bernard Sklar, "Digital Communication", 2nd edition, Pearson Education, 2013. 3. Taub and Schilling, "Principles of Communication Systems", 2nd edition, TMH, 1986
E-resources and other digital material	1. https://nptel.ac.in/courses/117105143 2. https://nptel.ac.in/courses/117101051 3. https://web.stanford.edu/class/ee179/index.html

Dr N Satyanarayana Murthy	Course Coordinator	
Dr P Phani Kumar	Program Coordinator	
Dr D Venkata Rao	Head of the Department	

24EC207: ELECTROMAGNETIC WAVES AND TRANSMISSION LINES

Course Category:	Programme Core	**Credits:**	3
Course Type:	Theory	**Lecture - Tutorial -Practice:**	3-0-0
Prerequisites:	24PH102 Engineering Physics	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	40 60 100

Course outcomes	Upon successful completion of the course, the student will be able to:	
	CO1	Apply the appropriate physical laws of electrostatics and magnetostatics to estimate fields.
	CO2	Apply boundary conditions at different interfaces, and analyze wave propagation in conducting and dielectric media.
	CO3	Analyze the reflection and refraction of electromagnetic waves at media interfaces.
	CO4	**Determine primary and secondary constants of transmission lines.**
	CO5	Compute the impedance and reflection coefficients in transmission lines for impedance matching.

Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3 – High)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2
CO1	3	2	1	1	1	1	1	1	1	1	1	2	1
CO2	2	2	2	1	1	1	1	1	1	1	1	2	1
CO3	2	2	2	1	1	1	1	1	1	1	1	2	1
CO4	2	2	2	1	1	1	1	1	1	1	1	2	1
CO5	2	2	2	1	1	1	1	1	1	1	1	2	1

Course Content

UNIT I: Electrostatics:, Maxwell's Two Equations for Electrostatic Fields, Energy Density, Convection and Conduction Currents, Continuity Equation, Relaxation Time, Poisson's and Laplace's Equations.
MagnetoStatics : Maxwell's Two Equations for Magneto static Fields, Magnetic Scalar and Vector Potentials, Magneto static Energy **(9 Hours)**

UNIT II: Maxwell's Equations (Time Varying Fields): Faraday's Law, Inconsistency of Ampere's Law and Displacement Current Density, Maxwell's Equations in Differential and integral Forms and Word Statements. Conditions at a Boundary Surface: Dielectric-Dielectric and Dielectric-Conductor Interfaces. Wave Equations for Conducting and Perfect Dielectric Media, Relations Between E & H. **(9 hours)**

	UNIT III: EM Wave Characteristics: Sinusoidal Variations, Wave Propagation in Lossy dielectrics, lossless dielectrics, free space, Wave propagation in good conductors, skin depth, Polarization. Reflection and Refraction of Plane Waves – Normal and Oblique Incidences for both Perfect Conductor and Perfect Dielectrics, Poynting Theorem. **(9 hours)** **UNIT IV: Transmission Lines - I** : Types, Parameters, T&π Equivalent Circuits, Transmission Line Equations, Primary & Secondary Constants, Expressions for Characteristic Impedance, Propagation Constant, Phase and Group Velocities **9 hours)** **UNIT V: Transmission Lines – II :** Input Impedance Relations, SC and OC Lines, Reflection Coefficient, VSWR, UHF Transmission lines, UHF Lines as Circuit Elements, Significance of λ/2, λ/4, λ/8 Lines, Smith Chart – Applications, Single Stub Matching. **(9 hours)**
Text Books And References Books	**Text Books:** 1. Matthew N.O. Sadiku, "Elements of Electromagnetics", Oxford Univ. Press, 6th edition. (Unit –I). 2. E.C. Jordan and K.G. Balmain, "Electromagnetic Waves and Radiating Systems", PHI, 2nd edition . (Unit –II, III). 3. Networks, Lines and Fields – John D. Ryder, PHI, 2nd edition.(Unit –IV,V). **Reference Books** 1. Nathan Ida, "Engineering Electromagnetics", Springer (India) Pvt. Ltd., New Delhi, 2nd edition, 2005. 2. William H. Hayt Jr. and John A. Buck, "Engineering Electromagnetics", TMH, 7th edition, 2006. 3. Joseph A Edminister, "Electromagnetics", Schaums Outlines Series, 2nd edition, 2010.
E-resources and other digital material	1. http://nptel.ac.in/courses/108106073/ 2. https://freevideolectures.com/course/3288/electromagnetic-theory 3. https://freevideolectures.com/course/2326/transmission-lines-and-em-waves 4. http://www.mike-willis.com/Tutorial/PF2.htm

Dr S Suryanarayana	Course Coordinator	
Dr P Phani Kumar	Program Coordinator	
Dr D Venkata Rao	Head of the Department	

24EC208: MICROCONTROLLERS & INTERFACING

Course Category:	Programme Core	**Credits:**	3
Course Type:	Theory	**Lecture - Tutorial -Practice:**	3-0-0
Prerequisites:		**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	40 60 100

Course outcomes

Upon successful completion of the course, the student will be able to:

CO1	Explain the basic organization and functional units of a computer.
CO2	Interpret various ways to program the different microprocessors.
CO3	Design and analyze the operation of control units using both hardwired and microprogrammed control techniques.
CO4	Illustrate the internal architecture of the 8051 microcontroller and interface it with external memory and I/O devices.
CO5	Develop and test assembly-level programs for 8051 microcontroller.

Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3 – High)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PS PO1	PS PO2
CO1	3	2	1	1	1	1	2	1	1	1	1	2	2
CO2	3	3	3	2	2	1	1	1	2	1	1	2	2
CO3	3	2	2	2	2	1	1	2	2	2	2	2	2
CO4	3	3	3	2	2	1	1	1	1	1	2	2	2
CO5	3	3	3	2	3	2	1	1	2	2	2	2	2

Course Content

UNIT I:

Basic organization of computer and block level description of the functional units. Introduction to bus structure and connecting I/O devices to CPU and Memory. Memory Hierarchy, Cache memory.

(9 **Hours)**

UNIT II:

Instruction formats- Addressing modes, Basic Instruction cycle, Pipeline basic concepts: processing, instruction pipelining, pipeline stages, Pipeline Hazards. Data Representation-Number representation: Binary Data representation, two's complement representation.

(9 **Hours)**

	UNIT III: Micro-operations & control signals, Hardwired control unit design methods, Micro programmed control, Micro instructions, Micro instructions with next address field. **(9 Hours)** **UNIT – IV:** 8051 Introduction and Architecture, 8051 Memory Organization, Special Function Registers, 8051 Pins and Signals, Memory Interfacing, I/O Interfacing. **(9 Hours)** **UNIT – V:** Programming 8051 Resources – Timers/Counters, Serial Interface, Multiprocessor Communication, Interrupts – Response Time, Interrupt Control Registers. **(9 Hours)**
Textbooks and Reference books	**Textbooks:** 1. Carl Hamacher, Zvonko Vranesic and Safwat Zaky, "Computer Organization", Fifth Edition, Tata McGraw-Hill. 2. Mohammed Ali Mazidi and Janice Gillispie Mazidi, "The 8051 Microcontroller and Embedded Systems", 2nd Edition, Pearson, Education Asia, New Delhi, ISBN 978-0-13-119402-1. **Reference Books:** 1. John P. Hayes, "Computer Architecture and Organization", Third Edition' 2. William Stallings, "Computer Organization and Architecture: Designing for Performance", Eighth Edition, Pearson. 3. M. Moris Mano. "Computer System Architecture" 3rd edition, Pearson/ PHI.
E-resources and other digital material	1. https://nptel.ac.in/courses/108105102/ 2. http://www.datasheetarchive.com/8051-datasheet.html 3. www.engenuics.com

Dr Shaik Fayaz Ahamed	Course Coordinator	
Dr P Phani Kumar	Program Coordinator	
Dr D Venkata Rao	Head of the Department	

24EC283 : ANALOG ELECTRONICS-II LAB

Course Category:	Core	**Credits:**	2
Course Type:	LAB	**Lecture - Tutorial -Practice:**	0-0-3
Prerequisites:	24EC201-Analog Electronics, Analog Electronics-II	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	30 70 100

Course outcomes	Upon successful completion of the course, the student will be able to:											
	CO1	Understand the concepts of linear integrated circuits and special IC's (IC 565, IC 566) and use them for different applications										
	CO2	Design oscillators, waveform generators and filter circuits using IC741										
	CO3	Use the concepts of A/D , D/A converters and design voltage regulators										
	CO4	Design the circuits using 555 timers for particular application										
Contribution of Course Outcomes towards achievement of Program Outcomes (L – Low, M - Medium, H – High)		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
	CO1	2	1	2	2	2	1	1	1	2	1	1
	CO2	1	2	2	2	2	1	1	1	2	1	1
	CO3	2	2	2	2	2	1	1	1	2	1	1
	CO4	2	1	2	2	2	1	1	1	2	1	1
Course Content	1) Measurement of Op-Amp Parameters. 2) Design Inverting and Non-inverting amplifier circuits using Op-Amp. 3) Design Comparator and zero-crossing detector circuits using 741. 4) Design and Verification of Applications of Op-amp (Adder, Subtractor, Integrator, Differentiator). 5) Design of Full wave rectifier using 741 IC. 6) Design of Instrumentation Amplifier using Op-Amp. 7) Design of Triangular waveform generators using 741 IC. 8) Design of Monostable multivibrator circuit using 741 IC. 9) Design of Schmitt Trigger circuit using 741 IC. 10) Design of Astable multivibrator circuit using 741 IC 11) Design of Active Filters using Op-Amp (Second Order LPF & HPF circuits). 12) Design of Voltage Regulator using IC 723. 13) Design of 4-bit R – 2R Ladder D-A Converter. 14) 555 Timer as Astable multivibrator.											

	15) Design of Voltage Regulator using IC 7805/7905. **NB: A minimum of 10(Ten) experiments have to be performed and recorded by the candidate to attain eligibility for External Practical Examination.**
Text books and Reference books	1. D.Roy Choudhary, Shail Jain, "Linear Integrated Circuits", 4th edition, New Age International Pvt. Ltd., 2010. 2. Ramakant A.Gayakwad, 'OP-AMP and Linear IC's', Prentice Hall / Pearson Education, 1994. 3. 3. Sergio Franco, 'Design with operational amplifiers and analog integrated circuits', McGraw-Hill, 1997.
E-resources and other digital material	1. http://www2.mvcc.edu/~jfiore/et262.html

24EC284 : ANALOG AND DIGITAL COMMUNICATIONS LAB

Course Category:	Programme Core	**Credits:**	1.5
Course Type:	Practical	**Lecture-Tutorial-Practice:**	0-0-3
Prerequisites:	Signals and Systems, Analog & Digital Communications	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	60 40 100

Course outcomes	Upon successful completion of the course, the student will be able to:													
	CO1	Demonstrate practical implementation of analog modulation and demodulation techniques.												
	CO2	Implement various digital modulation techniques using hardware and software tools.												
Contribution of Course Outcomes towards achievement of Program Outcomes (1–Low, 2-Medium, 3–High)		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2
	CO1	3	2	2	1	3	1	2	3	2	1	1	1	3
	CO2	3	2	2	1	3	1	2	3	2	1	1	1	3

Course Content

Experiments using Hardware (using Discrete Components/Kits):

1. Generation and Detection of Amplitude Modulated signal.
2. Generation and Detection of Frequency Modulated signal.
3. Generation and Detection of DSB-SC Modulated signal.
4. Generation and Detection of PCM signal.
5. Generation and Detection of DM signal.
6. Generation and Detection of DPSK signal.
7. Perform Spectrum analysis of Amplitude modulated and demodulated signals using spectrum analyzer.

Experiments using Software: - (Matlab, LabVIEW, Scilab, Any other Open source software)

1. Simulation of Amplitude Modulation and Demodulation.
2. Simulation of Frequency Modulation and Demodulation.
3. Simulation of DSB-SC Modulation and Demodulation.
4. Simulation of Linecodes (unipolar, polar, bipolar and Manchester).
5. Simulation of Matched Filter for a rectangular pulse.
6. Simulation of ASK, FSK and PSK Modulation.
7. Measure the Performance of BPSK Communication System in term of Bit Error Rate (BER).

Course-based project:

1. Design and implement an envelope detector to recover an AM signal. A modulated AM signal with a carrier frequency of 100 kHz and a

	modulation index of 0.7 is provided. Design an envelope detector using a diode and capacitor. Compare the recovered message signal with the original message signal and analyze distortions **2.** Perform DSB-SC Modulation and analyze the spectrum using an open-source software (Python/SCILAB). Generate a DSB-SC signal with a carrier frequency of 100 kHz. Represent the signal in both time and frequency domains using FFT. **3.** Use a spectrum analyzer to demodulate and listen to a live FM station. Capture an FM broadcast signal using a spectrum analyzer. Perform demodulation and listen to the output
Reference books	1. Simon Haykin. "Introduction to Analog and Digital Communication Systems", 3rd edition, 2009, John Wiley and Sons 2. George Kennedy, Electronic Communication Systems, sixth edition, Tata McGraw Hill Edition -2017 3. Abhay Gandhi, "Analog and Digital Communications – Theory and Lab work", 1st edition, Cengage Learning, 2014.
E-resources and other digital material	1. https://vlab.amrita.edu/index.php?sub=59&brch=163 2. https://scilab.in/lab_migration/generate_lab/16/1

NB: Eligibility for External Practical Examination:

1. A minimum of 10(Ten) experiments to be performed and recorded by the candidate.
2. Execute and submit a course-based project

24EC285 : MICROCONTROLLERS LAB

Course Category:	**Program Core**	**Credits:**	1.5
Course Type:	**Lab**	**Lecture - Tutorial -Practice:**	0-0-3
Prerequisites:	**---**	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	30 70 100

Course outcomes	Upon successful completion of the course, the student will be able to:	
	CO1	Develop assembly and C language programs on 8051.
	CO2	Interface the peripherals to 8051 and program using assembly and C Language.

Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3 – High)

	PO a	PO b	PO c	PO d	PO e	PO f	PO g	PO h	PO i	PO j	PO k	PO l	PSPO 1	PSPO 2
CO1	3	3	3	3	3	3	2	2	3	3	3	3	3	3
CO2	3	3	3	3	3	3	2	2	3	3	3	3	3	3

Course Content

List of experiment to be implemented on 8051 using both assembly and C language.

1. Basic programs on Microcontroller Instruction set.
2. Programs on Serial Communications.
3. Programs on Timer operation.
4. Programs on counter operation.
5. Programs on Interrupt Mechanism.
6. Programs on LCD Display interfacing.
7. Programs on ADC interfacing
8. Programs on DAC interfacing.
9. Programs on Keyboard interfacing.
10. Programs on stepper motor interfacing
11. Programs on memory interfacing
12. Programs on I2C bus interfacing

Course based Project

1. Design and development a digital thermometer.
2. Design and development of Bluetooth Controlled Home Automation System using 8051
3. Design and development of line follower robot.

E-resources and other digital material

1. www.8052.org
2. www.datasheetarchive.com/8051-datasheet.html

1. A minimum of 10 (Ten) experiments to be performed and recorded by the candidate.
2. Execute and submit a course-based project

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B.Tech – V-Semester (SU24)

Scheme of Instructions-Department of ECE

S.No	Course Code	Course Category	Course Name	L	T	P	Credits
1	24EC301	PC 8	Digital Signal Processing	3	0	0	3
2	24EC302	PC 9	VLSI Design	3	0	0	3
3	24EC303	PC 10	Antenna & Wave Propagation	3	0	0	3
4	24EC310	PE	ProgramElective-1 A. Information Theory & Coding B. Computer Networks C. Electronic Measurements & Instrumentation D. RISC - V Microcontroller Design and Debugging with JTAG E. Embedded Systems and RTOS	3	0	0	3
5	24EC360	IE	**Inter disciplinary Elective – 1** (Basket of courses from other engineering departments) A. Introduction to Embedded Systems B. Introduction to Communication Engineering	3	0	0	3
6	24EC383	PL	DSP Lab	0	0	3	1.5
7	24EC384	PL	VLSI Design Lab	0	0	3	1.5
8	24EC381	PR	EPICS*	0	0	4	2
9	24EC382	SEC	Skill Course-I (Program specific) A. Antenna Design & Modelling B. Signal Visualization and Time Domain Analysis C. ARM Architecture & Programming D. Digital Design Foundations using Verilog E. CCNA – 1	1	0	2	2
10	24UC302	MC	Environmental Science	2	0	0	0
			Total	**18**	0	**12**	22
			Minors **VLSI Design Flow: RTL-to-GDSII (NPTEL)**	3	0	1.5	4.5

- **4 week summer Internship after 4th semester (EPICS)**

24EC301 : DIGITAL SIGNAL PROCESSING

Course Category:	Programme Core	**Credits:**	3
Course Type:	Theory	**Lecture - Tutorial -Practice:**	3-0-0
Prerequisites:	Signals & Systems	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	40 60 100

Course Outcomes	Upon successful completion of the course, the student will be able to:	
	CO1	Apply DIT for computation of the DFT
	CO2	Apply DIF FFT algorithms for efficient computation of the DFT
	CO3	Design and verify the frequency response of Digital IIR Filters.
	CO4	Design and verify the frequency response of Digital FIR filters
	CO5	Analyze and implement various realization structures for FIR and IIR digital filters

Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3– High)		**Program Outcomes (POs)**											**PSOs**		
		1	2	3	4	5	6	7	8	9	10	11	1	2	3
	CO1	3	2										2		
	CO2	3	3	2		2							2		
	CO3	3	3	2		2							2		
	CO4	1	2										1		
	CO5	1	2	2		2							2		

Course Content

UNIT I:

The Discrete Fourier Transform - Its Properties and applications: Frequency Domain Sampling and Reconstruction of Discrete Time Signals, The Discrete Fourier Transform (DFT), The DFT as a Linear Transformation, Relationship of the DFT to Other Transforms, Properties of the DFT, Linear Filtering methods based on the DFT. **(9 Hours)**

UNIT II):

Fast Fourier Transform Algorithms: Efficient Computation of the DFT: FFT Algorithms - Direct Computation of the DFT, Divide-and-Conquer approach to Computation of the FFT, Radix-2 FFT Algorithms. Applications of FFT Algorithms – Use of the FFT Algorithm in Linear Filtering and Correlation. **(9 Hours)**

	UNIT III: **Design of IIR Filters from Analog Filters:** IIR filter Design by Approximation of Derivatives, IIR Filter Design by Impulse Invariance, IIR filter Design by the Bilinear Transformation, Characteristics of commonly used Analog Filters. Frequency Transformations - Frequency Transformations in the Analog Domain and Frequency transformations in digital domain **(9 Hours)** **UNIT IV:** **Design of FIR Filters:** General Conditions, Design of FIR Filters - Symmetric & Anti-symmetric FIR filters, Design of Linear-phase FIR filters using Rectangular, Hamming and Hanning Windows, Design of Linear Phase FIR filters by the Frequency-Sampling Method, Comparison of Design methods for Linear-Phase FIR filters. **(9 Hours)** **UNIT-V**: **Structures for FIR Systems:** Direct Form Structures, **Linear Phase Structures** and Cascade Form Structures **Structures for IIR Systems**: Direct-Form Structures, Signal Flow Graph and Transposed Structures, Cascade Form Structures **(9 Hours)**
Text books and Reference books	**Text Books:** 1. John G. Proakis, & Dimitris G. Manolakis, "Digital Signal Processing: Principles, Algorithms and Applications", 4th Edition, 2007, Prentice-Hall of India Private Limited **Reference Books:** 1. Oppenheim, Alan V., Ronald W. Schafer, and John R. Buck. Discrete-time signal processing, 2nd Edition, Pearson Education. 2. Ifeacher E.C. & Jervis B.W, "Digital Signal Processing, A Practical Approach", 3rd Edition, 2003, Addison Wesley. 3. Lonnie C Ludeman, "Fundamentals of Digital Signal Processing", John Wiley & Sons, 2003. 4. S K Mitra, "Digital Signal Processing: A Computer Based Approach", 2nd Edition, 2003, TMH.
E-resources and other digital material	1. https://nptel.ac.in/courses/117102060 2. https://archive.nptel.ac.in/courses/108106151 3. https://ocw.mit.edu/resources/res-6-008-digital-signal-processing-spring-2011/

24EC302 : VLSI DESIGN

Course Category:	**PC8**	**Credits:**	**3**
Course Type:	**Theory**	**Lecture -Tutorial-Practice:**	**3-0-0**
Prerequisites:	23EC202: Digital Circuit Design	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	**40** **60** **100**

Course outcomes	Upon successful completion of the course, the student will be able to:	
	CO1	Analyze VLSI fabrication processes, electrical parameters and inverter characteristics
	CO2	Understand MOS layers, stick diagrams, and design rules, and apply them to construct layouts for nMOS and CMOS circuits
	CO3	Evaluate different scaling models and their impact on performance, reliability, and physical limitations in modern MOS circuits
	CO4	Design and analyze structured combinational logic, architectural issues
	CO5	Comprehend testing and testing techniques

		Program Outcomes (POs)											PSOs		
Contribution of Course Outcomes towards achievement of Program Outcomes (1 - Low, 2 - Medium, 3 - High)	**Course Outcomes**	1	2	3	4	5	6	7	8	9	10	11	1	2	3
	CO1	3	2	1	2							1	1	2	2
	CO2	3	2	2	1							1	1	2	2
	CO3	3	3	3	2							1	1	2	2
	CO4	2	2	1	3							1	1	3	2
	CO5	3	3	3	2							1	1	3	2

Course Content

UNIT – I

Introduction to MOS Technology: NMOS fabrication, CMOS fabrication.

Basic Electrical Properties Of MOS Circuits: Drain-to-Source Current I_{ds} versus Voltage V_{ds} relationships, Aspects of MOS Transistor, Threshold voltage V_t, MOS Transistor Trans conductance g_m and Output Conductance g_{ds}, MOS Transistor Figure of Merit,NMOS inverter, Alternative forms of Pull-up, CMOS Inverter, Latch-up in CMOS Circuits. **(9 Hours)**

UNIT – II

MOS Circuit Design Processes: Switch Logic, Gate Logic,MOS Layers,

	Stick Diagrams nMOS design style,CMOS design style, Design Rules and Layout nMOS design style ,CMOS design style. **(9 Hours)** **UNIT – III** **Basic Circuit Concepts**: Sheet Resistance R_s, Standard Unit of Capacitance, The Delay Unit. **Scaling of MOS Circuits**: Scaling Models and Scaling Factors, Scaling Factors for Device Parameters.Limitations of scaling. **(9 Hours)** **UNIT-IV** **Subsystem Design**: Architectural Issues, Examples of Structured Design (Combinational Logic): A parity generator,Multiplexer, Bus Arbitration logic for n-line Bus, A four line Gray code to Binary Code Converter. **(9 Hours)** **UNIT-V** **Testing and Testability :**Fault types and Models, **Design for Testability** : Controllability and Observability, **Testing Combinational and Sequential Logic:** Testing combinational logic,Testing sequential logic, Scan Design Techniques, BIST LFSR, BILBO, Self-checking techniques. **(9 Hours)**
Textbooks and Reference books	**Text Books:** 1. Douglas A. Pucknell, Kamran Eshraghian "Basic VLSI Design", Prentice Hall of India, 3rd Edition, reprint 2009. **2.** Design of Analog CMOS Integrated Circuits by Behzad Razavi, McGraw Hill, 2003. **Reference Books:** 1. Weste & Eshraghian, "Principles of CMOS VLSI Design: A systems Perspective", Addison Wesley, 2nd Edition, 2008. 2. John P. Uyemura, "Introduction to VLSI Circuits and Systems", John Wiley & Sons, Reprint 2009. 3. Allen, Phillip E, Holberg, Douglas R," CMOS Analog Circuit Design" Oxford University Press, USA, 2011.
E-resources and other digital material	1. https://www.cdac.in/index.aspx?id=DVLSI_modules&courseid=20 2. https://nptel.ac.in/courses/117106030 3. The domain certification for VLSI: https://vlsiresources.com/nptel/

24EC302 : ANTENNA & WAVE PROPAGATION

Course Category:	PC9	Credits:	3
Course Type:	Theory	Lecture -Tutorial-Practice:	3-0-0
Prerequisites:	24EC207: EM Waves & Transmission Lines	Continuous Evaluation: Semester end Evaluation: Total Marks:	40 60 100

Course outcomes	Upon successful completion of the course, the student will be able to:														
	CO1	Analyze the propagation characteristics of rectangular waveguide.													
	CO2	Quantify the antenna performance by evaluating its parameters such as directivity, gain, and polarization.													
	CO3	Apply Maxwell's equations and potential functions to determine the radiation characteristics of current elements and dipoles.													
	CO4	Design and analyze the performance characteristics of antenna arrays and practical antennas.													
	CO5	Interpret the performance behavior of EM wave propagation mechanisms (Ground, Sky, and Space waves) and their interaction with the Ionosphere.													
		Program Outcomes (POs)											**Program Specific Outcomes (PSOs)**		
Contribution of Course Outcomes towards achievement of Program Outcomes (1 - Low, 2 - Medium, 3 - High)	**Course Outcomes**	1	2	3	4	5	6	7	8	9	10	11	1	2	3
	CO1	3	2	1	1	1	1	1	1	1	2	1	1	2	2
	CO2	3	3	1	1	1	1	1	1	1	2	1	1	2	2
	CO3	3	3	1	2	1	1	1	1	1	2	1	1	2	2
	CO4	3	3	2	2	1	1	1	1	1	3	1	1	3	2
	CO5	3	3	3	3	1	1	1	1	1	3	1	1	3	2
Course Content	**UNIT – I RECTANGULAR WAVEGUIDES:** Transverse Magnetic Waves, Transverse Electric Waves, Impossibility of TEM Waves in Hollow Waveguides, Wave Impedance and Characteristic Impedance, Attenuation factor and Q Factor. **(9 Hours)**														

	UNIT – II ANTENNA PARAMETERS: Introduction, Radiation pattern, Isotropic, Directional, Omni-directional patterns, Principle patterns, Radiation pattern lobes, field regions, Radian and Steradian, Radiation power density, Radiation intensity, Directivity, Directional patterns, Power gain, Antenna efficiency Half power Beam width, beam efficiency, band width, Antenna polarization, Polarization loss factor and efficiency, input impedance, radiation efficiency, Effective aperture(area) of antenna, Relation between maximum effective aperture and directivity, Friss transmission equation. **(9 Hours)** **UNIT – III RADIATION MECHANISM :** Potential functions-heuristic approach, Maxwell's equation approach, Potential functions for sinusoidal oscillations, Alternating current element, Power radiated by current element, Application to short antennas, Assumed current distribution, Radiation from quarter wave Monopole / half wave dipole. **(9 Hours)** **UNIT – IV DESIGN OF ARRAYS & PRACTICAL ANTENNAS:** Two element array, Linear arrays: N-Element linear array: Uniform amplitude and spacing, broad side array, Ordinary end fire array, Multiplication of patterns, Binomial array, Folded Dipole,Yagi-Uda array, Horn antennas, Helical antenna, parabolic reflector. **(9 Hours)** **UNIT – V WAVE PROPAGATION:** Ground Wave Propagation, Space Wave Propagation: Field Strength Relation, Super Refraction, Troposphere Propagation. Sky Wave Propagation: Structural details of the Ionosphere, Wave propagation Mechanism, Refraction and Reflection of Sky waves by Ionosphere. **(9 Hours)**
Textbooks and Reference books	**Text Books:** 1. E.C. Jordan & K.G. Balmain, Electromagnetic waves & Radiating Systems, PHI, 2nd Edition, 2015. 2. Antenna Theory: Analysis and Design – Constantine A. Balanis, John Wiley & Sons, 4 th Ed., 2016. **Reference Books:** 1. John D. Kraus, Antennas, 4 th Edition, McGraw Hill, 2016. 2. R.E. Collins, Antennas and Radiowave Propagation, Singapore: McGraw Hill, 2013.
E-resources and other digital material	1. https://nptel.ac.in/courses/108105114 2. https://nptel.ac.in/courses/108104130 2. 3. http://digimat.in/nptel/courses/video/108104130/L26.html

24EC360 A : Introduction to Embedded Systems

Course Category:	**IE**	**Credits:**	**3**
Course Type:	**Theory**	**Lecture -Tutorial-Practice:**	**3-0-0**
Prerequisites:	**Microcontrollers**	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	**40** **60** **100**

Course outcomes	Upon successful completion of the course, the student will be able to:	
	CO1	Understand the basics of embedded systems, their hardware components, and design process.
	CO2	Understand different memory types, memory hierarchy and the role of the Memory Management Unit (MMU) in embedded systems
	CO3	Analyze timers, interrupts and ISR mechanisms concepts in embedded systems.
	CO4	Illustrate the communication protocols, and I/O interfacing.
	CO5	Analyze real-time design examples and case studies of embedded systems

		Program Outcomes (POs)											(PSOs)		
Contribution of Course Outcomes towards achievement of Program Outcomes (1 - Low, 2 - Medium, 3 - High)	**Course Outcomes**	1	2	3	4	5	6	7	8	9	10	11	1	2	3
	CO1	2	2										2	2	
	CO2	1	1										2	2	
	CO3			1									2	2	
	CO4			1	2								2	2	
	CO 5			3	3		2						2	2	

Course Content

UNIT-I

Introduction to Embedded Systems: Embedded systems, processor embedded into a system, embedded hardware units and devices, design process in embedded system, design process and design examples, classification of embedded systems, skill required for an embedded system designer.

(9 Hours)

UNIT-II

Memory: Common memory types, Composing memory, Memory hierarchy and

	Cache, Advanced RAM, Extended Data Out DRAM, Synchronous (S) and Enhanced Synchronous (ES) DRAM, Rambus DRAM (RDRAM), DRAM integration problem, Memory Management Unit (MMU). **(9 Hours)** **UNIT-III** **Timers & Interrupts:** Timers and Counting devices, Watchdog timer**,** Real-time clocks, ISR concept, Interrupt sources, Interrupt servicing mechanism, multiple interrupts, context and the periods for the context switching in interrupts latency and deadline. **(9 Hours)** **UNIT-IV** **Communication Protocols and Interfacing:** I/O types and examples, Serial communication devices, Parallel device ports, Serial communication protocol, Parallel bus device protocols, Parallel port interfacing with- switches and keypad, stepper motor, LCD controller and touchscreen. **(9 Hours)** **UNIT-V** **Design examples and case studies**: Case study of Embedded System Design for Automatic Chocolate Vending Machine (except RTOS concept), Digital camera, Adaptive Cruise Control (ACC) in car and smart card. **(9 Hours)**
Textbooks and Reference books	**Textbooks:** 1. Rajkamal, "Embedded Systems Architecture, Programming and Design", Tata Mc. Graw Hill, 1st edition, Oct 2003. 2. Frank Vahid, Tony Givargis (2005), "Embedded System Design", J Wiley India. **Reference Books:** 1. S. Heath, "Embedded Systems Design", 2nd edition, 2003. 2. K V K K Prasad, "Embedded Real Time Systems: Concepts, Design Programming" Dreamtech Press.
E-resources and other digital material	1. nptel.ac.in/courses/108102045. 2. https://www.ema-eda.com/ema-resources/blog/serial-and-parallel-communication-protocols-for-electronic-devices/

24EC360 B :
INTRODUCTION TO COMMUNICATION ENGINEERING

Course Category:	IE	**Credits:**	3
Course Type:	Theory	**Lecture -Tutorial-Practice:**	3-0-0
Prerequisites:	24MA101: Mathematics-I (Linear Algebra, Series and Calculus) 24MA102: Mathematics-II (Differential Equations and Computational Methods)	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	40 60 100

Course outcomes	Upon successful completion of the course, the student will be able to:	
	CO1	Interpret the electronic communication concept.
	CO2	Describe and Understand various analog modulation schemes.
	CO3	Describe the working of digital modulation and digital transmission.
	CO4	Demonstrate the understanding of wireless communication concept and wireless systems and their evolution.
	CO5	Explain working of various wireless systems and understand wireless standards.

		Program Outcomes (POs)											**Program Specific Outcomes (PSOs)**		
Contribution of Course Outcomes towards achievement of Program Outcomes (1 - Low, 2 - Medium, 3 - High)	**Course Outcomes**	1	2	3	4	5	6	7	8	9	10	11	1	2	3
	CO1	3	3	1	1	1	1	1	1	1	1	1	1	1	1
	CO2	3	3	1	1	1	1	1	1	1	1	1	1	1	1
	CO3	3	3	1	1	1	1	1	1	1	1	1	1	1	1
	CO4	3	3	1	1	1	1	1	1	1	1	1	1	1	1
	CO 5	3	3	1	1	1	1	1	1	1	1	1	1	1	1

Course Content	**UNIT-I** **Introduction to Electronic Communication:** Significance of Human Communication, Communication Systems, Types of Electronic Communication, Modulation and Multiplexing, The Electromagnetic Spectrum, Bandwidth, Gain, Attenuation and decibels, A Survey of Communication Application. **(9 Hours)**

	UNIT-II **Analog Modulation Fundamentals:** Basic Principle of Amplitude Modulation (AM), AM Concepts, Modulation Index and Percentage of Modulation, Amplitude Modulators, Amplitude Demodulators, Basic Principle of Frequency Modulation, Principle of Phase Modulation, Frequency Modulators, Phase Modulators, Frequency Demodulators. **(9 Hours)** **UNIT-III** **Digital Modulation and Digital Transmission:** Digital Transmission of Data, Parallel and Serial Transmission, Data Conversion, Pulse Modulation, Transmitter Fundamentals, Basic Principle of Signal Reproduction, Superheterodyne Receivers, Frequency Conversion, Intermediate Frequency and Images, Noise, Receivers and Transceivers. **(9 Hours)** **UNIT-IV** **Introduction to Wireless Communication Systems:** Evolution of Mobile Radio Communications, Mobile Radio Systems Around the World, Examples of Wireless Communication Systems, Second Generation (2G) Cellular Networks, Third Generation (3G) Wireless Networks, Wireless Local Area Networks (WLANs), Bluetooth and Personal Area Networks (PANs). **(9 Hours)** **UNIT-V** **Wireless systems and standards:** AMPS and ETACS, Global System for Mobile (GSM), CDMA Digital Cellular Standard (IS-95), CT2 Standard for Cordless Telephones, Digital European Cordless Telephone (DECT), PACS — Personal Access Communication Systems, Personal Handyphone System (PHS), Summary of Standards Throughout the World. **(9 Hours)**
Textbooks and Reference books	**Textbooks:** 1. Louis E. Frenzel Jr., "Principles of Electronic Communication Systems", Fourth Edition, Tata McGraw Hill Education Press, 2008. 2. Theodore S. Rappaport, "Wireless Communications- Principles and Practices", Updated 2th Edition, Cambridge University Press, 2002. **Reference Books:** 3. Molisch Andreas F., "Wireless Communications", 2nd Edition, John Wiley and Sons, 2012. 4. Kamilo Feher, "Wireless Digital Communications", 2003, PHI.
E-resources and other digital material	1. http://nptel.ac.in/courses/106106167/ 2. http://nptel.ac.in/courses/117104099/

24EC310 A INFORMATION THEORY AND CODING

Course Category:	**PE**	**Credits:**	**3**
Course Type:	**Theory**	**Lecture -Tutorial-Practice:**	**3-0-0**
Prerequisites:		**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	**40** **60** **100**

Course outcomes	Upon successful completion of the course, the student will be able to:	
	CO1	Explain the fundamental concepts of information theory including entropy and source coding techniques.
	CO2	Analyze discrete memory less channels and determine channel capacity.
	CO3	Apply linear block coding techniques for error detection and correction.
	CO4	Apply cyclic and convolution coding techniques for reliable data transmission.
	CO5	Describe the principles of Turbo and LDPC codes used in modern communication systems

		Program Outcomes (POs)											**PSOs**		
Contribution of Course Outcomes towards achievement of Program Outcomes (1 - Low, 2 - Medium, 3 - High)	**Course Outcomes**	1	2	3	4	5	6	7	8	9	10	11	1	2	3
	CO1	3	2									2	2		
	CO2	3	3		1							2	3		
	CO3	3	3	2	1							2	3		
	CO4	3	2	2	1							2	3		
	CO 5	3	2	1								2	2		

Course Content

UNIT-I

Fundamentals of Information Theory: Introduction, Uncertainty, Information and Entropy, Properties of Entropy, Entropy of Binary Memory Less Source, Source Coding Theorem, Prefix Codes, Huffman Coding, Lempel–Ziv Coding. **(9 Hours)**

UNIT-II

Channel Concepts and Capacity: Discrete Memoryless Channels, Binary Symmetric Channel, Binary Erasure Channel, Mutual Information, Properties of mutual information, Channel Capacity, Channel Coding Theorem. **(9 Hours)**

	UNIT-III **Linear Block Codes:** Introduction to Error Control Coding, Linear Block Codes Design of Code, Syndrome Definition and Properties, Minimum Distance Consideration, Syndrome Decoding, Hamming Codes. **(9 Hours)** **UNIT-IV** **Cyclic and Convolutional Codes:** Cyclic Codes, Polynomial Representation, Generator and Parity-check Matrices, Encoder, Calculation of Syndrome, Convolutional Codes, Code Tree, Trellis and State Diagram. **(9 Hours)** **UNIT-V** **Turbo and LDPC Codes:** Turbo Codes, Performance of Turbo Codes, Turbo Decoding, Low Density Parity Check (LDPC) Codes, Construction of LDPC codes, Minimum Distance of LDPC Codes. **(9 Hours)**
Textbooks and Reference books	**Text Books:** 1. Simon Haykins, "Communication Systems", 4th Edition, John Wiley & Sons Inc. **Reference Books:** 1. Bernard Sklar "Digital Communications-Fundamental and Application" 2nd Edition, PE. 2. John G. Proakis, "Digital Communications", 5th Edition, 2008, TMH. 3. Ranjan Bose, Information Theory, Coding and Cryptography, 2015, 1st Edition, McGraw Hill Education (India) Pvt. Ltd., India.
E-resources and other digital material	1. https://nptel.ac.in/courses/108102117 2. https://nptel.ac.in/courses/117101053

24EC310B: COMPUTER NETWORKS

Course Category:	Program Elective-I	Credits:	3
Course Type:	Theory	Lecture -Tutorial-Practice:	3-0-0
Prerequisites:	None	Continuous Evaluation: Semester end Evaluation: Total Marks:	40 60 100

Course outcomes	Upon successful completion of the course, the student will be able to:	
	CO1	Describe the fundamental concepts of computer networks, reference models, and the physical layer.
	CO2	Apply stop-and-wait and Go-back-N protocols to design data communication links and implement framing techniques.
	CO3	Explain the working principles of medium access control protocols and the Ethernet standard.
	CO4	Analyze network layer design issues, routing algorithms, congestion control mechanisms, and IP addressing schemes.
	CO5	Explain the elements of transport protocols and analyze the functioning of key application layer protocols such as DNS, Email, and WWW.

		Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
Contribution of Course Outcomes towards achievement of Program Outcomes (1 - Low, 2 - Medium, 3 - High)	**Course Outcomes**	1	2	3	4	5	6	7	8	9	10	11	1	2	3
	CO1	3	2	1									2		
	CO2	3	3	2	1								2	1	
	CO3	3	3	1									2		
	CO4	3	3	2	1								2	1	
	CO 5	2	2	1									2		

Course Content	**UNIT-I** **Introduction:** Network Hardware, Network Software, The OSI Reference Model, The TCP/IP Reference Model. **The Physical Layer:** Guided Transmission Media, Wireless Transmission Media **(9 Hours)**

	UNIT-II **The Data Link Layer:** Data Link Layer Design Issues, Error Detection and Correction, Elementary Data Link Protocols, Sliding Window Protocols. **(9 Hours)** **UNIT-III** **Medium Access Control Sub Layer:** Static and Dynamic Channel Allocation, Multiple Access Protocols, ALOHA, CSMA, Collision Free Protocols, Ethernet. **(9 Hours)** **UNIT-IV** **The Network Layer:** Network Layer Design Issues, Routing Algorithms, Congestion Control Algorithms, Internetworking, IPv4, IP Addresses. **(9 Hours)** **UNIT-V** **The Transport Layer:** The Transport Service, Elements of Transport Protocols, The Internet Transport Protocols: UDP, TCP. **Application Layer:** Domain Name System, Electronic Mail, WWW **(9 Hours)**
Textbooks and Reference books	**Text Books:** 1. Andrew S Tanenbaum & David J Wetherall, "Computer Networks", 5th edition, Pearson Education. (Units I,II,III,IV) 2. Behrouz A. Forouzan "Data Communications and Networking". 4th edition, TMH. **Reference Books:** 1. Kurose, J. F., & Ross, K. W. "Computer networking: A top-down approach", 7th edition, Pearson Education. 2. Dimitri Bertsekas and Robert G. Gallager. "Data Networks", 2nd edition, Athena Scientific, 2021
E-resources and other digital material	3. http://home.iitk.ac.in/~navi/sidbinetworkcourse/ 4. https://nptel.ac.in/courses/106105081

24EC310 C Electronic Measurements & Instrumentation

Course Category:	PE	Credits:	3
Course Type:	Theory	Lecture -Tutorial-Practice:	3-0-0
Prerequisites:		Continuous Evaluation: Semester end Evaluation: Total Marks:	40 60 100

Course outcomes	Upon successful completion of the course, the student will be able to:	
	CO1	Measure various electrical parameters using different types of meters and develop a comprehensive understanding of the fundamental definitions of these measurement parameters.
	CO2	Analyze the Instruments for Measuring Basic Parameters.
	CO3	Analyze the bridge circuits for the measurement of resistance, capacitance and inductance.
	CO4	Utilize various types of signal generators and signal analyzers for the generation and real-time analysis of signals and operate an oscilloscope to accurately measure and characterize different signal waveforms.
	CO5	Accurately measure various physical parameters by selecting and utilizing appropriate transducers.

		Program Outcomes (POs)											(PSOs)		
Contribution of Course Outcomes towards achievement of Program Outcomes (1 - Low, 2 - Medium, 3 - High)	**Course Outcomes**	1	2	3	4	5	6	7	8	9	10	11	1	2	3
	CO1	3	3	1	2			1				3	3	2	
	CO2	3	3	1	2			1				3		2	3
	CO3	2	3	1	2			1				3	3		3
	CO4	3	3	1	2			1				3		3	3
	CO 5	3	3	1	2			1				3	3	2	

Course Content

UNIT-I

Basic Electronic Measurement Concepts: Introduction Performance characteristics, Static characteristics, Error in measurement, Types of static errors, Dynamic characteristics, Statistical analysis.

Indicating Instruments:

Ammeters: DC Ammeter, Multi-range Ammeter, Aryton shunt, Requirement of shunt.

Voltmeters: Introduction, Basic meter as DC voltmeter, DC Voltmeter, Multi-

	range Voltmeter, Extending voltmeter ranges, Loading. **(9 Hours)** **UNIT-II** **Instruments for Measuring Basic Parameters**- AC Voltmeters Using Rectifiers, Multi-range AC voltmeters, True RMS voltmeter, Peak responding voltmeters, Average responding voltmeters **Digital Voltmeters**: - Introduction, Ramp Technique, Stair Case Ramp, Integrating type, Continuous Balance DVM, Successive Approximation DVM. **(9 Hours)** **UNIT-III** **Bridges**: Introduction to Bridge Measurements – Wheatstone, Kelvin, Kelvin Double Bridge, Maxwell, Hay, Schering, Wien Bridge, Wager Ground, Resonance Bridge, Andersons Bridge. **(9 Hours)** **UNIT-IV** **Oscilloscopes**: Basic principle of Oscilloscope, Block diagram, Cathode Ray Tube, Application of Oscilloscopes, Dual beam CRO, Dual Trace CRO, Digital Storage Oscilloscope, Sampling Oscilloscope. **Signal Generator**: AF Oscillator, Function Generator, Square and Pulse generator. **Signal Analysis**: Basic Wave Analyzer, Harmonic Distortion Analyzers, Spectrum Analyzer. **(9 Hours)** **UNIT-V** **Transducers**: Introduction , Electrical Transducers, Selecting a Transducer, Resistive Transducers, Strain gauges, Potentiometer, Resistance thermometer, Thermistor, Linear variable differential transducer, Piezoelectric Transducer, Temperature Transducers, Mechanical transducers. **(9 Hours)**
Textbooks and Reference books	**Text Books**: 1. H S Kalsi, "Electronics Instrumentation", Third Edition, Tata McGraw Hill, 2004. (Units I, II, III, IV) **Reference Books:** 1. Albert D. Helfrick and William D .Cooper "Modern Electronic Instrumentation and Measurement Techniques", Prentice Hall of India, 2003. 2. A K Sawahney, "Electrical and Electronics Measurement and Instrumentation", DhanpatRai, 2000.
E-resources and other digital material	1. https://nptel.ac.in/courses/108106070

24EC310 D RISC - V Microcontroller Design and Debugging with JTAG

Course Category:	PE	Credits:	3
Course Type:	Theory	Lecture -Tutorial-Practice:	3-0-0
Prerequisites:		Continuous Evaluation: Semester end Evaluation: Total Marks:	40 60 100

Course outcomes	Upon successful completion of the course, the student will be able to:														
	CO1	Explain RISC-V architecture and basic assembly language programming.													
	CO2	Describe RISC-V machine language representation and instruction formats.													
	CO3	Explain compiling, assembling, linking, loading, and RISC-V architectural features.													
	CO4	Analyze single-cycle and multicycle processor microarchitectures.													
	CO5	Explain pipelined and advanced processor microarchitectures.													
		Program Outcomes (POs)											**(PSOs)**		
Contribution of Course Outcomes towards achievement of Program Outcomes (1 - Low, 2 - Medium, 3 - High)	**Course Outcomes**	1	2	3	4	5	6	7	8	9	10	11	1	2	3
	CO1	3	2	1	1	1	1	1	1	1	2	1	1	2	2
	CO2	3	3	1	1	1	1	1	1	1	2	1	1	2	2
	CO3	3	3	1	2	1	1	1	1	1	2	1	1	2	2
	CO4	3	3	2	2	1	1	1	1	1	3	1	1	3	2
	CO 5	3	3	3	3	1	1	1	1	1	3	1	1	3	2
Course Content	**UNIT-I: Architecture and Basic Assembly Language Programming** Introduction, Assembly Language, Instructions, Operands: Registers, Memory, and Constants, Programming, Program Flow, Logical, Shift, and Multiply Instructions, Branching, Conditional Statements **(9 Hours)** **UNIT-II: Advanced Assembly Programming and Machine Language** Getting Loopy, Arrays, Function Calls, Pseudoinstructions, Machine Language, R-Type Instructions, I-Type Instructions, S/B-Type Instructions, U/J-Type Instructions, Immediate Encodings, Addressing Modes, Interpreting Machine Language Code, The Power of the Stored Program **(9 Hours)**														

	UNIT-III: Compiling, Assembling, Loading and Microarchitecture Foundations Lights, Camera, Action: Compiling, Assembling, and Loading, The Memory Map, Assembler Directives, Compiling, Assembling, Linking, Loading, Odds and Ends, Endianness, Exceptions, Signed and Unsigned Instructions, Floating-Point Instructions, Compressed Instructions, Evolution of the RISC-V Architecture, RISC-V Base Instruction Sets and Extensions, Comparison of RISC-V and MIPS Architectures, Comparison of RISC-V and ARM Architectures, Introduction, Architectural State and Instruction Set, Design Process, Microarchitectures, Performance Analysis **(9 Hours)** **UNIT-IV: Processor Microarchitecture Basics** Single-Cycle Processor, Sample Program, Single-Cycle Datapath, Single-Cycle Control, More Instructions, Performance Analysis, Multicycle Processor, Multicycle Datapath, Multicycle Control, More Instructions, Performance Analysis **(9 Hours)** **UNIT-V: Advanced Processor Microarchitecture** Pipelined Processor, Pipelined Datapath, Pipelined Control, Hazards, Performance Analysis, HDL Representation, Single-Cycle Processor, Generic Building Blocks, Testbench, Advanced Microarchitecture, Deep Pipelines, Micro-Operations, Branch Prediction, Superscalar Processors, Out-of-Order Processor, Register Renaming, Multithreading, Multiprocessors, Real-World Perspective: Evolution of RISC-V Micro architecture **(9 Hours)**
Textbooks and Reference books	**Textbooks:** 1. Sarah L. Harris and David Harris, Digital Design and Computer Architecture: RISC-V Edition, Elsevier, 2022. 2. David A. Patterson and John L. Hennessy, Computer Organization and Design: RISC-V Edition, Morgan Kaufmann, 2021. **Reference Books:** 1. John L. Hennessy & David A. Patterson, Computer Architecture: A Quantitative Approach, Elsevier. 2. Michael D. Ciletti, Advanced Digital Design with the Verilog HDL, Pearson.
E-resources and other digital material	1. https://nptel.ac.in 2. https://riscv.org 3. https://godbolt.org

24EC310 E EMBEDDED SYSTEMS & RTOS

Course Category:	Program Elective-1	**Credits:**	3
Course Type:	Theory	**Lecture - Tutorial -Practice:**	3-0-0
Prerequisites:	Microcontrollers	**Continuous Evaluation:**	40
		Semester end Evaluation:	60
		Total Marks:	100

Course outcomes	Upon successful completion of the course, the student will be able to:														
	CO1	Understand the basics of Embedded systems													
	CO2	Demonstrate Embedded systems and its application													
	CO3	Apply concepts of Real Time Operating System to develop Embedded system													
	CO4	Develop concurrent processes for Real time systems													
	CO5	Evaluate the Message queues, Pipes, event registers, signals and other building blocks.													
		Program Outcomes (POs)											**PSOs**		
Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3 – High)		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
	CO1	3					3				3				3	2
	CO2	3					3				2				3	2
	CO3	3	2								2				3	2
	CO4	3	2	2							2				3	2
	CO5	3	2	2							2				3	2

Course Content

UNIT-I

Introduction to Embedded Systems

Common Design Metrics, Processor technology, IC technology,
Real Life Examples of Embedded Systems, Real- Time Embedded Systems.
(9Hrs)

UNIT-II

Embedded System Initialization - Target System Tools and Image Transfer, Target Boot Scenarios, Target System Software Initialization Sequence, On- Chip Debugging. **(9 Hrs)**

UNIT-III

Introduction to Real-Time Operating Systems –History, defining an RTOS, the

	scheduler- Schedulable Entities- Multi Tasking- Context Switching- Dispatcher- Scheduling Algorithms, Kernel Objects, Key characteristics of an RTOS. **(9Hrs)** **UNIT-IV** **Task**- Defining a Task, Task States and Scheduling- Ready State- Running State- Blocked State. **Semaphores-**Defining Semaphores- Binary Semaphores- Counting Semaphores- MUTEX: Ownership- Recursive Locking- Task Deletion Safety- Priority Inversion Avoidance, Deadlock situation between two tasks. **(9Hrs)** **UNIT-V** **Message Queues -** Defining Message Queues, Message Queue States, Message Queue Content, Message Queue Storage **Pipes**- Pipe Control Blocks- Pipe States- Named and Unnamed Pipes **Event Registers**- Event Register Control Block, **Signals**- Signal Control Blocks. **(9Hrs)**
Text books and Reference books	**Text Books:** 1. Frank Vahid, Tony Givargis (2005), "Embedded System design" Wiley India. (Unit I) 2. Qing Li, Caroline Yao (2003), "Real-Time Concepts for Embedded Systems", CMP Books. (Unit II,III &IV) **Reference Books:** 1. Albert Cheng, (2002), "Real-Time Systems: Scheduling, Analysis and Verification", Wiley Interscience. 2. Hermann Kopetz, (1997), "Real-Time Systems: Design Principles for Distributed Embedded Applications", Kluwer. 3. Insup Lee, Joseph Leung, and Sang Son, (2008) "Handbook of Real-Time Systems", Chapman and Hall.
E-resources and other digital material	1. https://nptel.ac.in/courses/106105036/ 2. https://www.udemy.com/courses/search/?src=ukw&q=rtos 3. https://www.coursera.org/lecture/real-time-systems/rtos-overview-RIAFe

24EC383 DIGITAL SIGNAL PROCESSING LAB

Course Category:	Program Core	**Credits:**	1.5
Course Type:	Lab	**Lecture - Tutorial -Practice:**	0-0-3
Prerequisites:	Signals & Systems Digital Signal Processing	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	40 60 100

Course Outcomes	Upon successful completion of the course, the student will be able to:	
	CO1	Design and analyze various DSP Algorithms for signal and image processing applications using MATLAB Software.
	CO2	Implement DSP algorithms using Code Composer Studio with TMS320C67XX floating point Processor.

	Program Outcomes (POs)												PSOs		
Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3– High)		1	2	3	4	5	6	7	8	9	10	11	1	2	3
	CO1	2			2	3				3	1	2			3
	CO2	2			2	3				3	1	2			3

Course Content

List of Experiments using MATLAB:

1. Computation of DFT using DIT FFT algorithm.
2. Computation of DFT using DIF FFT algorithm.
3. Design of Butterworth and Chebyshev digital IIR filters using Impulse Invariance method
4. Design of Butterworth and Chebyshev digital IIR filters using Bilinear transformation method.
5. Design of digital FIR filters using windowing techniques.
6. Decimation and Interpolation of a discrete time sequence.
7. Power spectrum estimation of the discrete time signal.
8. Image enhancement and smoothing operations
9. Feature extraction from 1D and 2D signals
10. Image edge detection using various operators

List of Experiments using Code Composer Studio:

11. Compute the N-point DFT of a given sequence
12. Implement and verify linear and circular convolution of two sequences

	Course-based Projects 1) Design of IIR digital filter for filtering out female voice from a signal consists of both male and female voices together. 2) For a given input signal and a moving average filter, analyze the filtered output signal showing spectrum of it. Compute energy content of the filtered signal and compare it with actual energy content of the input signal.
Text books and Reference books	**Text Books:** 1. John G. Proakis, & Dimitris G. Manolakis, "Digital Signal Processing : Principles, Algorithms and Applications", 4th Edition, 2007, Prentice-Hall of India Private Limited, 2. Oppenheim, Alan V., Ronald W. Schafer, and John R. Buck. Discrete-time signal processing, 2nd edition, Pearson Education. **Reference Books:** 1. Ifeacher E.C. & Jervis B.W, "Digital Signal Processing, A Practical Approach", 3rd edition, 2003, Addison Wesley. 2. Lonnie C Ludeman, "Fundamentals of Digital Signal Processing", John Wiley & Sons, 2003. 3. S K Mitra, "Digital Signal Processing: A Computer Based Approach", 2nd edition, 2003, TMH.
E-resources and other digital material	1. Virtual Labs: http://vlabs.iitkgp.ac.in/dsp/# 2. NPTEL Course: Digital Signal Processing, IIT Delhi, Prof. S. C DuttaRoyhttps://nptel.ac.in/courses/117102060

24EC384: VLSI DESIGN LAB

Course Category:	Program Core	**Credits:**	1.5
Course Type:	Practical	**Lecture - Tutorial -Practice:**	0-0-3
Prerequisites:	24EC5XX: DCD Lab	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	60 40 100

Course Outcomes	Upon successful completion of the course, the student will be able to:													
	CO1	Design, synthesize and analyze Digital Circuits using Verilog HDL.												
	CO2	Design combinational and sequential circuits at circuit level, verify DC and transient analysis.												
Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3 - High)		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO1	PSO2
	CO1			2	3	2						2	2	
	CO2			2	3	2						2	2	
Course Content	**PART-A**: Design, Simulate, Synthesize the following experiments using Verilog HDL(Minimum 5) 1. 4-bit Ripple carry adder 2. 8 to 3 Priority Encoder 3. 8-bit parity generator and checker 4. Modulo-N up-down counter 5. Universal Shift register 6. 16-Bit ALU with 8 Arithmetic Operations, 4 Logic Operations and 2 Shift Operations 7. 4-bit Magnitude Comparator 8. Sequence detector using FSM. **PART-B:** Design circuits using the flow of the Full Custom IC design cycle at schematic level using CMOS logic (Minimum 5) **Note:** Develop layout and perform LVS and DRC for any two circuits 1. An Inverter 2. 2-input NAND Gate Design 3. 2-input XOR Gate Design 4. A Full adder design 5. A Latch Design 6. 4-bit Gray to Binary code Converter 7.Differential amplifier 8.Common Source Amplifier													

	*Course based Projects: Design and simulation of 1. PLL 2. Two-Stage CMOS Opamp Design

NB: Eligibility for External Practical Examination:

1. A minimum of 10(Ten) experiments have to be performed and recorded by the candidate.
2. Execute and submit a course-based project

Semester - VI

S.No	Course Code	Course Category	Course Name	L	T	P	Credits
1	24EC304	PC	Linear Control Systems	3	0	0	3
2	24EC305	PC	Digital System Design using PLDs	3	0	0	3
	24EC306	PC	Microwave & Optical Communications	2	0	0	2
3	24EC370	IE	Inter disciplinary Elective – 2 (Basket of courses from other engineering departments) A. Digital Image Processing B. Quantum Communications C. Wireless Communications D. Digital Design and RISC-V Architectures	3	0	0	3
4	24EC320	PE	**Professional Elective -2** A. Cellular & Mobile Communications B. Smart Antenna C. Image & Video Processing D. Analog IC Design E. Embedded C	3	0	0	3
			F. Systems Thinking and Systems Engineering	2	0	2	
5	24EC330	PE	**Professional Elective -3** A. RADAR Engineering B. Introduction to Machine Learning C. Semiconductor Device Modeling D. DSP Processors & Architectures	3	0	0	3
			E. QNX RTOS	2	0	2	
			F. Internet of Things	2	0	2	
6	24EC386	PC	Digital System Design using PLDs Lab	0	0	3	1.5
7	24EC387	PC	Microwave & Optical Communications Lab	0	0	3	1.5
8	24EN381	HS	Advanced communication skills	0	0	2	1
9	24EC383	PC	Skill Course-II (Program specific) A. Applications of Machine Learning in Real Time B. ARM Development: Emphasis on Communication and External peripherals C. Switching Routing and Wireless Essentials using Cisco Networking Academy D. System Verilog for Verification E. Data Analytics	0	0	2	1
10	24UC301	MC	Constitution of India	2	0	0	0
			Total				**22**
			Minor/Honours Courses (Optional)	4	0	0	**4**
			Minor/Honours Courses (Optional)		0	2	**1**

24EC304 : LINEAR CONTROL SYSTEMS

Course Category:	PC	**Credits:**	3
Course Type:	Theory	**Lecture - Tutorial -Practice:**	3-0-0
Prerequisites:	24EC203: Signals & Systems	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	40 60 100

Course outcomes	Upon successful completion of the course, the student will be able to:	
	CO1	Explain the basic concepts of control systems and formulate mathematical models of electrical and mechanical systems.
	CO2	Determine transfer functions and analyse control systems using block diagrams, signal flow graphs and time-domain response characteristics.
	CO3	Analyze the time-domain performance and stability of control systems using steady-state error, second-order response characteristics and the Routh–Hurwitz criterion.
	CO4	Analyse the relative stability and frequency response of control systems using root-locus and Bode plot techniques.
	CO5	Analyze control systems using state-space representations and determine their controllability and Observability.

		Program Outcomes (POs)											**Program Specific Outcomes (PSOs)**		
Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3– High)		1	2	3	4	5	6	7	8	9	10	11	1	2	3
	CO1	3	2									1	2		
	CO2	3	3	2		1						1	3	1	
	CO3	3	3	2	1							1	2	1	
	CO4	3	3	2	1	1						1	2	1	
	CO5	3	3	2	1	1						1	2	2	

Course Content	**UNIT I: Introduction and Mathematical Modelling** **Introduction:** Basic Components of a Control System, Examples of Control System Applications, Open Loop Control Systems, Closed Loop Control Systems, Effect of Feedback on System Parameters. **Mathematical Modeling of Physical Systems:** Introduction, Equations of Electric Networks, Modeling of Mechanical System Elements. **(09 Hrs)**

	UNIT II: Transfer Functions and Block Diagrams Impulse Response and Transfer Functions of Linear Systems, Block Diagrams, Signal Flow Graphs. **Time Domain Analysis of Control Systems:** Time Response of Continuous Data Systems, Typical Test Signals for the Time Response of Control Systems, Steady State Error. **(09 Hrs)** **UNIT III: Time Response and Stability** Unit Step Response and Time Domain Specifications, Transient Response of Prototype Second Order System, Effect of Adding Poles and Zeros to Transfer Functions, Dominant Poles of Transfer Function. **Stability of Linear Control Systems:** Introduction Bounded Input – Bounded Output Stability, Methods of Determining Stability: Routh-Hurwitz Criterion, Special Cases When Routh's Tabulation Terminates Prematurely. **(09 Hrs)** **UNIT – IV: Root Locus and Frequency-Domain Analysis** **Root-Locus Technique:** Introduction, Basic Properties of the Root Loci, Properties and Construction of the Root Loci, Some Important Aspects of the Construction of the Root Loci. **Frequency-Domain Analysis:** Introduction, M_r, , W_r, Bandwidth of the Prototype Second-Order System, Relative Stability, Stability Analysis with the Bode Plot. (**09 Hrs)** **UNIT – V: State-Variable Analysis** **State Variable Analysis**: Introduction, State Transition Matrix, State Transition Equation, Relation Between State Equations and Transfer Functions, Characteristic Equation, Eigen Values and Eigen Vectors, Controllability of Linear Systems, Observability of Linear Systems, Relationship among Controllability, Observability and Transfer Functions. **(09 Hrs)**
Text books and Reference books	**Text Books:** 1. Benjamin C. Kuo, "Automatic Control Systems", 7th edition, PHI, 2013. **Reference Books:** 1. J Nagrath& M Gopal, "Control Systems Engineering", 3rd edition, New Age International, 2003. 2. K Ogata, Modern Control Engineering, 4th edition, Pearson Education, 2003.
E-resources and other digital material	1. https://ed.iitm.ac.in/~shankarram/Course_Files/ED2040/ED2040.html 2. https://onlinecourses.nptel.ac.in/noc20_ee90/preview 3. https://ed.iitm.ac.in/~shankarram/Course_Files/ED2040/ED2040.html

24EC305 :DIGITAL SYSTEM DESIGN USING PLDs

Course Category:	PC	**Credits:**	**3**
Course Type:	Theory	**Lecture -Tutorial-Practice:**	**3-0-0**
Prerequisites:	24EC202: Digital Circuit Design	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	**40** **60** **100**

Course outcomes	Upon successful completion of the course, the student will be able to:	
	CO1	Analyze hazards and timing characteristics of digital circuits and develop RTL models using Verilog HDL.
	CO2	Explain FPGA architectures, programming technologies and FPGA logic implementation techniques.
	CO3	Design arithmetic digital systems using Verilog RTL modeling.
	CO4	Analyze FPGA synthesis, technology mapping, placement, routing and resource utilization.
	CO5	Design digital controllers and interfacing circuits using Verilog HDL.

		Program Outcomes (POs)											**Program Specific Outcomes (PSOs)**		
Contribution of Course Outcomes towards achievement of Program Outcomes (1 - Low, 2 - Medium, 3 - High)	**Course Outcomes**	1	2	3	4	5	6	7	8	9	10	11	1	2	3
	CO1	3	3	2	1	2	-	-	-	-	-	-	2	-	-
	CO2	3	2	-	-	-	-	-	-	-	-	-	2	-	-
	CO3	3	3	3	-	2	-	-	-	-	-	-	3	-	-
	CO4	3	3	2	2	3	-	-	-	-	-	-	3	-	-
	CO5	3	2	3	-	2	-	-	-	-	-	-	3	-	-

Course Content

UNIT-I: Hazards, Sequential Circuit Timing and Verilog HDL (8 Periods)
Sequential Circuit Timing: Propagation delay, setup time, hold time, clock skew and maximum operating frequency. Introduction to Verilog HDL: Computer-aided design, hardware description languages, Verilog description of combinational circuits, modules, continuous and procedural assignments, modeling flip-flops using always blocks, event-control statements, compilation, simulation and synthesis of Verilog code.

UNIT-II: FPGA Architecture and Logic Implementation (9 Periods)
Field Programmable Gate Arrays: FPGA organization, FPGA programming technologies, programmable logic block architectures, look-up tables (LUTs),

	programmable interconnections, programmable input/output blocks and FPGA design flow. FPGA Logic Implementation: Implementing functions in FPGAs, Shannon's decomposition, carry chains and cascade chains. FPGA Architectural Resources: Examples of logic blocks in commercial FPGAs, dedicated memory and dedicated multipliers. **UNIT-III: RTL Design of Arithmetic Digital Systems (10 Periods)** Verilog RTL Modeling: Verilog data types and operators, behavioral and structural modeling, modeling registers and counters using Verilog always statements. Arithmetic Digital System Design: 32-bit adders, shift-and-add multiplier, array multiplier. **UNIT-IV: FPGA Synthesis and Implementation (10 Periods)** FPGA Design Considerations: Cost of programmability, one-hot state assignment, FPGA capacity: maximum gates versus usable gates. FPGA Design Translation: Logic synthesis, combinational and sequential synthesis, FPGA-oriented logic optimization. FPGA Design Implementation: Technology mapping, placement and routing. FPGA Implementation Analysis: Resource utilization, timing analysis and interpretation of synthesis and implementation reports. **UNIT-V: FPGA-Based Control Systems and Applications (8 Periods)** Digital System Controllers: Traffic light controller, state graphs for control circuits, scoreboard and controller. System Interfacing: Synchronization and debouncing, keypad scanner.
Textbooks and Reference books	**Textbook (single prescribed textbook):** 1. Charles H. Roth Jr., Lizy Kurian John and Byeong Kil Lee, Digital Systems Design Using Verilog, Cengage Learning, First Edition.
E-resources and other digital material	1. https://nptel.ac.in/courses/117108040/ 2. https://ocw.mit.edu/courses/6-111-introductory-digital-systems-laboratory-spring-2006/ 3. https://www2.eecs.berkeley.edu/Courses/EECS151/

24EC306 :MICROWAVE AND OPTICAL COMMUNICATIONS

Course Category:	Program Core	**Credits:**	2
Course Type:	Theory	**Lecture - Tutorial -Practice:**	2-0-0
Prerequisites:	Electromagnetic field theory	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	40 60 100

Course Outcomes	Upon successful completion of the course, the student will be able to:	
	CO1	Analyze and evaluate the operating principles, performance characteristics, and applications of microwave amplifiers and oscillators. Applications
	CO2	Evaluate the performance of microwave components and measurement techniques based on their operating characteristics and application requirements.
	CO3	Analyze and compare the operating characteristics and performance of different microwave solid-state devices for specific applications.
	CO4	Analyze and evaluate the characteristics of optical fibers, including propagation modes, attenuation, and dispersion, to determine their impact on optical signal transmission.
	CO5	Design and evaluate optical transmitters, receivers, and amplifiers to meet the performance requirements of optical communication systems.

Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3 – High)		**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PSO 1**	**PSO 2**
	CO1	3	2		2	3							3	
	CO2	3	2		3	3							3	
	CO3	3	2		3	3							3	
	CO4	3	3	2	3	3							3	
	CO5	3	3	2	3	3							3	

Course Content

UNIT I

Microwave Amplifiers and Oscillators

Two-cavity Klystron: Velocity Modulation, Output Power and Beam Loading, Reflex Klystron: Velocity Modulation, Power Output and Efficiency, Helix Traveling Wave Tube Amplifiers- principle of operation, Cylindrical Magnetron, π-mode oscillations**.**

(9 Hrs)

	UNIT II **Microwave Components** Basic properties of three port and four port components, Directional coupler – E plane Tee, H- plane Tee – Magic Tee – Circulators – Isolators – Attenuators –Phase Shifters. **(9 Hrs)** **UNIT III** **Microwave solid-state devices** Tunnel diodes, Varactor Diode, PIN diode, Gunn Diode, IMAPATT, TRAPATT Diodes **Microwave Measurements**: Power Measurement, Insertion loss and Attenuation Measurements, Impedance Measurement, VSWR **(9 Hrs)** **UNIT IV** **Introduction to Optical Fibers and Transmission Characteristics** The propagation of light in optical waveguides – Classification of optical fibers – Numerical aperture, Step index and Graded index fiber – Modes in cylindrical fiber – Linearly polarized modes, Attenuation: Absorption, Scattering, Bending losses. Modal dispersion and chromatic dispersion – Single mode fiber -waveguide dispersion– MFD – PMD. **(9 Hrs)** **UNIT V** **Optical Transmitters and Receivers** Optical Sources: - Light source materials – LED homo and hetero structures – surface and edge emitters –Quantum efficiency. Optical detectors: – Physical principles – PIN and APD diodes – Photo detector noise **(9 Hrs)**
Text books and Reference books	**Text Books:** 1. Samuel Y. Liao, "Microwave Devices and Circuits", 3rd edition, Pearson education, 2011 reprint. (Unit I, II, III) 2. Keiser G, "Optical Fiber Communication Systems", 4th edition, Tata McGraw Hill. Edition, 2010. (Unit IV, V) **Reference Books:** 1. Collin.R.E, "Foundations for Microwave Engineering", 2nd edition, Tata McGraw Hill, 2006. 2. Djafar.K. Mynbaev Lowell and Scheiner, "Fiber Optic Communication Technology", Pearson Education Asia, 9th impression, 2011
E-resources and other digital material	1. https://www.microwaves101.com/encyclopedias/klystrons 2. https://www.microwaves101.com/encyclopedias/traveling-wave-tubes 3. https://www.rfwireless-world.com/Tutorials/Gunn-diode-oscillator.html 4. https://www.microwaves101.com/encyclopedias/directional-couplers 5. https://www.rfcafe.com/references/electrical/microwave-isolators-circulators.htm

24EC370 A : DIGITAL IMAGE PROCESSSING

Course Category:	Interdisciplinary Elective -2	**Credits:**	3
Course Type:	Theory	**Lecture -Tutorial-Practice:**	3 – 0 – 0
Prerequisites:	Signals and Systems Digital Signal Processing	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	40 60 100

Course outcomes	Upon successful completion of the course, the student will be able to:	
	CO1	Explain the fundamentals of digital image formation, acquisition, sampling, quantization, and pixel relationships.
	CO2	Apply intensity transformations, spatial-domain and frequency-domain techniques for image enhancement.
	CO3	Analyze color image processing techniques for enhancement, segmentation, noise reduction, and compression.
	CO4	Apply image restoration techniques to remove noise and recover degraded images.
	CO5	Implement morphological operations and image segmentation techniques to extract and analyze objects and regions in digital images.

		Program Outcomes (POs)											(PSOs)		
Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, – High)	**Course Outcomes**		2	3	4	5	6	7	8	9	10	11	1	2	3
	CO1	3	2			1							3	1	
	CO2	3	3	2	2	3					2		3	2	
	CO3	3	2	2	2	2					2		3	2	
	CO4	3	3	2	3	2							3	2	
	CO 5	3	3	3	2	3							3	2	

Course Content

UNIT-I

Digital Image Fundamentals: Origin of Digital Image Processing. Components of an Image Processing System. Elements of visual perception. Image sensing and acquisition. Image sampling and quantization. Some Basic relationships between pixels. Mathematical tools used in Digital Image Processing.

(9 Hrs)

UNIT-II

Intensity Transformations and Spatial Filtering: Fundamentals of spatial-

	domain processing. Basic intensity transformation functions. Histogram processing. Smoothing spatial filters. Sharpening spatial filters. Combining Spatial Enhancement Methods. **Filtering in the Frequency Domain:** Sampling and the Fourier transform of sampled functions. Discrete Fourier Transform (DFT) of one variable and two-variables. Properties of the 2-D DFT and inverse DFT. Basics of filtering in the frequency domain filters. Image smoothing using low-pass filters. Image sharpening using high-pass filters. Selective filtering. Fast Fourier transform. **(9 Hrs)** **UNIT-III** **Color Image Processing:** Color Fundamentals. Color Models. Pseudocolor Image Processing. Basics of Full-Color Image Processing. Color Transformations. Color Image Smoothing and Sharpening. Using Color in Image Segmentation. Noise in Color Images. Color Image Compression. **UNIT-IV** **Image Restoration and Reconstruction:** A model of Image Degradation /Restoration process. Noise models. Restoration in the presence of noise only using spatial filters. Periodic noise reduction using frequency-domain filtering. Linear, position-invariant degradations. Estimating degradation function. Inverse filtering. Minimum mean-square-error (Wiener) filtering. Constrained least-squares filtering. Geometric mean filter. Image reconstruction from projections. **(9 Hrs)** **UNIT-V** **Image Segmentation**: Fundamentals of Image Segmentation. Point, Line, and Edge Detection. Segmentation by Region Growing and by Region Splitting and Merging, Region Segmentation Using Clustering and Super pixels, Region Segmentation Using Graph Cuts. The use of motion in segmentation. **(9 Hrs)**

Textbooks and Reference books	**Textbooks:** 1. Rafael C. Gonzalez and Richard E. Woods, "Digital Image Processing", 4th Edition, Pearson, 2018. **Reference Books:** 2. S. Jayaraman, S. Esakkirajan and T. Veerakumar, "Digital Image Processing", 2nd Edition, McGraw Hill Education, 2020 3. Munesh Chandra Trivedi and Dr. Sanjay M. Shah, "Digital Image Processing", Khanna Publishing House, 2026. 4. Rafael C. Gonzalez, Richard E. Woods and Steven L. Eddins, "Digital Image Processing Using MATLAB", 2nd Edition, McGraw-Hill Education, 2010. 5. Dr. Manish Kashyap, "Digital Image Processing Using Python", BPB Publications, 2025.
E-resources	https://nptel.ac.in/courses/117105135

24EC370 B : QUANTUM COMMUNICATIONS

Course Category:	Interdisciplinary Elective–2	**Credits:**	3
Course Type:	Theory	**Lecture - Tutorial -Practice:**	3-0-0
Prerequisites:	Basic Engineering Physics and Mathematics	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	40 60 100

Course Outcomes		Upon successful completion of the course, the student will be able to:													
	CO1	Describe the fundamental principles of classical communication systems and binary information representation.													
	CO2	Interpret quantum states, superposition, measurement and entanglement using basic quantum mechanical concepts.													
	CO3	Apply basic quantum gates to represent and manipulate qubit states in simple quantum circuits.													
	CO4	Illustrate the working principles of superdense coding and quantum teleportation protocols.													
	CO5	Analyze the principles of quantum key distribution and emerging applications of quantum communication.													
Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3– High)		**Program Outcomes (POs)**											**PSOs**		
		1	2	3	4	5	6	7	8	9	10	11	1	2	3
	CO1	3	2	–	–	1	–	–	–	–	1	–	2	1	1
	CO2	3	2	–	1	1	–	–	–	–	–	–	1	1	2
	CO3	3	3	–	2	2	–	–	–	–	1	–	2	2	2
	CO4	3	3	1	2	2	–	–	–	–	1	–	3	2	2
	CO5	2	2	–	1	2	1	1	1	–	1	–	2	2	3
Course Content		**UNIT I: FUNDAMENTALS OF CLASSICAL COMMUNICATION** **Introduction to Classical Communication:** Communication process, Basic elements of communication systems , Analog and digital communication, Signals and noise, Introduction to analog-to-digital conversion, Classical bits and binary information representation, Need for secure communication. **(9 Hrs)** **UNIT II: FUNDAMENTALS OF QUANTUM MECHANICS** Introduction to complex numbers ,Vectors and basic operations, Bra-ket notation, Quantum states, Superposition principle, Dirac Notation, Quantum														

		measurement, Quantum entanglement and its significance, **(9 Hrs)** **UNIT III: QUANTUM INFORMATION AND QUBIT SYSTEMS** Quantum Information and Qubit Systems: Introduction to quantum gates, Single-qubit gates: Pauli-X, Pauli-Y, Pauli-Z, and Hadamard gates ,Two-qubit gates: CNOT gate, No-cloning theorem. **(9 Hrs)** **UNIT IV: QUANTUM COMMUNICATION PROTOCOLS** Introduction to Quantum Communication ,Classical and Quantum Channels, Bell Circuits, Superdense Coding, Quantum Teleportation **(9 Hrs)** **UNIT V: QUANTUM CRYPTOGRAPHY AND APPLICATIONS** Introduction to Quantum Cryptography ,Quantum Key Distribution (QKD), Recent Advances: quantum internet, Challenges and future trends in Quantum Communication. **(9 Hrs)**
Text books and Reference books		**Text Books:** 1. Simon Haykin and Michael Moher, "Communication Systems", 5th Edition, 2009, John Wiley & Sons. 2. Chris Bernhardt, "Quantum Computing for Everyone", 1st Edition, 2019, MIT Press. **Reference Books:** 1. Michael A. Nielsen and Isaac L. Chuang, "Quantum Computation and Quantum Information", 10th Anniversary Edition, 2010, Cambridge University Press. 2. Rodney Van Meter, "Quantum Networking", 1st Edition, 2014, John Wiley & Sons. 3. Eleanor Rieffel and Wolfgang Polak, "Quantum Computing: A Gentle Introduction", 1st Edition, 2011, MIT Press.
E-resources and other digital material		1. NPTEL – Quantum Information and Computing https://nptel.ac.in/courses/115106925 2. NPTEL – Quantum Algorithms and Cryptography https://nptel.ac.in/courses/106106241 3. IBM Quantum Learning – Basics of Quantum Information https://quantum.cloud.ibm.com/learning/en/courses/basics-of-quantum-information 4. IBM Quantum Learning – Quantum Educational Modules https://quantum.cloud.ibm.com/learning/en/modules

24EC370 C : WIRELESS COMMUNICATIONS

Course Category:	Inter Disciplinary Elective - II	**Credits:**	3
Course Type:	Theory	**Lecture -Tutorial-Practice:**	3-0-0
Prerequisites:		**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	40 60 100

Course outcomes	Upon successful completion of the course, the student will be able to:	
	CO1	Explain the fundamental principles governing information transmission and the limitations imposed by communication channels.
	CO2	Apply suitable transmission techniques to meet basic communication requirements.
	CO3	Explain the factors influencing the transmission and reception of wireless signals.
	CO4	Apply appropriate techniques to improve transmission reliability and reduce the effects of interference.
	CO5	Apply cellular communication principles to explain capacity improvement in wireless networks.

		Program Outcomes (POs)											**(PSOs)**		
Contribution of Course Outcomes towards achievement of Program Outcomes (1 - Low, 2 - Medium, 3 - High)	**Course Outcomes**	1	2	3	4	5	6	7	8	9	10	11	1	2	3
	CO1	3	1									2	2		
	CO2	3	2	1								2	2		
	CO3	3	1									2	2		
	CO4	3	2	1								2	2		
	CO5	3	2	1								2	2		

Course Content

UNIT-I

Transmission Fundamentals: Introduction, signals for conveying information, analog and digital data transmission, channel capacity: Nyquist bandwidth and Shannon capacity. **(9 Hrs)**

UNIT-II

Transmission Techniques and Signal Encoding: Transmission media, multiplexing techniques, signal encoding criteria, digital data to analog signals (ASK, FSK and PSK), analog data to digital signals (PCM).

(9 Hrs)

	UNIT-III **Antennas and Wireless Propagation:** Antenna radiation pattern and types, propagation modes, line-of-sight transmission, fading in the mobile environment. **(9 Hrs)** **UNIT-IV** **Spread Spectrum and Error Detection:** The concept of spread spectrum, frequency-hopping spread spectrum (FHSS), direct-sequence spread spectrum, error detection, parity check, cyclic redundancy check. **(9 Hrs)** **UNIT-V** **Cellular Wireless Communication:** Cellular network organization, frequency reuse, increasing capacity in cellular systems, operation of cellular systems. **(9 Hrs)**
Textbooks and Reference books	**Text Books:** 1. William Stallings, "Wireless Communications and Networks", 2nd edition, Pearson Education. **Reference Books:** 1. Theodore S. Rappaport, "Wireless Communications: Principles and Practice", 2nd Edition, Pearson Education. 2. Behrouz A. Forouzan, "Data Communications and Networking", 5th Edition, McGraw-Hill Education.
E-resources and other digital material	1. https://nptel.ac.in/courses/106106167 2. http://www.digimat.in/nptel/courses/video/117102062/117102062.html

24EC370 D : Digital Design and RISC-V Architecture

Course Category:	Inter Disciplinary Elective - II	**Credits:**	3
Course Type:	Theory	**Lecture -Tutorial-Practice:**	3-0-0
Prerequisites:	Digital Logic and Design/ Digital Electronics	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	40 60 100

Course outcomes	Upon successful completion of the course, the student will be able to:	
	CO1	Develop HDL descriptions of combinational and sequential circuits using modules, assignments, finite state machines and parameterized modules.
	CO2	Design and analyze arithmetic circuits, sequential building blocks and programmable logic structures.
	CO3	Interpret RISC-V assembly and machine instructions, including operands, program flow, instruction formats and addressing modes.
	CO4	Develop and compare single-cycle and multicycle processor Data path and control structures.
	CO5	Analyze pipelined processor operation and use HDL representations and test benches.

Contribution of Course Outcomes towards achievement of Program Outcomes (1 - Low, 2 - Medium, 3 - High)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	-	-	-	-	-	-	-	1	2	-	-
CO2	3	2	2	-	-	-	-	-	-	-	1	2	-	-
CO3	3	2	3	2	-	-	-	-	-	-	1	3	-	-
CO4	2	3	3	3	-	-	-	-	-	-	2	3	-	-
CO5	2	3	3	3	-	-	-	-	-	-	2	3	-	-

Course Content

UNIT-I

Hardware Description Languages and RTL Design

Introduction: Modules, Language Origins, Simulation and Synthesis

Combinational Logic: Bitwise Operators, Comments and White Space, Reduction Operators, Conditional Assignment, Internal Variables, Precedence, Numbers, Z's and X's, Bit Swizzling, Delays.

Structural Modeling, Sequential logic: Registers, Resettable Registers, Enabled Registers, Multiple Registers, Latches, More Combinational Logic: Case Statements, If Statements, Truth Tables with Don't Cares, Blocking and Nonblocking Assignments, Finite State Machines, Parameterized Modules **(9 Hrs)**

	UNIT-II **Digital Building Blocks for VLSI Design** Introduction, Arithmetic Circuits: Addition, Subtraction, Comparators, ALU, Shifters and Rotators, Multiplication, Division, Further Reading Number Systems: Fixed-Point Number Systems, Floating-Point Number Systems Sequential Building Blocks: Counters, Shift Registers Logic Arrays: Programmable Logic Array (PLA), Field Programmable Gate Array (FPGA) Implementations **(9 Hrs)** **UNIT-III** **RISC-V Instruction Set Architecture and Programming** Introduction, Assembly Language: Instructions, Operands: Registers, Memory, and Constants Programming: Program Flow, Logical, Shift, and Multiply Instructions, Branching, Conditional Statements, Getting Loopy, Arrays, Function Calls, Pseudo instructions Machine Language: R-Type Instructions, l-Type Instructions, S/B-Type Instructions, U/J-Type Instructions, Immediate Encodings, Addressing Modes, Interpreting Machine Language Code, The Power of the Stored Program **(9 Hrs)** **UNIT-IV** **RISC-V Single-Cycle and Multicycle Processor Design** Introduction: Architectural State and Instruction Set, Design Process, Microarchitectures Single-Cycle Processor: Sample Program, Single-Cycle Datapath, Single-Cycle Control, More Instructions, Multicycle Processor: Multicycle Datapath, Multicycle Control, More Instructions **(9 Hrs)** **UNIT-V** **RISC-V Pipelined Processor Design and HDL Representation** Pipelined Processor: Pipelined Datapath, Pipelined Control, Hazards HDL Representation: Single-Cycle Processor, Generic Building Blocks, Testbench **Note:** Teaching Adaptation Plan: Deliver the course SystemVerilog perspective. **(9 Hrs)**
Textbooks and Reference books	**Textbooks:** 1. Sarah L. Harris and David Money Harris, Digital Design and Computer Architecture: RISC-V Edition, 1st ed., Morgan Kaufmann, 2021. 2. David A. Patterson and John L. Hennessy, Computer Organization and Design RISC-V Edition: The Hardware Software Interface, 2nd ed., Morgan Kaufmann, 2020.

	Reference Books: **1.** John F. Wakerley, Digital Design: Principles and Practices, 5th ed., Pearson. **2.** Stephen Brown and Zvonko Vranesic, Fundamentals of Digital Logic with Verilog Design, 3rd ed., McGraw-Hill, 2014. **3.** David A. Patterson and Andrew Waterman, The RISC-V Reader: An Open Architecture Atlas, Strawberry Canyon LLC, 2017.
E-resources and other digital material	1. https://www.asic-world.com/systemverilog/index.html 2. https://verificationguide.com/systemverilog/systemverilog-tutorial/ 3. https://riscv.org/developers/

24EC320A : CELLULAR AND MOBILE COMMUNICATIONS

Course Category:	Professional Elective-II	**Credits:**	3
Course Type:	Theory	**Lecture -Tutorial-Practice:**	3-0-0
Prerequisites:		**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	40 60 100

Course outcomes	Upon successful completion of the course, the student will be able to:	
	CO1	Infer the cellular concept, frequency reuse, channel assignment strategies, handoff mechanisms, and techniques to improve coverage and capacity.
	CO2	Apply basic propagation mechanisms—reflection, diffraction, and scattering—including the two-ray ground reflection model, to determine radio wave behavior.
	CO3	Construct practical link budgets using path loss models and analyze small-scale multipath fading distributions.
	CO4	Illustrate the working principles of multiple access techniques, including FDMA, TDMA, CDMA.
	CO5	Classify GSM system architecture, radio subsystems, traffic/control channel types, and call sequence procedures.

		Program Outcomes (POs)											(PSOs)		
Contribution of Course Outcomes towards achievement of Program Outcomes (1 - Low, 2 - Medium, 3 - High)	**Course Outcomes**	1	2	3	4	5	6	7	8	9	10	11	1	2	3
	CO1	3	3	1									2		
	CO2	3	3	2									2		
	CO3	3	2	2									2		
	CO4	3	2	1									2		
	CO5	3	2										3		

Course Content	**UNIT-I** **Introduction to Wireless Communication Systems:** Examples of Wireless Communication Systems, Comparison of Common Wireless Communication Systems. **Cellular Concept**: Introduction, Frequency Reuse, Channel Assignment Strategies, Handoff Strategies, Interference and System Capacity, Improving Coverage & Capacity in Cellular Systems. **(9 Hrs)**

	UNIT-II **Mobile Radio Propagation - I:** Introduction to Radio Wave Propagation, Free Space Propagation Model, The Three Basic Propagation Mechanisms, Reflection, Ground Reflection (Two-Ray) Model, Diffraction, Scattering. **(9 Hrs)** **UNIT-III** **Mobile Radio Propagation -II:** Practical Link-Budget Design Using Path Loss Models. Small-Scale Multipath Propagation, Types of Small-Scale Fading, Rayleigh and Ricean Distributions. **(9 Hrs)** **UNIT-IV** Multiple Access Techniques: Introduction to Multiple Access, Frequency Division Multiple Access (FDMA), Time Division Multiple Access (TDMA), Spread Spectrum Multiple Access- Frequency Hopped Multiple Access (FHMA), Code Division Multiple Access (CDMA), Hybrid Spread Spectrum Techniques **(9 Hrs)** **UNIT-V** Global System for Mobile (GSM): GSM Services and Features, GSM System Architecture, GSM Radio Subsystem, GSM Channel Types, GSM Traffic Channels, GSM Control Channels, Examples of GSM Call. **(9 Hrs)**
Textbooks and Reference books	**Text Books:** 1. Theodore Rappaport, "Wireless Communications – Principles and Practices", 2nd edition, 2002, Pearson. (Unit I, II, III, IV,V) **Reference books:** 1. Molisch, Andreas F. "Wireless communications". John Wiley & Sons, 2012. (2nd Edition) 2. Kamilo Feher, "Wireless Digital Communications", 2003, PHI.
E-resources and other digital material	1. https://nptel.ac.in/courses/106106167/ 2. https://nptel.ac.in/courses/117104099/

24EC320B : SMART ANTENNAS

Course Category:	Professional Elective	**Credits:**	3
Course Type:	Theory	**Lecture - Tutorial -Practice:**	3-0-0
Prerequisites:	Antennas and Wave Propagation	**Continuous Evaluation:**	40
		Semester end Evaluation:	60
		Total Marks:	100

Course outcomes	Upon successful completion of the course, the student will be able to:	
	CO1	Explain the fundamentals and evolution of cellular communication systems and power control techniques.
	CO2	Explain the performance issues of MIMO systems in SINR environments.
	CO3	Describe the configuration and architecture of antennas in a smart antenna system.
	CO4	Explain smart antenna system aspects and mobility procedures for high-speed data transfer.
	CO5	Describe the CDMA techniques for smart antenna system.

		Program Outcomes (POs)											(PSOs)		
Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3 – High)	**Course Outcomes**	1	2	3	4	5	6	7	8	9	10	11	1	2	3
	CO1	3	2	1	1	1	1	2	1	1	1	1	3	1	1
	CO2	3	3	3	2	2	1	1	1	2	1	1	3	1	2
	CO3	3	2	2	2	2	1	1	2	2	2	2	2	1	3
	CO4	3	3	3	2	2	1	1	1	1	1	2	3	1	2
	CO5	3	3	3	2	3	2	1	1	2	2	2	2	1	3

Course Content

UNIT I:

Mobile Communications Overview: General Description**,** Cellular Communications Overview, The Evolution of Mobile Telephone Systems, The Framework, Cellular Radio Systems: Concepts and Evolution, Power Control.

(9 Hrs)

UNIT II:

	MIMO Systems: Introduction, Principles of MIMO Systems, Transmission Strategies, MIMO Approaches, MIMO Advantages and Key Performance Issues, SINR Environment. **(9 Hrs)** **UNIT III:** **Introduction to Smart Antennas**: Need for Smart Antennas, Overview, Smart Antenna Configurations, Space Division Multiple Accesses, Architecture of Smart Antenna System, Benefits, Drawbacks, Basic Principles, and Mutual Coupling Effects**.** **(9 Hrs)** **UNIT – IV:** **Smart Antennas System Aspects:** Introduction, Third Generation Air Interfaces and Protocol Stacks, Physical Layer, Mobile Call States, Mobility Procedures to Support High-Speed Data Transfer. **(9 Hrs)** **UNIT – V:** **Smart Antenna Techniques for CDMA**: Non-coherent CDMA spatial processors, coherent CDMA spatial processors and the spatial processing rake receiver, multi-user spatial processing, dynamic re-sectoring using smart antennas, downlink beam forming for CDMA **(9 Hrs)**
Textbooks and Reference books	**Textbooks:** 1. C. A. Balanis & P. I. Ioannides, "Introduction to Smart Antennas", Morgan & Claypool Publication. (I, III). 2. Ahmed El Zooghby, "Smart Antenna Engineering", Artech House. (II, IV). 3. Joseph C. Liberti, Theodore S. Rappaport, Smart Antennas for Wireless Communications: IS95 and third generation CDMA Applications, Prentice Hall Communications Engineering and Emerging Technologies Series. (V). **Reference Books:** 1. John D. Kraus, Antennas, 3rd Edition, McGraw Hill, 2001. **2.** R.E. Collins, Antennas and Radio Propagation, Singapore: McGraw Hill, 1985.
E-resources and other digital material	1.https://nptel.ac.in/courses/108/105/108105114/ 2.https://nptel.ac.in/courses/108/101/108101092/ 3.https://nptel.ac.in/courses/117/107/117107035/

24EC320C : IMAGE AND VIDEO PROCESSING

Course Category:	Professional Elective	**Credits:**	3
Course Type:	Theory	**Lecture - Tutorial -Practice:**	3-0-0
Prerequisites:	Signals & Systems	**Continuous Evaluation:**	40
		Semester end Evaluation:	60
		Total Marks:	100

Course outcomes	Upon successful completion of the course, the student will be able to:														
	CO1	Understand the fundamentals of image processing for different applications.													
	CO2	Analyze the various techniques for image enhancement and restoration process.													
	CO3	Apply various image compression schemes for reducing data and segregate the data using image segmentation methods.													
	CO4	Understand the fundamentals of colour image processing and colour transformation techniques for different applications.													
	CO5	Understand the fundamentals and representation of video capture and display.													
		Program Outcomes (POs)											**(PSOs)**		
Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3 – High)	**Course Outcomes**	1	2	3	4	5	6	7	8	9	10	11	1	2	3
	CO1	3	2	–	–	1	–	–	–	–	1	–	2	1	–
	CO2	3	3	2	2	3	–	–	–	–	–	–	3	2	1
	CO3	3	3	2	3	3	–	–	–	–	–	–	3	3	2
	CO4	3	2	2	1	2	–	–	–	–	–	–	3	2	2
	CO5	2	2	–	–	2	–	–	–	–	1	–	2	2	2
Course Content	**UNIT I** **Digital Image Fundamentals**: Introduction, Applications of Digital Image Processing, Fundamental Steps in Digital Image Processing, Components of an Image Processing System, Elements of Visual Perception, Image Sampling and Quantization, Basic Relationships between Pixels. **(9 Hrs)** **UNIT II:**														

	Image Enhancement: Background, Basic Intensity Transformation Functions, Histogram Processing, enhancement using arithmetic/logical operations. Filtering techniques: Image Smoothing and Sharping using Spatial Domain Filters and Frequency Domain Filters. **Image Restoration**: A Model of the Image Degradation/Restoration Process, noise models, Linear Position-Invariant Degradations, Estimation of degradation function, Inverse filtering, Minimum Mean Square Error (Wiener) Filtering, Constrained Least Squares Filtering. **(9 Hrs)** **UNIT III** **Image Compression:** Fundamentals, image compression model, elements of information theory, error free compression: Arithmetic coding, Huffman coding, Run-Length coding, loss less Predictive coding. , Lossy compression: lossy predictive coding. **Image segmentation:** Fundamentals, Point, Line and Edge Detection, edge linking and boundary detection, Thresholding, Region-Based Segmentation. **(9 Hrs)** **UNIT IV** **Color Image Processing:** Color Fundamentals**,** Color models, pseudo color image processing**,** basics of full color image processing**.** Color transformations. **(9 Hrs)** **UNIT – V** **Video Processing:** Introduction, Video Formation, Perception and Representation, Video capture and display, Analog video raster: progressive scanning and interlaced scanning, Analog color television systems, Digital video **(9 Hrs)**
Textbooks and Reference books	**Textbooks:** 1. Gonzalez and Wood, "Digital Image Processing", 3rd Edition, Pearson Education, 2009. (Unit I, II , III & IV) 2. Yao wang, Joem Ostarmann and Ya – quin Zhang, "Video Processing and Communications", 1st Edition, Prentice Hall International, 2010. (Unit V) **Reference Books:** 1. S. Jayaraman, S. Esakkirajan, T. Veerakumar, "Digital Image Processing", 3rd Edition, Tata McGraw Hill Education Private Limited, 2009. 2. M. Tekalp, "Digital Video Processing", 1stEdition, Prentice Hall International, 1995.
E-resources and other digital material	1. http://nptel.ac.in/courses/117105079/ 2. http://nptel.ac.in/courses/106105032/ 3. http://nptel.ac.in/courses/117104069/

24EC320D : ANALOG IC DESIGN

Course Category	Professional Elective-2	**Credits**	3
Course Type	Theory	**Lecture-Tutorial-Practice**	3-0-0
Prerequisite	Electronic Devices and Circuits, Analog Electronic Circuits, VLSI Design	**Internal Evaluation** **Semester end Evaluation:** **Total Marks:**	40 60 100

Course Outcomes	Upon successful completion of the course, the student will be able to:														
	CO1	Explain the operation of MOSFETs and develop their large-signal and small-signal models including second-order effects.													
	CO2	Design CMOS current mirrors, single-stage amplifiers and basic differential pairs.													
	CO3	Analyze the frequency response of single-stage amplifiers and differential pairs.													
	CO4	Design CMOS operational amplifiers to meet specified performance requirements.													
	CO5	Analyze the operation and non-ideal effects of phase-locked loops.													
Contribution of Course Outcomes towards achievement of Program Outcomes & PSOs (1–Low, 2-Medium, 3 – High)		**Program Outcomes (POs)**											**(PSOs)**		
		1	2	3	4	5	6	7	8	9	10	11	1	2	3
	CO1	3	2										3		
	CO2	3	2	3		1							3	1	
	CO3	3	3	2	2								3		
	CO4	3	2	3	2	2							3	2	
	CO5	2	2	2								1	2	1	1
Course Content	**UNIT-I:** **(9 Hrs)** **Basic MOS Device Physics:** MOS I/V Characteristics, Second-Order Effects, MOS Device Models. **UNIT-II:** **(9 Hrs)** **Current Mirrors:** Basic Current Mirrors, Biasing Techniques. **Single-Stage-Amplifiers:** Common source, Common gate and Source-Follower stages; Cascode and folded cascode structures, Single-Ended-Differential Pair, Basic-Differential Pair. **UNIT-III:** **(9 Hrs)** **Frequency Response of Amplifiers:** Miller Effect, Association of Poles and Zeros. Common-Source, Source Followers, Common-Gate Stage, cascode stage and Differential-Pair; Gain-Bandwidth Trade-off. **UNIT-IV:** **(9 Hrs)** **Operational Amplifiers** – Performance Parameters, One-stage Op-Amps, Folded cascode op-amps and properties, Two-stage op-amps **UNIT-V:** **(9 Hrs)** **Phase-Locked Loops:** Simple PLL, Charge Pumped PLL, Non-ideal Effects in PLLs, Case study of PLL														

Textbooks and Reference Books	**Text Books:** 1. Behzad Razavi (2017), "Design of Analog CMOS Integrated Circuits", Second Edition, McGraw Hill Education. **Reference Books:** 1. Philip Allen & Douglas Holberg (2002), "CMOS Analog Circuit Design", Oxford University Press. 2. David A Johns & Ken Martin (2001), "Analog Integrated Circuit Design", John Wiley and Sons. 3. 3. Behzad Razavi (2002), "Design of Analog CMOS Integrated Circuits", First Edition, Tata McGraw-Hill.
E-resources and other digital material	CMOS Analog VLSI Design by Prof. A.N. Chandorkar, Department of Electronics & Communication Engineering, IIT Bombay. For more details on NPTEL visit http://nptel.ac.in

24EC320E : EMBEDDED C

Course Category:	Professional Elective-II	**Credits:**	3
Course Type:	Theory	**Lecture - Tutorial -Practice:**	3-0-0
Prerequisites:	Micro Controllers and C Programming	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	40 60 100

Course outcomes	Upon successful completion of the course, the student will be able to:														
	CO1	Describe fundamental techniques for reading from and writing to microcontroller port pins using C Programming.													
	CO2	Apply structured programming techniques to develop modular embedded C programs.													
	CO3	Implement hardware delays and timeout mechanisms to meet real-time constraints.													
	CO4	Analyze state-driven architectures for embedded operating systems and real-time control applications.													
	CO5	Implement serial communication interfaces for data acquisition and remote control applications.													
		Program Outcomes (POs)											**(PSOs)**		
Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3 – High)	**Course Outcomes**	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PS01	PSO2	PSO3
	CO1	3	2			2							2	2	1
	CO2	3	2	2		3							2	3	2
	CO3	3	3	2	2	3							2	3	2
	CO4	3	3	3	2	3	2						3	3	2
	CO5	3	3	2	2	3	2	2					2	3	3
Course Content	**UNIT I:** **Reading switches in C**: Basic techniques for reading from port pins, Reading and writing bytes, Reading and writing bits (simple version), Reading and writing bits (generic version). The need for pull-up resistors, Dealing with switch bounce, Reading switch inputs (basic code), Counting goats. (9Hrs)														

	UNIT II: **Adding structure to your code**: Object-oriented programming with C, The Project Header (MAIN.H), The Port Header (PORT.H), Restructuring the 'Hello Embedded World' example, Restructuring the goat-counting example. (9Hrs) **UNIT III**: **Meeting real-time constraints**: Creating 'hardware delays' using Timer 0 and Timer 1, Generating a precise 50 ms delay, Creating a portable hardware delay, The need for 'timeout' mechanisms, Creating loop timeouts, Creating hardware timeouts. (9Hrs) **UNIT IV:** **Creating an embedded operating system**: The basis of a simple embedded OS, Introducing sEOS, Using Timer 0 or Timer 1, Important design considerations when using sEOS, Implementing a Multi-State (Timed) system, Traffic light sequencing, Implementing a Multi-State (Input/Timed) system, Controller for a washing machine. (9Hrs) **UNIT – V:** **Serial interface**: RS-232 protocol, Asynchronous data transmission and baud rates, Flow control, The software architecture, Using the on-chip UART for RS-232 communications, Memory requirements, Displaying elapsed time on a PC, The Serial-Menu architecture, Data acquisition, Remote-control robot. (9 Hrs)
Textbooks and Reference books	**Textbooks:** 1. Michael J. Pont, "Embedded C", Pearson Education, 2007. (Unit I,II,III,IV,V) **Reference Books:** 1. Michael Barr, "Programming Embedded System in C and C++", O' Reilly publications, 2012. 2. James K. Peckol, "Embedded Systems: A contemporary design tool", 2nd Edition, Wiley.
E-resources and other digital material	1. https://nptel.ac.in/courses/108102045/ 2. https://nptel.ac.in/courses/106105036/

24EC330A : RADAR Engineering

ourse Category:	Professional Elective – 3	**Credits:**	3
Course Type:	Theory	**Lecture - Tutorial -Practice:**	3-0-0
Prerequisites:	Electromagnetics & Transmission Lines	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	40 60 100

Course Outcomes	Upon successful completion of the course, the student will be able to:	
	CO1	Explain the factors affecting RADAR performance.
	CO2	Apply the operating principles of CW and FM-CW RADAR systems for target range and Doppler measurement.
	CO3	Analyze the principles and performance of MTI RADAR systems for moving target detection and clutter rejection.
	CO4	Describe RADAR tracking techniques for target tracking and position estimation.
	CO5	Explain the functions and characteristics of RADAR receiver subsystems

Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3– High)		**Program Outcomes (POs)**											**PSOs**		
		1	2	3	4	5	6	7	8	9	10	11	1	2	3
	CO1	3	3	1	2	1				1		1	3	1	1
	CO2	3	2	1	2	1				1		1	3	1	1
	CO3	3	3	2	3	1				1		1	3	2	1
	CO4	3	2	2	2	1				1		1	3	1	2
	CO5	3	2	1	1	1				2		1	3	2	1

Course Content

UNIT I

Basics of RADAR: Introduction, Maximum Unambiguous Range, Simple form of Radar Equation, Radar Block Diagram and Operation, Prediction of Range Performance, Minimum Detectable Signal, Receiver Noise.

Radar Equation: SNR, False Alarm Time and Probability, Integration of Radar Pulses, PRF and Range Ambiguities, System Losses**.** **(9Hrs)**

UNIT-II

CW AND FREQUENCY MODULATED RADAR: Doppler Effect, CW

	Radar: Block Diagram; Isolation, Non-zero IF receiver, receiver bandwidth, applications of CW radar, FM-CW radar, range and Doppler measurement, FM-CW altimeter, multiple frequency CW radar. **(9Hrs)** **UNIT- III** **MTI RADAR:** Doppler and MTI Radar- Delay Line Cancellers, Blind speeds, Staggered PRF, Doppler Filter Banks, Digital MTI Processing, Moving Target Detector, MTI Performance Limitations. **(9Hrs)** **UNIT- IV** **TRACKING RADAR:** Tracking with Radar, Mono-pulse Tracking-Amplitude Comparison and Phase Comparison, Conical Scan and Sequential Lobing, Comparison of Trackers. **(9Hrs)** **UNIT- V** **Radar Receivers:** Matched filter receiver, Detection Criteria, Noise Figure and Noise Temperature, Phased Array Antennas –Basic Concepts, Radar Displays – Types and Applications, Advantages and Limitations, Radomes. **(9Hrs)**
Text books and Reference books	**Text Books:** 1. Merrill I Skolnik, Introduction to Radar Systems, 3rd edition, TMH. 2. V. S. Bagad-Radar Systems, Technical Publications, 1st Edition. 3. Principles of Modern radar system, M. H. Carpentier, Artech House. **Reference Books:** 1. Radar: Principles, Technology, Applications – Byron Edde, Pearson Education, 2004. 2. Radar Principles – Peebles, Jr., P.Z., Wiley, New York, 1998.
E-resources and other digital material	1. https://ocw.mit.edu/resources/res-ll-003-build-a-small-radar-systemcapable-of-sensing-range-doppler-and-synthetic-aperture-radar-imagingjanuary-iap-2011/lecture-notes/ 2. http://www.radartutorial.eu/07.waves/wa04.en.html 3. https://archive.nptel.ac.in/courses/108/105/108105154/

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24EC330B : Introduction to Machine Learning

Course Category:	Programme Core	**Credits:**	3
Course Type:	Theory	**Lecture - Tutorial -Practice:**	3-0-0
Prerequisites:	Probability Theory & Random Processes	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	40 60 100

Course Outcomes	Upon successful completion of the course, the student will be able to:														
	CO1	Explain the fundamental concepts and basic principles of Machine Learning.													
	CO2	Analyze linear models used for regression and parameter estimation.													
	CO3	Analyze linear and probabilistic models used for classification.													
	CO4	Apply feed-forward neural networks and back propagation to machine-learning problems.													
	CO5	Analyze kernel methods and Support Vector Machines for classification.													
Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3– High)		**Program Outcomes (POs)**											**PSOs**		
		1	2	3	4	5	6	7	8	9	10	11	1	2	3
	CO1	3	2	-		1							1	2	1
	CO2	3	3	2	1	2							1	2	2
	CO3	3	3	2	2	2							1	2	2
	CO4	3	2	3	2	3							1	3	2
	CO5	3	2	2	2	2							1	2	3
Course Content	**UNIT I:** **Introduction to Machine Learning and Fundamentals :** Introduction to Artificial Intelligence and Machine Learning, **Types of Machine Learning** – Supervised, Unsupervised and Reinforcement Learning. Basic Probability, Conditional Probability and Bayes' Theorem, Dataset, Features, Labels, Training and Testing, Data Preprocessing – Data Cleaning, Normalization and Standardization **(9 hrs)** **UNIT II:** **Supervised Learning – Regression :** Introduction to Supervised Learning,														

	Linear Regression and Multiple Linear Regression, Polynomial Regression, Cost Function and Mean Square Error (MSE), Gradient Descent Algorithm. **(9hrs)** **UNIT III:** **Classification Algorithms** Introduction to Classification, K-Nearest Neighbour (KNN) Algorithm, Decision Tree Classifier, Naive Bayes Classifier, Support Vector Machine (SVM), Random Forest Algorithm **(9hrs)** **UNIT – IV:** **Unsupervised Learning and Model Evaluation** Introduction to Unsupervised Learning, K-Means Clustering Algorithm, Hierarchical Clustering, Principal Component Analysis (PCA), Confusion Matrix, Accuracy, Precision, Recall and F1-Score, Overfitting, Underfitting and Cross-Validation **(9 hrs)** **UNIT – V:** **Neural Networks and Applications of Machine Learning** Introduction to Artificial Neural Networks, Biological Neuron and Artificial Neuron Models, Perceptron and Multilayer Perceptron, Activation Functions – Sigmoid, ReLU and Tanh, Applications of Machine Learning in ECE – Signal Processing, Wireless Communication, Image Processing **(9 hrs)**
Text books and Reference books	**Text Books:** 1. Ethem Alpaydin, "Introduction to Machine Learning", PHI Learning Private Limited, 2nd Edition, 2012 **Reference Books:** 2. Tom Mitchell, "Machine Learning", McGraw-Hill Education (India) Private Limited, 1st Edition, 2013. 3. Ethem Alpaydin, "Introduction to Machine Learning", PHI Learning Private Limited, 2nd Edition, 2012 4. Richard O. Duda, Peter E. Hart, David G. Stork, "Pattern Classification", 2nd Edition John Wiley & Sons, 2001. 5. Trevor Hastie, Robert Tibshirani, Jerome H. Friedman, "The Elements of Statistical Learning", 2nd Edition, Springer, 2009
E-resources and other digital material	1. https://nptel.ac.in/courses/106106139/ 2.https://nptel.ac.in/courses/106105152/

24EC330C : SEMICONDUCTOR DEVICE MODELING

Course Category:	Program Elective-II	**Credits:**	3
Course Type:	Theory	**Lecture -Tutorial-Practice:**	3 – 0 – 0
Prerequisites:	Electronic Devices	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	40 60 100

Course outcomes	Upon successful completion of the course, the student will be able to:	
	CO1	Explain physics of PN junctions, abrupt, linearly graded and Hetero-junctions.
	CO2	Understand MOS capacitor working principles using band diagram, modes of operations, CV curve, frequency dependence, non-idealities and their measurements.
	CO3	Analyze the physics of MOSFET the current-voltage characteristics, short channel effects and possible solutions, MOSFET reliability issues, gate leakage and high-k dielectrics.
	CO4	Understand the principles of Silicon on Insulator MOSFET, PDSOI, FDSOI, Multigate FETs and Junctionless FETs .
	CO5	Understand the physics and working of emerging transistor architectures such as FinFETs, GAA and 2D FETs.

		Program Outcomes (POs)											**(PSOs)**		
Contribution of Course Outcomes towards achievement of Program Outcomes (1 - Low, 2 - Medium, 3 - High)	**Course Outcomes**	1	2	3	4	5	6	7	8	9	10	11	1	2	3
	CO1	3	2			1							3		1
	CO2	3	3	2	2	3					2		3		2
	CO3	3	2	2	2	2					2		3		2
	CO4	3	3	2	3	2							3		2
	CO 5	3	3	3	2	3							3		2

Course Content	**UNIT-I** **Physics of PN Junctions:** Built in potential of abrupt junction, depletion layer capacitance, I-V characteristics, generation and recombination, diffusion capacitance, junction breakdown, linearly graded junction, hetero-junction.

	(9Hrs) **UNIT-II** **MOS Capacitor Basics**: Ideal MOS capacitor (MOSCAP) working principles using band diagram, modes of operations, CV characteristics of MOSCAP, low frequency and high frequency CV characteristics, Non-idealities in MOSCAP: oxide fixed charges, interfacial charges, mobile charges and their measurement, carrier transport in insulating films, ultrathin gate-oxide, high-k dielectrics. **(9Hrs)** **UNIT-III** **MOSFET: Ideal and Non-ideal Behaviour:** Drift-Diffusion Approach for current-voltage analysis, Gradual Channel Approximation, charge sheet model, channel conductance, trans conductance, MOSFET equivalent circuit, Sub-threshold current and slope, Body effect, mobility behavior, temperature behaviors MOSFET two dimensional effects, short channel effects and their reduction methods. **(9Hrs)** **UNIT-IV** **Beyond CMOS and Multigate FETs:** **SOI FET:**Latch up issue in CMOS technology, Silocon on insulator advantages, SOI materials, FDSOI and PDSOI, Floating body effects. **DGMOSFET:** Introduction and performance enhancement **JLT FETs:** Physics, structure and working principle of Junctionless MOSFETs. **(9Hrs)** **UNIT-V** **Emerging Transistor Architectures:** **FinFET:** A successor of MOSFET, Introduction to FinFETs Structure, Structural Classification of FinFETs, RLC FinFET Modeling, High Frequency Small Signal Modeling **Gate-All-Around FETs:** Introduction of Different Types of GAA Structure, Current Trends in GAA Devices, Nanosheet FET, Process Variation in Nanosheet FET **2D FETs**. Introduction of 2D materials, 2D Materials based FETs. **(9Hrs)**
Textbooks and Reference books	**Textbooks:** 1. S.M. Sze& Kwok K. Ng, Physics of Semiconductor Devices, Wiley. 2. Jean-Pierre Colinge Silicon-on-insulator Technology: Materials to vlsi, Springer

	Science Business Media, LLC. 3. Jean-Pierre Colinge, FinFETs and Other Multi-Gate Transistors, 2008. **Reference Books:** 1. N. Arora, MOSFET modeling for VLSI Simulation: Theory and Practice World. 2. Yannis Tsividis, Operation and Modeling of the MOS Transistor, Oxford University Press.
E-resources	1. https://onlinecourses.nptel.ac.in/e-learning/preview/noc25_ee75

24EC330D DSP PROCESSORS AND ARCHITECTURES

Course Category:	Professional Elective-III	**Credits:**	3
Course Type:	Theory	**Lecture - Tutorial -Practice:**	3-0-0
Prerequisites:	Digital Signal Processing, Microprocessors and C Programming	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	40 60 100

Course outcomes	Upon successful completion of the course, the student will be able to:	
	CO1	Analyze computational accuracy and architectural features of programmable DSP devices.
	CO2	Apply TMS320C54xx addressing modes and instructions to develop DSP programs.
	CO3	Analyze TMS320C6x architecture, instruction execution and programming constraints.
	CO4	Implement filtering, control and FFT algorithms using DSP processors.
	CO5	Design memory and I/O interfaces for DSP processors using interrupts, for real time applications.
		PO: Program Outcomes; PSO: Program Specific Outcomes

Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 – Medium, 3 – High) Proposed mapping		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
	CO1	3	2										2	2	1
	CO2	3	2										2	3	2
	CO3	3	3										2	3	2
	CO4	3	3	2		2							3	3	2
	CO5	3	2	3		2							2	3	3

Course Content	**UNIT I** **Computational Accuracy in DSP Implementations:** Number Formats for Signals and Coefficients in DSP Systems, Dynamic Range and Precision, Sources of Error in DSP Implementations, A/D Conversion Errors, DSP Computational Errors, D/A Conversion Errors. **Architectures for Programmable DSP Devices:** Basic Architectural Features, DSP Computational Building Blocks, Bus Architecture and Memory, Data Addressing Capabilities, Address Generation Unit, Programmability and Program Execution, Speed Issues, Features for External Interfacing. **(9Hrs)** **UNIT II TMS320C54xx Processor Architecture and Programming** Commercial Digital Signal-Processing Devices, Data Addressing Modes of TMS320C54XX DSPs, Data Addressing Modes of TMS320C54XX Processors, Memory Space of TMS320C54XX Processors, Program Control, TMS320C54XX Instructions and Programming, On-Chip Peripherals, Interrupts of TMS320C54XX Processors, Pipeline Operation of TMS320C54XX Processors. **(9Hrs)** **UNIT III TMS320C6x Architecture and Development Tools** Introduction; TMS320C6x Architecture; Functional Units; Fetch and Execute Packets; Pipelining; Registers; Linear and Circular Addressing Modes; TMS320C6x Instruction Set; Assembler Directives; Linear Assembly; ASM Statement Within C; Fixed- and Floating-Point Format; Code Improvement; Constraints; Programming Examples Using C, Assembly, and Linear Assembly. **(9Hrs)** **UNIT IV Implementation of DSP Algorithms** The Q-notation, FIR Filters, IIR Filters, Interpolation Filters, Decimation Filters, PID Controller, Adaptive Filters, 2-D Signal Processing. An FFT Algorithm for DFT Computation, A Butterfly Computation, Overflow and Scaling, Bit-Reversed Index Generation, An 8-Point FFT Implementation on the TMS320C54XX. **(9Hrs)** **UNIT V** **Interfacing Memory and I/O Peripherals Programmable DSP Devices:** Memory Space Organization, External Bus Interfacing Signals, Memory Interface, Parallel I/O Interface, Programmed I/O, Interrupts and I/O, Direct Memory Access (DMA). A Multichannel Buffered Serial Port (MCBSP), MCBSP Programming **(9Hrs)**
Textbooks and Reference books	**Textbooks:** 1. Avatar Singh and S.Srinivasan, "DSP Processors and Architectures", 2004, Thomson Publications. (Units I, II, IV, V) 2. R. Chassaing and D. Reay, Digital Signal Processing and Applications with the TMS320C6713 and TMS320C6416 DSK, 2nd ed., Wiley,

	2008. (Units III) **Reference Books:** 1. B. Venkataramani and M. Bhaskar, Digital Signal Processors: Architecture, Programming and Applications, 2nd ed., Tata McGraw-Hill, 2011 2. P. Lapsley, J. Bier, A. Shoham and E. A. Lee, DSP Processor Fundamentals: Architectures and Features, Wiley-IEEE Press, 1997.
E-resources and other digital material	1. TI TMS320C54x DSP Mnemonic Instruction Set: https://www.ti.com/lit/ug/spru172c/spru172c.pdf 2. IIT Kanpur DSP architecture and applications: https://iitk.ac.in/ee606a

24EC330E : QNX - REAL TIME OPERATING SYSTEM

Course Category:	Professional Elective-III	**Credits:**	3
Course Type:	Theory	**Lecture - Tutorial -Practice:**	3-0-0
Prerequisites:	1. Microcontrollers 2. Principles of Embedded Systems and RTOS	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	40 60 100

Course outcomes	Upon successful completion of the course, the student will be able to:														
	CO1	Explain the QNX OS architecture, microkernel components, process/thread model, scheduling, and resource management.													
	CO2	Implement process and thread management, synchronization techniques, and inter-process communication mechanisms in QNX.													
	CO3	Analyze QNX IPC mechanisms, including message passing, pulses, and shared memory, based on their performance, advantages, and limitations.													
	CO4	Implement hardware access, interrupt handling, DMA-safe memory allocation, and timing mechanisms in QNX-based systems.													
	CO5	Develop QNX boot/OS images and integrate serial communication, data acquisition, elapsed-time monitoring, and remote-control applications.													
		Program Outcomes (POs)											**(PSOs)**		
Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3 – High)	**Course Outcomes**	1	2	3	4	5	6	7	8	9	10	11	1	2	3
	CO1	3	2	2	2	1	2	1	3	2	3	3	3	2	3
	CO2	2	3	1	2	3	2	1	3	2	3	3	2	2	3
	CO3	3	3	3	2	2	2	1	3	2	3	3	2	1	3
	CO4	2	3	2	2	3	2	1	3	2	3	3	3	3	3
	CO5	3	3	3	2	3	2	1	3	2	3	3	2	3	3
Course Content	**UNIT I:** **Introduction to QNX OS Architecture**: Overview of QNX OS architecture: microkernel, process manager, and standards; Protected address spaces, process/thread model, and scheduling; Introduction to inter-process communication (IPC) and synchronization; Resource managers and shared objects. (9Hrs) **UNIT II:** **Processes, Threads, and Synchronization**: Process management: creation, termination, and memory protection; Thread management:														

	creation, termination, and synchronization; Synchronization techniques: mutexes, semaphores, and condition variables; Hands-on exercises: process/thread creation and synchronization. (9Hrs) **UNIT III**: **Inter-Process Communication (IPC)**: Overview of IPC methods in QNX: message passing, pulses, and shared memory; Comparing IPC methods: advantages and disadvantages; Practical implementation of IPC in QNX; Hands-on exercises: message passing and shared memory. (9Hrs) **UNIT IV:** **Hardware Programming and Timing**: Hardware access methods: IO-mapped and memory-mapped IO; Interrupt handling and DMA-safe memory allocation; Timing architecture: periodic timing, one-shot timing, and timeouts; Hands-on exercises: interrupt handling and timing mechanisms. (9Hrs) **UNIT – V:** **Building and Configuring QNX Boot/OS Images**: The software architecture, Using the on-chip UART for RS-232 communications, Memory requirements, Displaying elapsed time on a PC, The Serial-Menu architecture, Data acquisition, Remote-control robot. (9 Hrs)
Textbooks and Reference books	**Textbooks:** 1. Getting Started with QNX Neutrino 2 - A Guide for Real Time Programmers, by Rob Krten, PARSE Software Devices, 2022. **Reference Books:** 1. QNX Neutrino RTOS User's Guide, QNX Software Systems. 2. Programming for Embedded Systems, Michael Barr, O'Reilly Media. 3. Hands-on RTOS with Microcontrollers, Brian Amos, Packt Publishing,2020 4. Operating System Concepts, Abraham Silberschatz, Peter B. Galvin, Greg Gagne, 9th Edition, Wiley, 2018.
E-resources and other digital material	1. QNX online training 2. QNX training material 3. QNX Documentation for SDP 8.0 4. QNX Everywhere page -https://blackberry.qnx.com/en/products/qnx-everywhere 5. QNX Gitlab page - https://gitlab.com/qnx 6. QNX Developer Community: Access to forums and communities where they can ask questions and interact with other QNX developers. 7. QNX on Reddit: https://www.reddit.com/r/QNX/

	8. QNX on Stack Overflow: https://stackoverflow.com/questions/tagged/qnx 9. QNX on YouTube: https://www.youtube.com/qnxcam 10. Ported libraries that work on QNX: https://github.com/qnx-ports Collection of open-source projects (incl Links) for QNX: https://gitlab.com/qnx/projects

24EC386 : DIGITAL SYSTEM DESIGN USING PLDs LABORATORY

Course Category:	**PC**	**Credits:**	**1.5**
Course Type:	**Laboratory**	Lecture - Tutorial - Practical:	**0-0-3**
Prerequisites:	24EC202: Digital Circuit Design	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	60 40 100

Course outcomes	Upon successful completion of the course, the student will be able to:	
	CO1	Design synthesizable combinational and arithmetic circuits using Verilog HDL for FPGA implementation.
	CO2	Develop and implement sequential circuits and arithmetic systems using Verilog HDL.
	CO3	Design Mealy and Moore FSM-based sequence detectors and digital controllers using Verilog HDL.
	CO4	Implement ROM, synchronous RAM and FIFO architectures using FPGA resources.
	CO5	Simulate, synthesize and verify digital systems on FPGA hardware using appropriate tools.

		Program Outcomes (POs)											**Program Specific Outcomes (PSOs)**		
Contribution of Course Outcomes towards achievement of Program Outcomes (1 - Low, 2 - Medium, 3 - High)	**Course Outcomes**	1	2	3	4	5	6	7	8	9	10	11	1	2	3
	CO1	3	2	3	-	3	-	-	-	-	-	-	3	-	-
	CO2	3	3	3	-	3	-	-	-	-	-	-	3	-	-
	CO3	3	2	3	2	3	-	-	-	-	-	-	3	-	-
	CO4	3	2	3	-	3	-	-	-	-	-	-	3	-	-
	CO5	3	3	3	2	3	-	-	-	-	-	-	3	-	-

Course Content

LIST OF EXPERIMENTS (15 EXERCISES)

1. Design and implement a BCD-to-Seven-Segment Display Decoder using Verilog HDL on FPGA.
2. Design and implement a Two-Digit BCD Adder using Verilog HDL on FPGA.
3. Design and implement a 16-bit Carry Select Adder using Verilog HDL on FPGA.
4. Design and implement an 8-bit Arithmetic Logic Unit (ALU) using Verilog HDL on

	FPGA. **5.** Design and implement a 4 x 4 Array Multiplier using Verilog HDL on FPGA. **6.** Design and implement a 4-bit Universal Shift Register using Verilog HDL on FPGA. **7.** Design and implement a 4-bit Up/Down Counter using Verilog HDL on FPGA **8.** Design and implement an 8-bit Shift-and-Add Multiplier using Verilog HDL on FPGA. **9.** Design and implement a Digital Clock (HH:MM) using Verilog HDL on FPGA with a Four-Digit Seven-Segment Display. **10.** Design and implement a Mealy FSM-based Overlapping Sequence Detector (1010) using Verilog HDL on FPGA. **11.** Design and implement a Moore FSM-based Overlapping Sequence Detector (1010) using Verilog HDL on FPGA. **12.** Design and implement a Traffic Light Controller using Verilog HDL on FPGA. **13.** Design and implement a 16 x 8 ROM using Verilog HDL on FPGA. **14.** Design and implement a 16 x 8 Synchronous RAM using Verilog HDL on FPGA. **15.** Design and implement a 4 x 8 Synchronous FIFO using Verilog HDL on FPGA.
Tools	1. AMD/Xilinx Vivado Design Suite for synthesis, implementation and FPGA programming. 2. Vivado Simulator (XSim) for behavioral and post-synthesis simulation and waveform analysis. 3. FPGA development board and suitable peripheral interface(s), as available.

24EC387 : MICROWAVE AND OPTICAL COMMUNICATIONS LAB

Course Category:	Programme Core	**Credits:**	1.5
Course Type:	Laboratory	**Lecture - Tutorial -Practice:**	0-0-3
Prerequisites:	Electromagnetics and Transmission lines	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	60 40 100

Course outcomes	Upon successful completion of the course, the student will be able to:														
	CO1	Apply microwave measurement techniques to determine frequency, wavelength, VSWR, impedance, and the performance characteristics of microwave devices, components, and antennas.													
	CO2	Analyze and evaluate the performance of optical fiber and SDR communication systems by measuring numerical aperture, attenuation, dispersion, and losses, characterizing optical sources, and establishing analog, digital, and SDR communication links.													
Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3 – High)		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
	CO1	H	M		M	H						L	H	M	L
	CO2	H	H	M	H	H						M	H	H	M
Course Content	**Microwave Experiments:** **Perform an experiment to :** Measure the frequency and wavelength of microwaves using a slotted line. Measure the Voltage Standing Wave Ratio (VSWR) of a given load. Analyze and measure the performance of a Gunn diode oscillator. Measure the impedance of an unknown load using a Smith Chart. Determine the purpose of a directional coupler and measure its coupling coefficient. Study of E-plane and H-plane tees and measurement of their characteristics. Determine the characteristics of a reflex klystron Measure the gain of a microwave antenna. Study of circulator and isolator and measurement of insertion loss and isolation.														

	Optical experiments: **Perform an experiment to :** ● Measure the Numerical Aperture (NA) of an optical fiber. ● Study the different losses in optical fiber (bending, coupling, etc.). ● Determine the attenuation in an optical fiber. ● Measure the fiber dispersion. ● Study the characteristics of LED and laser diodes. ● Study of laser diode characteristics and optical power measurement. ● Analyze an analog and digital optical fiber link. ● Establish communication link using SDR

L	T	P	C
2	0	2	3

INTERNET OF THINGS

OBJECTIVE:
To develop the ability to architect and build IoT solutions across the complete Sense–Communicate–Analyze–Decide–Act loop—acquiring and processing sensor data at the edge, selecting communication technologies and protocols, storing, processing and analyzing data on an IoT platform, and closing the loop through decisions, commands and actuation to deliver measurable value.

COURSE OUTCOMES (COs):

The student will be able to:

CO No.	Course Outcome	Bloom's Level	Unit(s)
CO1	Explain IoT through the Sense–Communicate–Analyze–Decide–Act loop, describe IoT reference models and the edge, platform and enterprise tiers, and relate technology and business drivers to the value an IoT solution delivers.	Understand (L2)	I
CO2	Design sensing and data-acquisition chains by selecting sensors on their characteristics, sampling and placement, applying calibration, and specifying edge processing for cleaning, normalization, time stamping, storage and forwarding.	Apply/Analyze (L3/L4)	II
CO3	Select wired and wireless communication technologies, topologies, communication models and IoT protocols for given range, power, bandwidth and reliability constraints.	Analyze/Evaluate (L4/L5)	III
CO4	Design IoT data and event models, choose storage and processing approaches (stream, batch and event processing), and apply descriptive analytics and dashboards on an IoT platform for data-driven decisions.	Apply/Analyze (L3/L4)	IV
CO5	Design decision and control loops—rules, commands, actuation and feedback—for dependable and safe operation, and develop end-to-end IoT solutions for home, industrial and smart-city applications.	Create (L6)	V

Unit – I

IoT Overview, Reference Architecture and Value: Introduction to Internet of Things (IoT) - ***Sense, Communicate, Analyze and ACT***, IoT Reference architecture – Layers, Tiers, Interfaces, Examples. Technology and business drivers, Trends, and implications

Case Study: Building Management System

Unit – II

Sense & Processing
Fundamentals of Data Acquisition and digitalization, Analog and digital data acquisition, Sampling, Time averaging, Static and dynamic characteristics, placement of sensors, Calibration, and types of calibrations, Edge Processing – Data cleaning, Data normalization, Time stamping, storage handing and forwarding.

Case Studies: Temperature and Humidity Sensor, Ultrasonic Level Sensor, AC/DC Current Sensors

Unit – III

IoT communication technologies and protocols: Data communication basics, short range and long

L	T	P	C
2	0	2	3

range communication, communication devices, network topologies, communication at Edge, communication to platform, Internet and Web layering, Introduction to wired and wireless communication technologies for IoT, Physical and MAC layers, IP Versions, Edge connectivity and IoT protocols – Basic of Protocol – Header, Sequence Number, Device Identifier, Parameter Type, Channel/Input Number, Timestamp, CRC/Checksum; Modern Protocols - MQTT, MQTT-SN, Constrained Application Protocol (CoAP), STOMP, AMQP, Comparison of protocols, **Need for light weight and high throughput protocols**, **Design of light weight protocols**, Routing over low power and lossy networks,

Case Studies: Modbus Protocol, MQTT Protocol, Indian Railways Signaling Protocol

Unit - IV

Analyze: Structured vs Unstructured data and data in motion vs data in rest, **Spectrum of Analytics, Data driven decisions using Descriptive Analytics**, Databases for IoT – Relational Database, Timeseries Database (NOSQL), Data and Event models, Streaming Data processing, Batch Processing, Event Processing, Role of APIs, and TCP sockets for integration.

Use cases: Energy Management System in an industry, Air Quality and Weather Monitoring – Indoor and Outdoor, Drinking Water Network in an Industry

Unit – V

Control systems – General actuators for on/off and 0-100% adjustable, Fail-Safe Actuators, feedback from actuators, command, and event processing.

Use cases: Appliance Control, Blinds Control, Fail Safe Valve Control in Water Network

System of Systems – evolution, characteristics, understanding as whole, interactions, , dynamic behaviour and complexity. Case Studies: Modern Railways, Industry Utilities – multiple sources of power, distribution and consumption.

TEXTBOOKS:

- Internet of Things Reference Architecture – Whitepaper – CISCO
- IoT and Edge Computing for Architects: Implementing edge and IoT systems from sensors to clouds with communication systems, analytics, and security– Perry Lea, Packt Publishing Limited.
- IoT Fundamentals: Networking Technologies, Protocols and Use Cases for Internet of Things, David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Rob Barton and Jerome Henry, Cisco Press, 2017
- Architect IoT using the Gartner Internet of Things Reference Model – Gartner Research
- System Engineering Handbook, INCOSE

REFERENCE BOOKS

- Internet of Things – A hands-on approach, Arshdeep Bahga, Vijay Madisetti, Universities Press, 2015
- The Internet of Things – Key applications and Protocols, Olivier Hersent, David Boswarthick, Omar Elloumi and Wiley

L	T	P	C
2	0	2	3

- "From Machine-to-Machine to the Internet of Things – Introduction to a New Age of Intelligence", Jan Holler, Vlasios Tsiatsis, Catherine Mulligan, Stamatis, Karnouskos, Stefan Avesand. David Boyle and Elsevier
- The Internet of Things, revised and updated edition (The MIT Press Essential Knowledge series)
- Architecting the Internet of Things, Dieter Uckelmann, Mark Harrison, Michahelles and Florian (Eds), Springer

L	T	P	C
2	0	2	3

SYSTEMS THINKING AND INTRODUCTION TO SYSTEMS ENGINEERING

PRE-REQUISITES: Engineering Mathematics and Sciences

OBJECTIVE:

To develop the ability to define the purpose, boundary and environment of engineered systems, investigate how their parts cooperate, analyze and predict their behaviour over time, and model, evaluate and improve them—progressing from familiar physical systems to interacting independent systems.

COURSE OUTCOMES (COs):

The student will be able to:

CO No.	Course Outcome	Bloom's Level	Unit(s)
CO1	Identify the purpose, stakeholders, boundary, environment, inputs, outputs and measurable outcomes of a given system, and explain how the hierarchy of its parts and their relationships determines whole-system performance.	Understand/Analyze (L2/L4)	I
CO2	Analyze how a system works by decomposing it into functions, subsystems, components and interfaces, and by tracing energy, material and information flows, operating sequences, states and human interaction under stated constraints and trade-offs.	Analyze (L4)	II
CO3	Analyze and predict system behaviour over time using behaviour-over-time graphs, stocks and flows, balancing and reinforcing feedback, delays, capacity and bottlenecks, and explain emergence, failure propagation and unintended consequences using measured evidence.	Analyze/Evaluate (L4/L5)	III
CO4	Develop consistent models of an existing system—measurable requirements, context diagrams, functional decomposition, logical and physical architecture, interfaces and operational scenarios—and diagnose an observed problem through evidence-based root-cause analysis.	Create (L6)	IV
CO5	Evaluate alternative improvements through trade-off, risk and change-impact analysis, define verification and validation evidence, and build a small connected Capella model using Arcadia perspectives that explains system-of-systems interactions.	Evaluate/Create (L5/L6)	V

UNIT – I

Foundations of Systems Thinking—Seeing a System

System versus a collection of parts; purpose, functions and outcomes of a system; components, attributes and relationships; whole-system performance versus performance of individual parts. Stakeholders and their expectations. System boundary and environment; inputs, outputs and external influences; open and closed systems. Hierarchy—system, subsystem, assembly and component levels; levels of abstraction. Macro-level versus micro-level views of a system—the macro (whole-system, outside-in) view of purpose, boundary, environment and overall

L	T	P	C
2	0	2	3

performance versus the micro (part-level, inside-out) view of individual components, their local behaviour and connections; zooming in and zooming out between levels; how micro-level relationships produce macro-level outcomes, and the risks of optimising a part at the expense of the whole. Measurable outcomes and performance indicators. Consequences of a missing, degraded or poorly adjusted part on whole-system performance.

Ways of thinking about systems—linear (cause-and-effect chain) thinking versus systemic (circular, interconnected) thinking. The iceberg model—events, patterns of behaviour, underlying structures and mental models. Habits of a systems thinker—seeing the big picture, changing perspectives, recognising that structure generates behaviour, observing how elements change over time, considering how mental models shape current reality, and checking results. Learning by looking at systems—observe, question, predict, test and reflect; separating observation, inference and assumption; asking what is happening, what keeps happening, what causes it and what beliefs sustain it.

Case studies

1. Building water network (sources, storage tanks, pumps, pipelines, valves and users)
2. Building electrical energy network (main incomer, distribution panels and loads)
3. The campus lunch service as a socio-technical system of kitchen, menu, counters, students and feedback.

UNIT – II

Understanding How a System Works—Functions, Structure and Flows

Functions versus components—what a system does versus what it is made of; function-to-component allocation. Subsystem decomposition and hierarchical breakdown. Interfaces—mechanical, electrical, fluid, information and human interfaces; interface definition and interface failures. Energy, material and information flows; conversion of inputs into useful outputs; efficiency and losses. Operating sequences; operating modes, states and transitions; state diagrams. Human interaction and the role of the user/operator within the system. Constraints and trade-offs—physical, cost, safety and usability constraints.

Case studies

1. Tracing water from source to tap through tanks, pumps, pipelines and pressure
2. Tracing energy from the main incomer through panels to loads
3. The water–energy interface through pumps (energy per kilolitre delivered). Pump and tank operating modes and states.
4. The air-quality and weather monitoring station as an information system from sensor to data to decision.

UNIT – III

Understanding Behaviour over Time—Dynamics and Feedback

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2	0	2	3

Behaviour-over-time graphs and reading system dynamics from measured data. Stocks and flows; inflow, outflow and accumulation; balance relationships; dynamic equilibrium. Balancing and reinforcing feedback loops; causal-loop diagrams; goal-seeking behaviour and corrective action. Delays in sensing, decision and action; overshoot and oscillation; comparison of manual control with delayed responses. Demand, capacity, utilisation and bottlenecks; waiting time and queue growth. Emergence and non-obvious whole-system behaviour. Failure propagation, side effects and unintended consequences of local changes.

Case studies

1. Water tank with variable inflow and outflow (water balance, level-versus-time graph, and pump control as a balancing loop with delay that produces overshoot and overflow)
2. Peak electrical demand, daily load profiles and maximum demand as a capacity limit
3. Pollutant concentration as a stock driven by emissions and removed by wind and rain (daily and seasonal patterns; temperature inversion as a trap).

UNIT – IV

Modelling and Analysing Systems—Requirements and Architecture

Evidence-based analysis—observations, documentation, measurements and explicit assumptions. Stakeholder identification and stakeholder maps; capture of stakeholder needs and their translation into measurable, verifiable requirements; characteristics of good requirements. Context diagrams. Functional decomposition and functional architecture. Logical and physical architecture; allocation of functions to logical and physical components; consistency across connected views. Interface tables and interface management. Operational scenarios—normal, degraded and failure scenarios; scenario walkthroughs and failure propagation. Diagnosis of observed problems—symptoms versus root causes; root-cause analysis techniques (why-why analysis, cause-and-effect diagrams). Generation of alternatives and introductory trade-off analysis.

Case studies

1. Lift
2. Water network

Development of connected stakeholder, requirement, functional, logical and physical views on paper, and comparison of the initial mental model with what the data shows.

UNIT – V

Learning, Improving and Connecting Systems—Leverage, Lifecycle and Systems of Systems

Learning in and from systems—single-loop and double-loop learning; the Plan–Do–Check–Act cycle and the experiential learning cycle (experience, reflect, conceptualise, experiment); learning from feedback and data when delays are short or long; measures as feedback, and how targets change behaviour (Goodhart’s law); the learning organisation

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2	0	2	3

System lifecycle—concept, development, operation, maintenance and retirement; maintainability. Comparison of alternative improvements; trade-off records and selection criteria. Verification versus validation; definition of tests and traceability of requirements to functions, components and tests. Change-impact analysis; risk identification and accountability. Systems of systems—operational and managerial independence of constituent systems, interoperability, and interactions and emergent behaviour among independent systems. Model-based systems engineering (MBSE) fundamentals—document-centric versus model-centric engineering. Arcadia method—operational analysis, system analysis, logical architecture and physical architecture perspectives. Capella tool—basic model navigation and creation; transfer of paper-model elements into a small connected digital model at introductory depth.

Case studies: Railways as system of systems

TEXTBOOKS:

- Donella H. Meadows, Thinking in Systems: A Primer, Chelsea Green Publishing
- Pascal Roques, Systems Architecture Modeling with the Arcadia Method: A Practical Guide to Capella, ISTE Press – Elsevier
- Alexander Kossiakoff, Steven M. Biemer, Samuel J. Seymour and David A. Flanigan, Systems Engineering Principles and Practice, 3rd Edition, John Wiley & Sons

REFERENCE BOOKS

- Peter M. Senge, *The Fifth Discipline: The Art and Practice of the Learning Organization*, Revised Edition, Doubleday/Currency
- Jean-Luc Voirin, *Model-based System and Architecture Engineering with the Arcadia Method*, ISTE Press – Elsevier
- Eclipse Capella Project, *Capella Getting Started Guide and Arcadia Reference* (freely available at https://mbse-capella.org)
- Linda Booth Sweeney and Dennis Meadows, *The Systems Thinking Playbook*, Chelsea Green Publishing
- Derek Cabrera and Laura Cabrera, *Systems Thinking Made Simple: New Hope for Solving Wicked Problems*, Odyssean Press
- Donella H. Meadows, *Leverage Points: Places to Intervene in a System*, The Sustainability Institute
- Waters Center for Systems Thinking, *Habits of a Systems Thinker*

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0	0	3	1.5

DATA ANALYTICS LAB

PRE-REQUISITES: Engineering Mathematics

OBJECTIVE:

To provide hands-on practice, in acquiring, cleaning, describing, diagnosing and visualizing general and sensor/time-series data—using statistical tools, SQL, Microsoft Power BI and time-series techniques—and in communicating insights through reports and dashboards for data-driven decisions.

Tools:

- MySQL or PostgreSQL or SQLite relational database
- Microsoft Power BI Desktop and Power BI Service
- Grafana

Datasets:

1. Lunch Feedback Survey Responses
2. Accidents on highway stretch
3. Air Quality and weather: Physical parameters of a station
4. Water network: tank levels, flow, consumption
5. Energy consumption: Electrical parameters in entire electrical network of building

Experiments

1. Explore Power BI and Grafana Development Environment and understand their functions.

2. Given a dataset containing categorical, numerical and time-series data, perform data visualization using Power BI and Grafana. Identify the appropriate visualization for different analytical purposes and justify the selection of each visualization based on the analytical question being addressed.

3. Develop a Lunch Feedback Analytics dashboard using the feedback data collected from students for different food items (such as rice, dal, curry, salad, etc.) with ratings of Bad, Average and Good. Analyse satisfaction by food item, day and lunch time slot. Create appropriate visualizations to identify satisfaction trends, frequently disliked food items, changes in feedback over time and variations in food consumption. Provide insights to identify areas requiring improvement in food quality and service.

L	T	P	C
0	0	3	1.5

4. Develop a Road Accident Analytics dashboard using historical highway accident data containing accident date, time, location, vehicle type, nature of accident and number of fatalities. Analyse accident patterns by year, location, time of day, vehicle type and nature of accident. Create appropriate visualizations, including geographical maps, to identify accident-prone locations, high-risk time periods, major causes and vehicle categories contributing to fatalities. Derive insights that can help identify accident hotspots and support road safety planning and preventive measures.

5. Develop an Air Quality and Weather Analytics dashboard using data collected from an IoT-based monitoring station containing parameters such as PM2.5, PM10, CO_2, CO, SO_2, NO_2, O_3, temperature, humidity, wind speed, wind direction, rainfall and atmospheric pressure. Analyse variations in air quality and weather conditions over time and across different locations. Create appropriate visualizations to identify pollution trends, relationships between weather and air quality parameters, abnormal pollution levels, daily and seasonal variations, and possible pollution hotspots. Derive insights to assess environmental conditions, identify potential pollution sources and understand the influence of weather conditions on air quality.

6. Develop a Building Water Network Analytics dashboard consisting of water storage tanks, pipelines, pumps and other water distribution utilities. The monitoring system provides parameters such as tank water levels, pipeline flow rates, water pressure, pump operating status, pump runtime, energy consumption and electrical parameters (voltage, current, power and energy). Analyse water consumption, storage levels, distribution patterns, flow and pressure variations, pump performance and electrical energy usage. Create appropriate visualizations to identify abnormal water levels, leakage indicators, pressure drops, unusual consumption patterns, pump inefficiencies and excessive energy consumption. Examine the relationships between water demand, tank levels, pump operation and energy usage. Derive insights to assess system performance, identify operational problems and recommend improvements in water distribution, pump scheduling and energy efficiency.

7. Develop an Electrical Energy Consumption Analytics dashboard for a company's building electrical network using data collected from energy meters installed at the main incomer, distribution panels and individual electrical loads. The monitored parameters include voltage, current, frequency, power factor, active power, reactive power, apparent power, energy consumption (kWh), maximum demand and phase-wise electrical parameters. Analyse energy consumption patterns across different floors, departments, distribution panels and electrical utilities. Create appropriate visualizations to identify peak demand periods, energy-intensive areas, phase imbalance, poor power factor, abnormal load variations and inefficient energy usage. Examine the relationships between operating hours, electrical load, power demand and energy consumption. Derive insights to assess electrical network performance, identify opportunities for energy conservation, optimize load distribution and improve overall energy efficiency.