



# Imperial College of Engineering

Affiliated to Tribhuvan University · Bhaktapur, Nepal

## COURSE SYLLABUS HANDBOOK

# Bachelor in Electronics, Communication and Information Engineering

**BEI · Four years · Eight semesters**

The official curriculum of the Institute of Engineering, Tribhuvan University, for students admitted in 2080 and later. Years I to III, 36 course syllabi.



BEI · 2080 CURRICULUM

# About this handbook

This handbook brings every published syllabus for the Bachelor in Electronics, Communication and Information Engineering together in one place, arranged semester by semester, so that a student can see the whole degree from the first class to the last.

Each syllabus page is reproduced unchanged from the Institute of Engineering (IOE), Tribhuvan University. IOE writes and revises the curriculum and remains its authority. As a TU-affiliated college, Imperial College of Engineering teaches this same curriculum, and our students sit the same IOE examinations and receive the same Tribhuvan University degree as students on every other campus.

Years I to III are complete. IOE has named the Year IV courses but has not yet published their syllabi. They are listed on page 163 and will be added when IOE releases them.

|              |                                                                          |
|--------------|--------------------------------------------------------------------------|
| DEGREE       | Bachelor in Electronics, Communication and Information Engineering (BEI) |
| UNIVERSITY   | Tribhuvan University, Institute of Engineering                           |
| CURRICULUM   | 2080 batch and later                                                     |
| DURATION     | Four years, eight semesters                                              |
| IN THIS BOOK | 36 syllabi, Semesters 1 to 6                                             |
| SOURCE       | ioe.tu.edu.np, compiled 30 September 2026                                |



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YEAR I, PART I

# Semester 1

## 6 COURSES IN THIS SEMESTER

|                 |                                                       |           |
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| <b>ENSH 101</b> | Engineering Mathematics I                             | <b>6</b>  |
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# ENGINEERING MATHEMATICS I

ENSH 101

Lecture : 3  
Tutorial : 2  
Practical : 0

Year : I

Part : I

## Course Objectives:

To equip the students with the essential mathematical skills and techniques that are relevant to the engineering fields and enable them to solve engineering problems using mathematical methods.

### 1 Derivatives and its Applications (10 hours)

- 1.1 Review of derivative and differentiability, mean value theorems with interpretations
- 1.2 Indeterminate forms, types and their real life examples, L-Hospital's rule
- 1.3 Power series of single valued functions
  - 1.3.1 Taylor's series
  - 1.3.2 Maclaurin's series
- 1.4 Asymptotes to Cartesian and Polar curves
- 1.5 Pedal equation to Cartesian and Polar curves
- 1.6 Curvature and radius of curvature for Cartesian curves

### 2 Antiderivatives and its Applications (11 hours)

- 2.1 Review of definite and indefinite integrals
- 2.2 Differentiation under integral sign
- 2.3 Improper integrals
- 2.4 Application of Beta and Gamma functions
- 2.5 Area, arc length, volume and surface of revolution in plane for Cartesian curves
- 2.6 Centroid and moment of inertia under area of curve

### 3 Ordinary Differential Equations and its Applications (10 hours)

- 3.1 Review of order, degree, solution of first order first degree differential equations by variable separation method and solution of homogeneous equations
- 3.2 Linear differential equation and equations reducible to linear differential equation of first order Bernoulli's equation, modeling electric circuit
- 3.3 First order and higher degree differential equations; Clairaut's form

- 3.4 Linear second order differential equations with constant coefficient and variable coefficients reducible to constant coefficients, Cauchy's equations and modeling mass spring system
- 3.5 Application in physical sciences and engineering

#### **4 Plane Analytic Geometry (4 hours)**

- 4.1 Transformation of coordinates: Translation and rotation
- 4.2 Equation of conic in Cartesian and Polar form, identification of conics

#### **5 Three dimensional geometry (10 hours)**

- 5.1 The straight line: Symmetrical and general form
- 5.2 Coplanar lines
- 5.3 Shortest distance
- 5.4 Sphere: General equation, plane section by planes, tangent planes
- 5.5 Introduction to right circular cone and right circular cylinder

#### **Tutorials (30 hours)**

- 1. Derivatives and its applications
- 2. Antiderivatives and its applications
- 3. Ordinary differential equations and its applications
- 4. Plane analytic geometry
- 5. Three dimensional geometry

#### **Reference**

- 1. Jeffery, A., (2001), Advanced Engineering Mathematics. Academic Press.
- 2. O'Neill, P.V., (2003), Advanced Engineering Mathematics. Thomson Learning.
- 3. Kreyszig, A. (1993), Advanced engineering Mathematics (Latest Edition). John Wiley & Sons.
- 4. Sastry, S.S. (2008), Engineering Mathematics Volume I and II. PHI India.
- 5. Wylie, C., Barrett, L. (1995), Advanced Engineering Mathematics (Latest Edition), McGraw-Hill College.
- 6. Thomas, T., Finny, R. (1984), Calculus and Analytic Geometry (Latest Edition.), Addison-Wesley.

# ENGINEERING PHYSICS

ENSH 102

**Lecture** : 4  
**Tutorial** : 1  
**Practical** : 2

**Year** : I  
**Part** : I

## Course Objectives:

To provide students a concept and sound knowledge of physics with the emphasis in present day applications to apply them in relevant fields. The background of physics corresponding to proficiency certificate level is assumed.

## 1 Oscillation (6 hours)

- 1.1 Physical pendulum
  - 1.1.1 Bar pendulum
  - 1.1.2 Interchangeability of point of suspension and point of oscillation
  - 1.1.3 Minimum time period in case of physical pendulum
  - 1.1.4 Torsion pendulum
- 1.2 Damped and forced oscillation
  - 1.2.1 Damped harmonic oscillator
  - 1.2.2 Difference between free and damped oscillator
  - 1.2.3 Energy in damped oscillation
  - 1.2.4 Relaxation time
  - 1.2.5 Forced oscillation and resonance
  - 1.2.6 Sharpness of resonance
  - 1.2.7 Quality factor

## 2 Acoustics (3 hours)

- 2.1 Introduction
  - 2.1.1 Threshold of hearing and loudness
  - 2.1.2 Reverberation and reverberation time
  - 2.1.3 Absorption coefficient
  - 2.1.4 Sabine's law
  - 2.1.5 Conditions for good acoustics
- 2.2 Ultrasound
  - 2.2.1 Production (Piezoelectric) of ultrasound and its applications
  - 2.2.2 Test of structure and materials
  - 2.2.3 Medical uses

### **3 Heat and Thermodynamics**

**(8 hours)**

- 3.1 Quantity of heat
  - 3.1.1 Calorific value of foods and fuels
  - 3.1.2 Bomb calorimeter
  - 3.1.3 Specific heat of solid: Dulong-Petit law, Einstein's law
- 3.2 Nature of heat
  - 3.2.1 Degree of freedom
  - 3.2.2 Maxwell's law of equipartition of energy
  - 3.2.3 Atomicity of gases
  - 3.2.4 Vander-Waal's equation of real gases
  - 3.2.5 Critical constants
- 3.3 Thermodynamics
  - 3.3.1 Laws of thermodynamics
  - 3.3.2 Clapeyron latent heat equation
  - 3.3.3 Entropy and Third law of thermodynamics
  - 3.3.4 Negative energy
  - 3.3.5 Maxwell's thermodynamic relations
  - 3.3.6 Gibb's free energy and phase transitions
- 3.4 Heat and mass transfer
  - 3.4.1 Fourier's law of thermal conductivity
  - 3.4.2 Use of thermal conductivity in building sciences
  - 3.4.3 Thermal resistance
  - 3.4.4 Types of convection
  - 3.4.5 Law of diffusion
  - 3.4.6 Relation between Stefan's law and Newton's law of Cooling
  - 3.4.7 Pyrheliometer and Pyrometer

### **4 Optics**

**(17 hours)**

- 4.1 Geometrical optics
  - 4.1.1 Lens separation
  - 4.1.2 Chromatism in lens combination
- 4.2 Interference
  - 4.2.1 Interference in thin films (Reflected and transmitted light)
  - 4.2.2 Fringes produced by a wedge-shaped thin film
  - 4.2.3 Newton's rings (Both reflected and transmitted case)
  - 4.2.4 Determination of wavelength of light and refractive index of liquid by using Newton's rings.
- 4.3 Diffraction
  - 4.3.1 Introduction: Fresnel and Fraunhofer's diffraction
  - 4.3.2 Fraunhofer's diffraction at single slit
  - 4.3.3 Intensity distribution in the diffraction pattern due to a single slit
  - 4.3.4 Multiple slits, diffraction grating
  - 4.3.5 X-ray diffraction, X-rays in material testing

- 4.4 Polarization
  - 4.4.1 Introduction: double refraction, Nichol prism (Construction and uses)
  - 4.4.2 Retardation plate (Quarter and half wave plates), plane, elliptical and circular polarized light (Theoretical and mathematical explanation)
  - 4.4.3 Optical activity, specific rotation
- 4.5 Laser
  - 4.5.1 Introduction: Laser and ordinary light, properties of laser
  - 4.5.2 Induced absorption, spontaneous and stimulated emission, active medium, population inversion, metastable state
  - 4.5.3 Pumping (Types: Optical, electrical, chemical and thermal)
  - 4.5.4 He-Ne laser, semiconductor laser
  - 4.5.5 Uses of laser
- 4.6 Fiber optics
  - 4.6.1 Introduction: Propagation of light wave
  - 4.6.2 Types of optical fiber: Step index and graded index
  - 4.6.3 Fiber transmission- Single and multimode, self-focusing, acceptance angle and numerical aperture
  - 4.6.4 Applications

## 5 Electrostatics

(8 hours)

- 5.1 Electric field
  - 5.1.1 Electric field due to an electric dipole (Along axial line and equatorial line)
  - 5.1.2 Electric dipole in an external electric field
  - 5.1.3 Electric field due to linear electric quadrupole (Along axial line)
  - 5.1.4 Electric field: A ring of charge, circular ring and disc of charge
- 5.2 Electric potential
  - 5.2.1 Potential due to electric dipole
  - 5.2.2 Potential due to linear quadrupole
  - 5.2.3 potential due to continuous charge distribution, potential due to ring of charge and disc of charge
- 5.3 Capacitors
  - 5.3.1 Cylindrical capacitor
  - 5.3.2 Charging and discharging of capacitor
  - 5.3.3 Capacitor with dielectrics: dielectrics and Gauss law
  - 5.3.4 High intensity electrostatic fields: Uses and hazards (Xerography, inkjet, precipitation)

## **6 Electromagnetism (6 hours)**

- 6.1 Electromagnetic induction
  - 6.1.1 Faraday's laws
  - 6.1.2 Induction and energy transformation
  - 6.1.3 Induced electric field
  - 6.1.4 Self-induction and mutual induction
  - 6.1.5 LR circuit
  - 6.1.6 Energy stored in a magnetic field and energy density
  - 6.1.7 Induced magnetic field: Modified Ampere's law and displacement current
- 6.2 Eddy current
  - 6.2.1 Introduction
  - 6.2.2 Applications: Induction cooker, electric guitar, metal detector and Eddy current breaking
  - 6.2.3 Cyclotron and Synchrotron

## **7 Electromagnetic Waves (6 hours)**

- 7.1 Maxwell's equations
  - 7.1.1 Differential and integral forms
  - 7.1.2 Conversion of Maxwell's equations from integral form to differential form and differential form to integral form
  - 7.1.3 Maxwell's equations in different media
- 7.2 Applications
  - 7.2.1 Wave equations: Non conducting and conducting medium and free space
  - 7.2.2 Plane solution of wave equations, amplitude of electromagnetic waves, speed of electromagnetic waves, ratio of electric and magnetic fields
  - 7.2.3 Continuity equation
  - 7.2.4 Energy transfer and Poynting vector, radiation pressure

## **8 Photon and Matter Waves (6 hours)**

- 8.1 Quantum physics
  - 8.1.1 Inadequacy of classical mechanics and rise of quantum mechanics, quantization of energy
  - 8.1.2 Group velocity and phase velocity, electrons and matter waves
  - 8.1.3 de-Broglie wavelength, its applications
  - 8.1.4 Heisenberg uncertainty principle and its applications
  - 8.1.5 Wave functions and its significance

- 8.2 Schrodinger wave equation
  - 8.2.1 Time dependent and independent equation
  - 8.2.2 Probability distribution
  - 8.2.3 One dimensional infinite potential well, particle in a box
  - 8.2.4 Barrier tunneling (Reflection and transmission coefficient)

**Tutorial (15 hours)**

Students will practice numerical problems covering all units and sub-units to strengthen conceptual understanding and problem-solving skills.

**Practical (30 hours)**

1. To determine the acceleration due to gravity and radius of gyration of the given metal bar using bar pendulum
2. To determine the modulus of elasticity of the given material and moment of inertia of the circular disc about the wire as an axis passing through its center and perpendicular to its plane by using torsional pendulum
3. To determine the coefficient of thermal conductivity of a bad conductor by Lee's method
4. To determine the mechanical equivalent of heat by given method
5. To determine the wavelength of the sodium light using Newton's rings
6. To determine the wavelength of sodium light using wedge-shaped method
7. To determine the wavelength of LASER light using diffraction grating and hence determine the particle size of lycopodium powder
8. To determine the focal length of two lenses when they are separated by some finite distance
9. To determine the chromatic aberration of a convex lens between red and blue colors
10. To determine the capacitance of the given capacitor by the method of charging and discharging through resistor
11. To plot the graph between frequency and current in LCR series circuit and hence determine the quality factor of the circuit
12. To study the growth and decay of current in LR circuit then determine the self-inductance of the given inductor
13. To determine the dielectric constant of the given material

**Reference**

1. Halliday, D., Resnick, R., Walker, J. (2021). Fundamentals of physics. John Wiley & Sons.
2. Pokharel, B., Bhattarai, B.K., Paudel, M.D. (2023). Fundamentals of engineering physics. Benchmark Education Support.
3. Brij Lal, Subrahmanyam, N. (2012). A text book of optics. S. Chand Publishing.
4. Vasudeva, A.S. (2010). Modern engineering physics. S. Chand Publishing.

5. Caur, R.K., Gupta, S.L. (2012). Engineering physics. Dhanpat Rai Publications.
6. Brij Lal, Subrahmanyam, N. (2011). Waves and oscillations. Vikas Publishing House Pvt. Ltd.
7. Brij Lal, Subrahmanyam, N. (2012). Heat, thermodynamics and statistical physics. S. Chand Publishing.
8. Avadhanulu, M.N., Kshirsagar, P.G., Murthy, T.V.S.A. (2018). A textbook of engineering physics. S. Chand Publishing.

# COMPUTER PROGRAMMING

ENCT 101

**Lecture : 3**  
**Tutorial : 1**  
**Practical : 3**

**Year : I**

**Part : I**

## Course Objectives:

The primary goal of this course is to provide students with a solid foundation in the principles of programming and to impart practical skills in the C programming language. This course ensures that students comprehend the fundamental concepts of variables, data types, control structures, and functions within the context of C. Advanced topics such as pointers, structures, file handling and the standard C library are explored to broaden students' programming capabilities. Also, through project-based assessments and evaluations, students apply their knowledge to real-world scenarios, fostering creativity and project development skills.

## 1 Introduction to Computer Programming (3 hours)

- 1.1 Definition of a computer program and programming language
- 1.2 Types and generations of programming languages
- 1.3 Problem-solving using a computer
  - 1.3.1 Problem analysis
  - 1.3.2 Algorithm and flowchart
  - 1.3.3 Programming
  - 1.3.4 Compilation, linking and execution
  - 1.3.5 Debugging and testing
  - 1.3.6 Documentation

## 2 Overview of C Programming (3 hours)

- 2.1 Introduction to C programming
- 2.2 History and importance of C
- 2.3 C headers and library functions
- 2.4 Basic structure of a C program
- 2.5 Preprocessor directives
- 2.6 Tokens in C (Character set, keywords and identifiers)
- 2.7 Type casting (Implicit and explicit)
- 2.8 Data types, variables and constants
- 2.9 Compiler and IDE for C programming

### **3 Operators and Expressions (4 hours)**

- 3.1 Introduction to operators and expressions
- 3.2 Arithmetic, relational and logical operators
- 3.3 Assignment, increment and decrement operators
- 3.4 Conditional, bitwise and special operators
- 3.5 Comma operator, size of operator
- 3.6 Evaluation and type conversion in expressions
- 3.7 Operator precedence and associativity

### **4 Input and Output (3 hours)**

- 4.1 Introduction to data I/O in C
- 4.2 Unformatted I/O
  - 4.2.1 Character I/O
  - 4.2.2 String I/O
- 4.3 Formatted I/O
  - 4.3.1 Control string (Flags, field width, precision, and specifier)
  - 4.3.2 Formatted I/O (scanf(), printf())

### **5 Control Structures (8 hours)**

- 5.1 Introduction to simple and compound statement
- 5.2 Sequential statement
- 5.3 Branching statement
  - 5.3.1 Simple if statement
  - 5.3.2 if-else statement
  - 5.3.3 Nested if-else statement
  - 5.3.4 else-if ladder
  - 5.3.5 switch statement
  - 5.3.6 go to statement
- 5.4 Looping statement
  - 5.4.1 for loop
  - 5.4.2 while loop
  - 5.4.3 do while
  - 5.4.4 Nested loop
- 5.5 Loop interruption
  - 5.5.1 break
  - 5.5.2 continue

### **6 Array and Pointer (7 hours)**

- 6.1 Introduction to an array
- 6.2 One-dimensional array
- 6.3 Two-dimensional array

- 6.4 Multidimensional array
- 6.5 Introduction to string
- 6.6 String handling functions
- 6.7 Definition of a pointer
- 6.8 Pointer declaration
- 6.9 Pointer arithmetic
- 6.10 Relationship between pointer and arrays

## **7 User-defined Functions**

**(6 hours)**

- 7.1 Introduction to function
- 7.2 Advantages of function
- 7.3 Elements of user-defined function
  - 7.3.1 Function definition
  - 7.3.2 Function prototype
  - 7.3.3 Function parameters
- 7.4 Storage class
- 7.5 Scope rules
- 7.6 Category of functions
  - 7.6.1 Functions with no arguments and no return values
  - 7.6.2 Functions with arguments and no return values
  - 7.6.3 Functions with arguments and return values
  - 7.6.4 Functions with no arguments and return values
- 7.7 Recursive functions
- 7.8 Function call by values and reference
- 7.9 Passing array and string to function

## **8 Structures**

**(5 hours)**

- 8.1 Defining a structure
- 8.2 Declaring and accessing structure elements
- 8.3 Initializing structure
- 8.4 Array of structure
- 8.5 Array as member to structure
- 8.6 Pointer as member to structure
- 8.7 Structure as a member to structure
- 8.8 Passing and returning structures to/from function

## **9 File Management**

**(4 hours)**

- 9.1 Introduction
- 9.2 Binary and text file in C
- 9.3 File opening modes
- 9.4 Defining, opening and closing file

- 9.5 Input-output operations on files
  - 9.5.1 Character I/O (fputc(), fgetc())
  - 9.5.2 String I/O (fgets(), fputs())
  - 9.5.3 Formatted I/O (fscanf(), fprintf())
  - 9.5.4 Record I/O (fwrite(), fread())
- 9.6 Overview of random file access
- 9.7 Error handling

## 10 Recent Trends in Programming

(2 hours)

- 10.1 Introduction to object oriented programming (OOP)
- 10.2 Definitions of class, method and object in OOP
- 10.3 Difference between procedure oriented and OOP
- 10.4 Overview of other high level programming languages

## Practical

(45 hours)

- 1. Lab 1: Introduction and demonstrations of projects written in C
- 2. Lab 2: Formatted and unformatted Input/output in C
- 3. Lab 3: Branching in control structure
- 4. Lab 4: Looping in control structure
- 5. Lab 5: Array in C
- 6. Lab 6: String in C
- 7. Lab 7: Pointers in C
- 8. Lab 8: User defined functions in C
- 9. Lab 9: Structure in C
- 10. Lab 10: File handling in C
- 11. Group project on C maximum 4 students in a group at the end of the course.

## Reference

- 1. Lafore, R. (1993). *The Waite Group's C programming using Turbo C++* (1st ed.). SAMS Publishing.
- 2. Balagurusamy, E. (2019). *Programming in ANSI C* (8th ed.). McGraw Hill Education.
- 3. Gottfried, B. S. (2010). *Programming with C* (3rd ed.). McGraw Hill Education.

# ENGINEERING DRAWING

ENME 101

**Lecture : 2**  
**Tutorial : 0**  
**Practical : 4**

**Year : I**  
**Part : I**

## Course Objectives:

To develop basic projection concepts with reference to points, lines, planes and geometrical solids. Also, to develop sketching and drafting skills to facilitate communication.

### 1 Instrumental Drawing, Technical Lettering Practices and Techniques

(1 hour)

- 1.1 Equipment, materials and drawing sheets
- 1.2 Description of drawing instruments, auxiliary equipment and drawing materials
- 1.3 Techniques of instrumental drawing
- 1.4 Pencil sharpening, securing paper, proper use of T- squares, triangles, scales dividers, compasses, erasing shields, French curves, inking pens
- 1.5 Line: Types and uses, thickness

### 2 Dimensioning

(1 hour)

- 2.1 Fundamentals and techniques
- 2.2 Size and location dimensioning, SI conversions
- 2.3 Scales: Types and representative factor
- 2.4 Use of scales, measurement units, reducing and enlarging drawings
- 2.5 Placement of dimensions: Aligned and unidirectional, chain, parallel/baseline and combined type
- 2.6 Tolerance dimensioning

### 3 Geometrical Construction

(2 hours)

- 3.1 Plane geometrical construction: Proportional division of lines, trisection of angles, smooth arc and line tangents
- 3.2 Methods for drawing regular polygons and standard curves such as ellipses, parabolas, hyperbolas, involutes, spirals, cycloids and helices (Cylindrical and conical), ogee curve
- 3.3 Techniques to reproduce a given drawing (By construction)

#### **4 Basic Descriptive Geometry (4 hours)**

- 4.1 Introduction to orthographic projection, principal planes, four quadrants or angles
- 4.2 Projection of points on first, second, third and fourth quadrants
- 4.3 Projection of lines: Parallel to one of the principal planes, inclined to one of the principal plane and parallel to other, Inclined to both principal planes, traces of a line
- 4.4 Projection planes: Perpendicular to both principal planes, parallel to one of the principal planes and Inclined to one of the principal planes, perpendicular to other and Inclined to both principal planes
- 4.5 True length of lines: Horizontal, inclined and oblique lines
- 4.6 Rules for parallel and perpendicular lines
- 4.7 Point view or end view of a line
- 4.8 Shortest distance from a point to a line
- 4.9 Edge view and true shape of an oblique plane
- 4.10 Angle between two intersecting lines
- 4.11 Intersection of a line and a plane, visible portion of line
- 4.12 Angle between a line and a plane
- 4.13 Dihedral angle between two planes
- 4.14 Shortest distance between two skew lines
- 4.15 Angle between two non-intersecting (Skew) lines

#### **5 Multi View (Orthographic) Projections (8 hours)**

- 5.1 Orthographic projections
  - 5.1.1 First and third angle projection
  - 5.1.2 Principal views: Methods for obtaining orthographic views, projection of lines, angles and plane surfaces, analysis in three views, projection of curved lines and surfaces, object orientation and selection of views for best representation, full and hidden lines
  - 5.1.3 Orthographic drawings: Making an orthographic drawing, visualizing objects (Pictorial view) from the given views
  - 5.1.4 Interpretation of adjacent areas, true-length lines, representation of holes, conventional practices
- 5.2 Sectional views: Full, half, offset, broken (Partial), rotated/aligned, revolved, removed (Detail) sections, phantom of hidden section, specifying cutting planes for sections, convention practices
- 5.3 Auxiliary views: Basic concept and use, drawing methods and types, symmetrical and unilateral auxiliary views, auxiliary sectional views

#### **6 Developments and Intersections (7 hours)**

- 6.1 Introduction and projection of solids with points transfer
- 6.2 Developments: General concepts and practical considerations, triangulation method for approximate development of surfaces of a right/oblique; Prism, cylinder, pyramid, cone, prism and cylinder cut by oblique planes,

frustum/truncated pyramid and cone, transition pieces for connecting different shapes and sphere

- 6.3 Intersections: Lines of intersection of geometric surfaces, piercing point of a line and a geometric solid, intersection lines of two planes, intersections of – prism and prism, cylinder and prism, cylinder and cylinder, pyramid and prism, cone and prism, pyramid and cylinder, cone and cylinder

## **7 Pictorial Drawings**

**(7 hours)**

- 7.1 Classifications: Advantages and disadvantages
- 7.2 Isometric view
  - 7.2.1 Axonometric projection
  - 7.2.2 Isometric projection and isometric drawing (View)
  - 7.2.3 Isometric and non-isometric lines; Isometric and non-isometric surfaces
  - 7.2.4 Angles in isometric drawing
  - 7.2.5 Circles and circular arcs in isometric and non-isometric surfaces (Slopes)
  - 7.2.6 Irregular curves in isometric drawing
  - 7.2.7 Isometric sectional views
- 7.3 Oblique drawing
  - 7.3.1 Procedure for making an oblique drawing
  - 7.3.2 Rules for placing objects in oblique drawing
  - 7.3.3 Angles, circles and circular arcs in oblique drawing
- 7.4 Perspective projection
  - 7.4.1 Terms used in perspective projection
  - 7.4.2 Parallel and angular perspective
  - 7.4.3 Selection of station point
  - 7.4.4 Perspective projection of right prism and pyramid solid

### **Assignments**

- 1. Geometrical construction
- 2. Descriptive geometry
- 3. Multi-view Projection I
- 4. Multi-view Projection II
- 5. Surface development and intersection
- 6. Isometric drawing
- 7. Oblique drawing and perspective projection

### **Practical**

**(60 hours)**

- 1. Drawing sheet layout, freehand lettering, scale, common graphical symbols, sketching of parallel lines, circles, dimensioning
- 2. Geometrical construction (Sketch and instrumental drawing)
- 3. Descriptive geometry I (Sketch and instrumental drawing)
- 4. Descriptive geometry II (Sketch and instrumental drawing)
- 5. Multiview drawings I (Sketch and instrumental drawing)

6. Multiview drawings II (Sketch and instrumental drawing)
7. Multiview, sectional drawings and dimensioning (Sketch and instrumental drawing)
8. Auxiliary view, sectional drawings and dimensioning (Sketch and instrumental drawing)
9. Projection of regular geometrical solids with point transfer (Sketch and instrumental drawing)
10. Surface development of solids I (Sketch and instrumental drawing)
11. Surface development of solids II (Sketch and instrumental drawing)
12. Intersection of solids (Sketch and instrumental drawing)
13. Isometric drawing I (Sketch and instrumental drawing)
14. Isometric drawing II (Sketch and instrumental drawing)
15. Oblique drawing and perspective projection (Sketch and instrumental drawing)

## Reference

1. Luzadder, W.J., Duff, J.M. (1989). Fundamentals of engineering drawing: With an introduction to interactive computer graphics for design and production (Latest Edition). Prentice-Hall.
2. French, T.E., Vierck, C.J., Foster, R.J. (1993). Engineering drawing and graphic technology (Latest Edition). McGraw-Hill.
3. Giesecke, F.E., Mitchell, A., Spencer, H.C., Dygdon, J.T. (2016). Technical drawing with engineering graphics. Peachpit Press.
4. Bhatt, N.D. (2023). Elementary engineering drawing. Charotar Publishing House.
5. Gill, P.S. (2016). Engineering drawing. S. K. Kataria & Sons.
6. Dhawan, R.K. (2019). A textbook of engineering drawing. S. Chand and Company.
7. Luintel, M. C. (2021). Engineering Drawing I. Heritage Publishers & Distributors.
8. Luintel, M. C. (2020). Engineering Drawing II. Heritage Publishers & Distributors.

# **FUNDAMENTAL OF ELECTRICAL AND ELECTRONICS ENGINEERING**

## **ENEX 101**

**Lecture : 3**  
**Tutorial : 1**  
**Practical : 3**

**Year : I**  
**Part : I**

### **Course Objectives:**

Objective of the course is to understand the language of electronics, elements, and their functionality, to introduce the DC and AC circuit analysis and basic understanding of analog systems and their applications.

### **1 Basic Circuits Concepts (6 hours)**

- 1.1 Current and potential
- 1.2 Passive components: Resistance, inductance, capacitance; Series, parallel combinations; Kirchhoff's voltage and current laws for DC circuits
- 1.3 Signal sources: Voltage and current sources; Non ideal sources; Representation under assumption of linearity; Controlled sources: VCVS, CCCVS, VCCS, CCCS; Concept of gain, transconductance, transimpedance
- 1.4 Maximum power transfer, superposition theorem, Thevenin's theorem, Norton's theorem

### **2 Average and RMS Values (4 hours)**

- 2.1 Generation of AC voltage
- 2.2 Waveform and its characteristics
- 2.3 RMS and average values of periodic waveforms

### **3 AC Circuit Analysis (12 hours)**

- 3.1 Single-phase AC circuit analysis
  - 3.1.1 Series, parallel and network circuits with sinusoidal excitations
  - 3.1.2 The concept of complex impedance and admittance
  - 3.1.3 Sinusoidal excitation of inductive and capacitive reactance and complex impedance
  - 3.1.4 Concept of time phase differences between various sinusoidal quantities
  - 3.1.5 Phasor concept and phasor representation of AC quantities
  - 3.1.6 Transformed impedances and network reduction
  - 3.1.7 Real, reactive and apparent power concepts

- 3.2 Three phase AC circuit
  - 3.2.1 Generation of three phase voltage
  - 3.2.2 Wye and delta connection

#### **4 Diodes (7 hours)**

- 4.1 Semiconductor diode characteristics
- 4.2 Modeling the semiconductor diode
- 4.3 Diode circuits: Clipper; Clamper circuits
- 4.4 Zener diode, LED, photodiode, Varactor diode, tunnel diodes
- 4.5 DC power supply: Rectifier-half wave, full wave (Center tapped, bridge), Zener regulated power supply

#### **5 Transistor (10 hours)**

- 5.1 BJT configuration and biasing, small and large signal model
- 5.2 T and  $\pi$  model
- 5.3 Concept of differential amplifier using BJT
- 5.4 BJT as switch and logic circuits
- 5.5 Construction and working principle of JFET, MOSFET and CMOS
- 5.6 MOSFET as logic circuits

#### **6 Operational Amplifier and Oscillator (6 hours)**

- 6.1 Basic model; Virtual ground concept; Inverting amplifier; Non-inverting amplifier; Integrator; Differentiator, summing amplifier and their applications
- 6.2 Basic feedback theory; Positive and negative feedback; Concept of stability; Oscillator
- 6.3 Waveform generator using op-amp for square wave, triangular wave, phase shift oscillator and Wien bridge oscillator for sinusoidal waveform

#### **Practical (45 hours)**

- 1. Familiarization with passive components, function generator and oscilloscope
- 2. Measurement of amplitude, frequency, time period using oscilloscope
- 3. Ohm's law, series, parallel circuits and calculate average, RMS value
- 4. Verification of KCL, KVL and network theorems
- 5. Maximum power transfer/ capacitor charging and discharging
- 6. Diode characteristics, rectifiers, Zener diodes
- 7. BJT characteristics and single stage amplifier
- 8. BJT, PMOS, NMOS and CMOS as switch
- 9. Inverting, non-inverting, summing and subtractor amplifier using Op-amp
- 10. Relaxation oscillator
- 11. Analog sensor and small projects

#### **Reference**

- 1. Boylestad, R. L., Nashelsky, L. (2008). Electronic devices and circuit theory (10th ed.). Pearson Education.

2. Floyd, T.L. (2011). Electronic devices (9th ed.). Pearson Education.
3. Sedra, A.S., Smith, K.C. (2014). Microelectronic circuits (7th ed.). Oxford University Press.
4. Cogdell, J.R. (1996). Foundations of electrical engineering (Latest Edition). Prentice Hall.

# ENGINEERING WORKSHOP

ENME 106

**Lecture : 1**  
**Tutorial : 0**  
**Practical : 3**

**Year : I**  
**Part : I**

## Course Objectives:

After completing this course, the students will be able to practice workshop safety rules effectively with different hand tools and machine tools for producing metal and sheet metal components. Acquire knowledge and practice on casting, forging, welding, soldering, brazing and riveting.

- 1 Safety Measures in the Workshop (1 hour)**
  - 1.1 Causes of accident
  - 1.2 Types of safety: General safety, personal safety, machine and equipment safety, job safety
- 2 Bench Work and Fittings (4 hours)**
  - 2.1 Fitting Tools: Types, uses of holding tools, sticking tools, cutting tools (Files, chisels, hacksaw), scrapping tools (Scrappers), drilling tools (Drill bits), measuring, marking and testing tools (Steel rule, calipers, divider, surface plate, scribe, surface gauge, punches, angle plate, try square, combination sets, vernier caliper, micrometer, bevel protractor, miscellaneous tools (Wrenches, screw drivers and pliers)
  - 2.2 Benchwork and fitting operation
  - 2.3 Filling operations, chipping operations and sawing operation
- 3 Thread Cutting (1 hour)**
  - 3.1 Classification of threads
  - 3.2 Thread cutting tools for hand threading
  - 3.3 Threading taps: Types, uses and care
  - 3.4 Threading dies: Types, uses and care
  - 3.5 Thread cutting by hand: Cutting internal and external thread
- 4 Sheet Metal (2 hours)**
  - 4.1 Introduction, sheet metal tools, sheet metal operation
  - 4.2 Rivet types, types of rivet joints, riveting tools and their uses, riveting procedure

**5 Machine Tools (2 hours)**

- 5.1 Lathes: Working principle, types of lathes, main parts of lathe, lathe operations (Facing, centre drilling, turning, knurling, boring, chamfering, thread cutting, counter sinking, counter boring)
- 5.2 Drilling Machine: Types of drilling machine, types of drill bits, drilling operations (Drilling, counter boring, reaming, tapping)

**6 Forging and Casting (1.5 hours)**

- 6.1 Introduction, forging tools, forging operations
- 6.2 Introduction, pattern making foundry tools, core making, sand casting process

**7 Welding (2.5 hours)**

- 7.1 Arc welding: Introduction, arc welding equipment and accessories, influencing factor in arc welding, methods of striking an arc (Tap, scratch), electrodes, types of joint, welding positions, TIG, MIG welding
- 7.2 Gas welding: Oxyacetylene gas welding, oxyacetylene gas welding accessories, filler rods, fluxes, types of flames and uses

**8 Brazing and Soldering (1 hour)**

- 8.1 Introduction, brazing equipment and materials, brazing process, surface clearing, joint design, support parts, brazing operations (Heating, filler metal applications, flux application, clearing after brazing)
- 8.2 Introduction, flux, soft solder and soldering process

**Practical (45 hours)**

- 1. Fitting Practice: Demonstration, usage of different types of hand tools and measuring instruments
- 2. Perform filing, sawing, drilling and tapping operations on given mild steel strip
- 3. Machining practice: Perform lathe operations
- 4. Welding Practice: Perform arc welding and oxyacetylene gas welding operations
- 5. Sheet metal practice: Perform sheet metal operations
- 6. Soldering and brazing
- 7. Electrical installations

**Reference**

- 1. Khurmi, R.S., Gupta, J.K. (2008). A Textbook of Workshop Technology. S. Chand Publishing.
- 2. Raghuwanshi, B.S. (1990). A Course in Workshop Technology, Volume II (machine tools). New Delhi: Dhanpat Rai & Company.

3. Choudhary, S.K.H., Choudhary, A.K.H. (2005). Elements of Workshop Technology Vol. I and II: Manufacturing Processes. Media promoter & publishers.
4. Khurmi, R. S., Gupta, J. K. (2008). A Textbook of Workshop Technology. S. Chand Publishing.
5. Rajput, R.K. (2007). A textbook of manufacturing technology: Manufacturing processes. Firewall Media.
6. Rao, K.V. (2002). Manufacturing Science and Technology-Manufacturing Processes and Machine Tools. New Age International.
7. Heinrich, G. (2006). All About Machine Tools. New Age International.



YEAR I, PART II

# Semester 2

6 COURSES IN THIS SEMESTER

|                 |                                  |           |
|-----------------|----------------------------------|-----------|
| <b>ENSH 151</b> | Engineering Mathematics II       | <b>29</b> |
| <b>ENCT 151</b> | Object Oriented Programming      | <b>32</b> |
| <b>ENEX 151</b> | Electronic Device and Circuits   | <b>36</b> |
| <b>ENEX 152</b> | Digital Logic                    | <b>39</b> |
| <b>ENEE 154</b> | Electrical Circuits and Machines | <b>43</b> |
| <b>ENSH 153</b> | Engineering Chemistry            | <b>48</b> |

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# ENGINEERING MATHEMATICS II

## ENSH 151

**Lecture** : 3  
**Tutorial** : 2  
**Practical** : 0

**Year** : I  
**Part** : II

### Course Objectives:

After completion of the course students will be able to apply knowledge of partial differentiation, multiple integrals, vector calculus, optimization, matrices and infinite series in their corresponding study area.

## 1 Calculus of Two and More Variables (6 hours)

- 1.1 Partial differentiation
  - 1.1.1 Partial derivatives of first and higher order
  - 1.1.2 Homogeneous function: Euler's theorem for two and three variables
  - 1.1.3 Total derivatives and differentials, differentiation of composite and implicit functions
  - 1.1.4 Jacobians and their properties
- 1.2 Extreme values of two and three variables. Lagrange's multiplier
- 1.3 Application in optimization of function of two variables in one constraint

## 2 Multiple Integrals (7 hours)

- 2.1 Double integrals in Cartesian and Polar form, change of order of integration
- 2.2 Triple integrals in Cartesian, cylindrical and spherical coordinates
- 2.3 Area, volume, moment of inertia, mass and centroid by double and triple integrals

## 3 Vector Calculus (12 hours)

- 3.1 Review of scalar and vector products, scalar and vector triple product, scalar and vector product of four vectors
- 3.2 Vector differentiation and integration, their geometrical meaning, velocity and acceleration
- 3.3 Vector differential operators: Gradient, directional derivatives, divergence and curl
- 3.4 Line integrals, independent of path, conservative and irrotational vector fields, scalar potential
- 3.5 Introduction to Green's theorem and its application
- 3.6 Surface integrals, calculation of flux

- 3.7 Volume integrals, Gauss divergence theorem (Without proof) and its application in evaluation of surface integrals
- 3.8 Introduction to Stoke's theorem and its application

#### **4 Laplace Transform (7 hours)**

- 4.1 Definition of Laplace transform, condition for existence, Laplace transforms of some elementary functions, properties of Laplace transform, shifting and change of scale properties
- 4.2 Inverse Laplace transform, uniqueness of inverse Laplace transform, properties of inverse Laplace transform
- 4.3 Laplace transform of derivatives and integral, multiplication and division by  $t^n$  the convolution theorem
- 4.4 Laplace transform of Heaviside's unit function, Dirac-delta function and periodic functions
- 4.5 Application of Laplace transform to ordinary differential equations

#### **5 Matrices (8 hours)**

- 5.1 Review of algebra of real and complex matrices
- 5.2 Rank of matrices and its application in system of linear equations
- 5.3 Vector space, linear dependence and independence
- 5.4 Eigen values: Cayley Hamilton theorem and its applications
- 5.5 Eigen vectors, diagonalization of matrices
- 5.6 Reduction of quadratic forms into canonical forms (Three variables only)

#### **6 Solution of Differential Equation in Series and Special Functions (5 hours)**

- 6.1 Power series method
- 6.2 Bessel's functions: Introduction, properties and application
- 6.3 Legendre's function: Introduction, properties and application

#### **Tutorial (30 hours)**

- 1. Techniques of partial differentiation, differentiation of composite and implicit functions, total derivatives, and related exercises
- 2. Exercises related to Euler's theorem
- 3. Exercises related to extreme values of two and three variables
- 4. Change of order of integration in multiple integrals
- 5. Exercises related to application of double and triple integrals in finding area, volume, moment of inertia, mass and centroid
- 6. Examples related to revision of scalar and vector product of two and three vectors
- 7. Problems on gradient, directional derivatives, divergence and curl
- 8. Exercises on line integrals, independent of path
- 9. Exercises on surface integrals
- 10. Exercises on Green's theorem, verification and application in calculating line integrals
- 11. Verification of Stoke's theorem, application

12. Verification of Gauss' Divergence theorem, and application in calculating surface integrals
13. Exercises related to Laplace transforms
14. Exercises on inverse Laplace transforms
15. Problems related to application of Laplace transform to ordinary differential equations
16. Examples related to Laplace transform of Heaviside's unit function, Dirac-delta function and periodic functions
17. Rank and solution of simultaneous equations
18. Eigen values and Eigen vectors, diagonalization problems
19. Problems related to reduction of quadratic forms into canonical forms
20. Exercises related to Bessel's function and Legendre's polynomial

### Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

| Chapter      | Hours     | Mark distribution* |
|--------------|-----------|--------------------|
| 1            | 6         | 8                  |
| 2            | 7         | 8                  |
| 3            | 12        | 18                 |
| 4            | 7         | 8                  |
| 5            | 8         | 12                 |
| 6            | 5         | 6                  |
| <b>Total</b> | <b>45</b> | <b>60</b>          |

\* There may be minor deviation in marks distribution.

### References

1. Kreyszig, E. (2011). Advanced engineering mathematics. John Wiley & Sons.
2. Jeffrey, A. (2002). Advanced engineering mathematics. Academic Press.
3. O'Neil, P.V. (2011). Advanced engineering mathematics. Cengage Learning.
4. Sastry, S.S. (2008). Engineering mathematics (Vols. I–II). PHI Learning.
5. Wylie, C.R, Barrett, L.C. (1995). Advanced engineering mathematics (Latest Edition). McGraw-Hill.
6. Dutta, D. (2006). Textbook of engineering mathematics (Vols. I–II). New Age International.

# OBJECT ORIENTED PROGRAMMING

ENCT 151

**Lecture** : 3  
**Tutorial** : 1  
**Practical** : 3

**Year : I**  
**Part : II**

## Course Objectives:

To provide students with foundation in understanding and applying principles of object oriented programming. Emphasis will be given on developing object oriented programming skills using C ++.

### 1 Introduction to Object Oriented Programming (3 hours)

- 1.1 History of programming languages
- 1.2 Need of object oriented programming(OOP)
- 1.3 Object oriented programming versus procedure oriented programming
- 1.4 Concepts of object oriented programming
- 1.5 Popular object oriented languages
- 1.6 Advantages of OOP
- 1.7 Disadvantages of OOP

### 2 Basics of C++ Programming (5 hours)

- 2.1 C++ Program structure
- 2.2 Character set and tokens
- 2.3 Variable declaration and expression
- 2.4 Data types
- 2.5 Type conversion and casting
- 2.6 User defined constant const
- 2.7 Reference variables
- 2.8 Conditions and looping
- 2.9 Namespace scope
- 2.10 Functions
  - 2.10.1 Function overloading
  - 2.10.2 Inline function
  - 2.10.3 Default arguments
  - 2.10.4 Pass by reference and return by reference
- 2.11 Array, pointer and string
- 2.12 Structure and unions
- 2.13 Enumeration
- 2.14 Dynamic memory allocation

### **3 Objects and Classes**

**(7 hours)**

- 3.1 C++ classes
- 3.2 Objects and the member access
- 3.3 Relation of object, class and memory
- 3.4 Defining member function
- 3.5 Defining outer function inline
- 3.6 Objects as member
- 3.7 Constructors and destructors
- 3.8 Object as function arguments
- 3.9 Returning objects from functions
- 3.10 Array of objects
- 3.11 Pointer to objects
- 3.12 Dynamic memory allocation for objects
- 3.13 Dynamic constructors
- 3.14 Pointer
- 3.15 Static data member and static member function
- 3.16 Constant member functions and constant objects
- 3.17 Friend functions and friend classes

### **4 Operator Overloading**

**(5 hours)**

- 4.1 Overloadable and non- overloadable operators
- 4.2 Syntax of operator overloading
- 4.3 Operator overloading using member operator functions
- 4.4 Operator overloading using non member functions
- 4.5 Unary operator overloading
- 4.6 Binary operator overloading
- 4.7 Type conversion between objects
- 4.8 Explicit constructors

### **5 Inheritance**

**(5 hours)**

- 5.1 Base class and derived class
- 5.2 protected access specifier
- 5.3 Derived class declaration
- 5.4 Is\_a relation and Has\_a relation
- 5.5 Public, protected and private inheritance
- 5.6 Member overriding
- 5.7 Forms of inheritance
- 5.8 Constructors in derived class
- 5.9 Destructor in derived class
- 5.10 Need of virtual base class

## **6 Virtual Functions**

**(4 hours)**

- 6.1 What is virtual function
- 6.2 Need of virtual function
- 6.3 Pointer to derived class
- 6.4 Array of pointers to base class
- 6.5 Pure virtual functions and abstract class
- 6.6 Virtual destructors
- 6.7 Reinterpret cast operator
- 6.8 Run-time type information

## **7 Stream Computation**

**(6 hours)**

- 7.1 Input/output stream class hierarchy
- 7.2 Testing stream errors
- 7.3 Unformatted input/output and formatted input/output
- 7.4 Stream operator overloading
- 7.5 File input/output with streams
- 7.6 File stream class hierarchy
- 7.7 ASCII and binary files
- 7.8 Read/Write from file
- 7.9 Sequential access to file
- 7.10 Random access to file
- 7.11 File access pointers and their manipulators
- 7.12 Testing errors during file operations
- 7.13 File input/output with member functions

## **8 Templates**

**(6 hours)**

- 8.1 Function template
- 8.2 Overloading function template
- 8.3 Class template
- 8.4 Derived class template
- 8.5 Introduction to standard template library
  - 8.5.1 Components of STL
  - 8.5.2 Container
  - 8.5.3 Iterators
  - 8.5.4 Algorithms

## **9 Exception Handling**

**(4 hours)**

- 9.1 Basics of exception handling
- 9.2 Advantage over conventional error handling
- 9.3 Exception handling mechanism
- 9.4 Multiple handlers
- 9.5 Catching all exceptions

- 9.6 Rethrowing exception
- 9.7 Exception with arguments
- 9.8 Exceptions specification for function
- 9.9 Exceptions in constructors and destructors
- 9.10 Handling uncaught exceptions
- 9.11 Handling unexpected exception

### **Tutorial (15 hours)**

After completing each chapter some problems are solved and students are asked to solve programming problems with the teacher's assistance.

### **Assignment**

Appropriate assignment problems are given to students after the completion of each chapter.

### **Practical (45 hours)**

There will be nine laboratory exercises encompassing the entire course content. At the end of the course, students are required to submit a programming project demonstrating the application of object-oriented programming concepts.

### **Final Exam**

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as possible as indicated in the table below:

| Chapter      | Hours     | Marks Distribution* |
|--------------|-----------|---------------------|
| 1            | 3         | 4                   |
| 2            | 5         | 7                   |
| 3            | 7         | 9                   |
| 4            | 5         | 7                   |
| 5            | 5         | 7                   |
| 6            | 4         | 5                   |
| 7            | 6         | 8                   |
| 8            | 6         | 8                   |
| 9            | 4         | 5                   |
| <b>Total</b> | <b>45</b> | <b>60</b>           |

\* There may be minor deviation in marks distribution.

### **References**

1. Schildt, H. (2015). C++: The Complete Reference. McGraw-Hill Education.
2. Baral, D.S., Baral, D. (2010). Secrets of Object Oriented Programming in C++. Bhundipuram Prakasan.
3. Lafore, R. (2002). Object Oriented Programming in C++. Sams Publishing.
4. Deitel, H.M., Deitel, P.J. (2007). C++ How to Program. Prentice Hall.

# ELECTRONIC DEVICE AND CIRCUITS

ENEX 151

**Lecture : 3**

**Tutorial : 1**

**Practical : 3**

**Year : I**

**Part : II**

## Course Objectives:

To introduce the fundamentals of analysis of electronic circuits and to provide basic understanding of semiconductor devices and analog integrated circuits.

### **1 The Bipolar Junction Transistor (BJT) (9 hours)**

- 1.1 Review of operation of the npn transistor in the active mode
- 1.2 Review of graphical representation of transistor characteristics
- 1.3 Analysis of transistor circuits at DC
- 1.4 Graphical DC load line analysis
- 1.5 Transistor as an amplifier (  $r_{\pi}$ ,  $r_e$ ,  $g_m$  )
- 1.6 Biasing BJT for discrete-circuit design
- 1.7 Small signal equivalent circuit models ( $\pi$  and T)
- 1.8 Basic single-stage BJT amplifier configuration (C-B, C-E, C-C)
- 1.9 Small signal analysis of amplifier
- 1.10 Transistor as a switch – cutoff and saturation
- 1.11 A general large-signal model of the BJT: The Ebers-Moll model

### **2 Field-Effect Transistor (10 hours)**

- 2.1 Structure and physical operation of the junction field-effect transistor
- 2.2 Structure and physical operation of enhancement-type MOSFET
- 2.3 Current-voltage characteristic of enhancement-type MOSFET
- 2.4 The depletion-type MOSFET
- 2.5 Biasing in MOS amplifier circuits
- 2.6 MOSFET circuits at DC
- 2.7 MOSFET as an amplifier (Common source)
- 2.8 MOSFET and CMOS as logic circuits

### **3 Operational Amplifier Circuits and Oscillator (10 hours)**

- 3.1 Review of basic principles of sinusoidal oscillator
- 3.2 Review of Op-Amp square and triangular, RC oscillator circuits
- 3.3 LC and crystal oscillators
- 3.4 Integrated circuit timers
- 3.5 Precision rectifier circuits
- 3.6 Bias circuits suitable for IC design
- 3.7 The Widlar current source

- 3.8 The differential amplifier
- 3.9 Active loads
- 3.10 Output stages

#### **4 Output Stages and Power Amplifiers (10 hours)**

- 4.1 Classification of output stages
- 4.2 Class A output stage
- 4.3 Class B output stage
- 4.4 Class AB output stage
- 4.5 Biasing of class AB output stage
- 4.6 Power BJT's
- 4.7 Transformer-coupled push-pull stage
- 4.8 Tuned amplifiers

#### **5 Power Supplies, Breakdown Diodes, and Voltage Reference (6 hours)**

- 5.1 Unregulated power supply
- 5.2 Zener regulated power supply
- 5.3 Zener diodes, bandgap voltage reference, constant current diodes
- 5.4 Transistor shunt/series voltage regulator
- 5.5 Improving voltage regulator performance with feedback
- 5.6 IC voltage regulator

#### **Tutorial (15 hours)**

The tutorial sessions will focus on chapter-specific exercises aimed at enhancing understanding and application in electronic device and circuits.

#### **Practical (45 hours)**

1. Diode characteristics, rectifiers, Zener diodes
2. Bipolar junction transistor characteristics and single stage amplifier
3. BJT single stage amplifier ( $R_{in}$ ,  $R_{out}$ , Gain)
4. Power amplifiers
5. Field effect transistor characteristics
6. FET single stage amplifier
7. BJT differential amplifier
8. Relaxation oscillator and sinusoidal oscillator (Phase shift, Wien bridge)
9. Series, shunt and IC voltage regulators
10. Multivibrator using 555 timer IC
11. Project presentation

#### **Final Exam**

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

| <b>Chapter</b> | <b>Hours</b> | <b>Mark distribution*</b> |
|----------------|--------------|---------------------------|
| 1              | 9            | 12                        |
| 2              | 10           | 13                        |
| 3              | 10           | 13                        |
| 4              | 10           | 13                        |
| 5              | 6            | 9                         |
| <b>Total</b>   | <b>45</b>    | <b>60</b>                 |

\* There may be minor deviation in marks distribution.

## References

1. Sedra, A.S., Smith, K.C. (2010). Microelectronic circuits. Oxford University Press.
2. Boylestad, R.L., Nashelsky, L. (2013). Electronic devices and circuit theory. Pearson.
3. Floyd, T. L. (2013). Electronic devices. Pearson Education Limited.
4. Millman, J., Halkias, C., Parikh, C.D. (2010). Integrated electronics: Analog and digital circuits and systems. Tata McGraw-Hill Education.
5. Bell, D.A. (2009). Electronic devices and circuits. Oxford University Press.

# DIGITAL LOGIC

ENEX 152

**Lecture : 3**

**Tutorial : 1**

**Practical : 3**

**Year : I**

**Part : II**

## Course Objectives:

This course mainly focuses on study, analyze basic principle, design and applications of digital circuitries in various fields. It also shows an important branch of the electronics that revolutionizes the modern digital world.

### **1 Introduction (5 hours)**

- 1.1 Digital versus analog signals
- 1.2 Logic level diagram
- 1.3 Digital integrated circuits (ICs)
- 1.4 Clock triggering systems
- 1.5 Digital system applications
- 1.6 Digital codes and conversions
  - 1.6.1 Decimal, binary, octal and hexadecimal codes
  - 1.6.2 BCD code
  - 1.6.3 Excess-3 code
  - 1.6.4 Gray code
  - 1.6.5 Examples of code conversions
- 1.7 Alphanumeric codes: ASCII code and EBCDIC code
- 1.8 1's complement and 2's complement
- 1.9 Signed number representation

### **2 Logic Gates (3 hours)**

- 2.1 Basic gates and their equivalents
- 2.2 Universal gates and their equivalents
- 2.3 Exclusive gates and their equivalents
- 2.4 Positive and negative logic
- 2.5 De'Morgan's laws
- 2.6 Applications of logic gates

### **3 Boolean Algebra and K-Maps (4 hours)**

- 3.1 Boolean algebra and its laws
- 3.2 Simplifications of Boolean expressions
- 3.3 Minterms and maxterms
- 3.4 Sum-of-product and product-of-sum methods

- 3.5 Truth tables and Karnaugh map
- 3.6 Four variables K-maps.
- 3.7 Cell, pairs, quads and octets
- 3.8 Rolling, envelop effects and redundant groups
- 3.9 Don't care conditions

## **4 Combinational Logic Circuits (8 hours)**

- 4.1 Design procedures
- 4.2 Half-adder and full-adder
- 4.3 Half-subtractor and full-subtractor
- 4.4 Ripple carry adders and fast adders
- 4.5 Multiplexers design
- 4.6 Demultiplexers design
- 4.7 Basic encoders
- 4.8 Priority encoders
- 4.9 Encoder designs
- 4.10 Decoder designs
- 4.11 BCD-to-decimal decoder
- 4.12 Seven-segment decoder
- 4.13 Magnitude comparators

## **5 Sequential Logic Circuits (5 hours)**

- 5.1 Latches and flip-flops: SR, D, T and JK
- 5.2 Excitation tables, characteristic equations
- 5.3 Master-slave flip-flops
- 5.4 Flip-flop timing diagrams
- 5.5 Flip-flops as the state machines
- 5.6 Flip-flop conversions
- 5.7 Flip-flop applications

## **6 Registers and Counters (7 hours)**

- 6.1 Register fundamentals, register types
- 6.2 SISO, SIPO, PISO and PIPO registers
- 6.3 Data transfer timing diagrams
- 6.4 Asynchronous counters
- 6.5 Up, down and mod-n asynchronous counters
- 6.6 Synchronous counters
- 6.7 Up, down and mod-n synchronous counters
- 6.8 Register and counter applications

## **7 Sequential Machine Designs (8 hours)**

- 7.1 Machine design procedures

- 7.2 Primitive state diagrams
- 7.3 Transition/flow tables
- 7.4 Redundant states
- 7.5 Pure binary assignment tables
- 7.6 Excitation maps
- 7.7 Realization of the models
- 7.8 Circuit diagram of synchronous machine
- 7.9 One-bit and two-bit input sequence detectors

## **8 Digital Integrated Circuits**

**(5 hours)**

- 8.1 BJT and MOSFET switching circuits
- 8.2 TTL parameters
- 8.3 TTL circuits: NAND, NOT, NOR
- 8.4 CMOS parameters
- 8.5 CMOS logic circuits: NAND, NOR, NOT
- 8.6 Three-state TTL devices
- 8.7 Digital devices applications
  - 8.7.1 Multiplexing displays
  - 8.7.2 Frequency counters
  - 8.7.3 Time measurements

## **Tutorial**

**(15 hours)**

- 1. Different code conversion examples
- 2. Sign numbers addition and subtraction
- 3. Realization of positive and negative logic gates
- 4. Application of Boolean algebra and K-map for various logic designs
- 5. Multiplexer tree concepts
- 6. Realization of adder/subtractor using multiplexers
- 7. Demultiplexer tree concepts
- 8. Realization of adder/subtractor using demultiplexers
- 9. 16 - to – 4 line encoder design
- 10. Octal and decimal priority encoder designs
- 11. 4– to – 16 line decoder design
- 12. BCD-to-decimal decoder design
- 13. Any segment of 7-segment decoder design
- 14. Concept of designing n-bit magnitude comparator
- 15. Flip-flop conversion from one flip-flop to another type
- 16. Shift register timing diagram practice
- 17. Ripple counter design concept
- 18. Decade synchronous counter design
- 19. Up and down counter in a single circuit
- 20. 3-bit and 4-bit binary sequence detector synchronous machine design

## **Practical**

**(45 hours)**

- 1. Basic gates, universal gates and exclusive gates

2. De' Morgan's law and its familiarization with NAND and NOR Gates
3. Encoders and decoders
4. Multiplexers and demultiplexers
5. Binary addition and subtraction
6. Latches, RS, and T flip-flops.
7. D and JK flip-flop and master-slave flip-flop
8. Shift registers
9. Circuit realizations on ripple counters
10. Circuit realizations on synchronous counters

### Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

| Chapter      | Hours     | Marks distribution* |
|--------------|-----------|---------------------|
| 1            | 5         | 7                   |
| 2            | 3         | 4                   |
| 3            | 4         | 5                   |
| 4            | 8         | 10                  |
| 5            | 5         | 7                   |
| 6            | 7         | 10                  |
| 7            | 8         | 10                  |
| 8            | 5         | 7                   |
| <b>Total</b> | <b>45</b> | <b>60</b>           |

\* There may be minor deviation in marks distribution.

### References

1. Floyd, T. L. (2015). Digital fundamentals. Pearson Education.
2. Mano, M. M. (1995). Digital design (Latest Edition). Prentice Hall.
3. Leach, D.P., Malvino, A.P., Saha, G. (2012). Digital principles and applications. Tata McGraw-Hill Education.
4. Fletcher, W.I. (1980). An engineering approach to digital design (Latest Edition). Prentice-Hall.
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# ELECTRICAL CIRCUITS AND MACHINES

ENEE 154

**Lecture** : 4  
**Tutorial** : 1  
**Practical** : 3/2

**Year** : I  
**Part** : II

## Course Objectives:

To develop a comprehensive understanding of electric circuit theory and analysis techniques, alongside the principles and operation of electric machines including transformers, DC and AC machines.

### 1 Transients in Electric Circuit (7 hours)

- 1.1 Characteristics of various network elements
- 1.2 Nodal analysis with dependent and independent sources
- 1.3 Mesh analysis with dependent and independent sources
- 1.4 Application of matrix method in network analysis
- 1.5 Procedure of evaluating initial conditions
- 1.6 Initial values of derivatives
- 1.7 Initial condition in the case of R-L-C network

### 2 Transient Analysis R-L-C Circuit by Classical Method (10 hours)

- 2.1 Introduction
- 2.2 First order differential equation with constant coefficient
- 2.3 Higher order homogenous and non-homogenous differential equation with constant coefficient
- 2.4 Particular integral by method of undetermined coefficient
- 2.5 Response of R-L and R-C circuits with DC excitation
  - 2.5.1 DC excitation
  - 2.5.2 Exponential excitation
  - 2.5.3 Sinusoidal excitation
- 2.6 Response of Series R-L-C circuits with
  - 2.6.1 DC excitation
  - 2.6.2 Exponential excitation
  - 2.6.3 Sinusoidal excitation
- 2.7 Response of Parallel R-L-C circuits with
  - 2.7.1 DC excitation
  - 2.7.2 Exponential excitation

- 3 Transient Analysis Using Laplace Transform (7 hours)**
- 3.1 Introduction
  - 3.2 Response of R-L and R-C circuits with
    - 3.2.1 DC excitation
    - 3.2.2 Exponential excitation
    - 3.2.3 Sinusoidal excitation
  - 3.3 Response of series R-L-C circuits with
    - 3.3.1 DC excitation
    - 3.3.2 Exponential excitation
    - 3.3.3 Sinusoidal excitation
  - 3.4 Response of parallel R-L-C circuits with
    - 3.4.1 DC excitation
    - 3.4.2 Exponential excitation
- 4 Network Transfer Function and Frequency Response (8 hours)**
- 4.1 Concept of complex frequency
  - 4.2 Transfer functions of two port networks
  - 4.3 Poles and zeros of networks
  - 4.4 Magnitude and phase response
  - 4.5 Bode diagrams
  - 4.6 Band width, high-q and low-q circuits
  - 4.7 Basic concept of filters: High-pass, low-pass, band-stop and band-pass filters
- 5 Two-Port Parameters of Network (8 hours)**
- 5.1 Definitions of two-port networks
  - 5.2 Parameters of two-port networks
    - 5.2.1 Open circuit impedance parameters
    - 5.2.2 Short circuit admittance parameters
    - 5.2.3 Transmission line parameters
    - 5.2.4 Inverse transmission line parameters
    - 5.2.5 Hybrid parameters
    - 5.2.6 Inverse hybrid parameters
  - 5.3 Relationship and transformation between sets of parameters
  - 5.4 Interconnection of two port networks
  - 5.5 Condition for reciprocity and symmetry
- 6 Magnetic Circuit and Induction (3 hours)**
- 6.1 Magnetic circuit and its types
  - 6.2 B-H relationship and hysteresis with DC excitation
  - 6.3 Hysteresis with AC excitation
  - 6.4 Hysteresis loss and Eddy current loss

- 6.5 Faraday's law of electromagnetic induction, statically and dynamically induced EMF
- 6.6 Force on current carrying conductor

## **7 Transformers (6 hours)**

- 7.1 Construction, operating principle and EMF equation of single-phase transformer
- 7.2 No load and load operation of transformer
- 7.3 Equivalent circuit diagram of transformer
- 7.4 Transformer testing (Open circuit and short circuit)
- 7.5 Voltage regulation, losses, efficiency and condition for maximum efficiency
- 7.6 Auto transformer, Isolation transformer

## **8 DC Machine (5 hours)**

- 8.1 Constructional details of DC machine
- 8.2 Operating principle and EMF equation of DC generator
- 8.3 Operating principle and torque equation of DC motor
- 8.4 Types of DC machine
- 8.5 Back EMF and its role in DC motor
- 8.6 Performance characteristics of DC motor
- 8.7 Starting of DC motor using 3-point starter
- 8.8 Speed control of DC motor (Armature control, field control)
- 8.9 Losses and efficiency

## **9 AC Motor (6 hours)**

- 9.1 Construction, production of rotating magnetic field and operating principle of three-phase induction motor
- 9.2 Torque equation of three-phase induction motor at standstill and running condition
- 9.3 Torque slip characteristics, condition for maximum torque and effect of rotor resistance on torque slip characteristics
- 9.4 Single-phase induction motor
- 9.5 Double field revolving theory
- 9.6 Starting of single-phase induction motor (Capacitor start and run, shaded pole)
- 9.7 Introduction to permanent magnet brushless DC motor, hysteresis motor, stepper motor, servo motor, universal motor

## **Tutorial (15 hours)**

The tutorial sessions will focus on chapter-specific exercises aimed at enhancing understanding and application in electrical circuits and machines.

## **Practical (22.5 hours)**

- 1. Transient response in first order system passive circuit

- Measure step and impulse response RL and RC circuit using oscilloscope
- Relate time response to analytical transfer function calculation
- 2. Transient response in second order system passive circuit
  - Measure step and impulse response RLC series and parallel circuit using oscilloscope
  - Relate time response to analytical transfer function and pole-zero configuration
- 3. Two port network
  - To calculate and verify 'ABCD' parameters of two-port network
  - To determine equivalent parameters of parallel connection of two-port network
- 4. Two winding transformers
  - Measure amplitude and phase response and plot Bode diagram for RLC circuits
  - To perform open circuit (OC) and short circuit (SC) test to determine
- 5. DC motor
  - speed control of DC Shunt motor by (a) armature control method (b) field control method
  - To observe the effect of increasing load on DC shunt motor's speed, armature current and field current
- 6. Single phase AC motors
  - To study the effect of a capacitor on the starting and running of a single-phase induction motor
  - Reversing the direction of rotation of a single-phase capacitor start induction motor

### Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

| Chapter      | Hours     | Mark distribution* |
|--------------|-----------|--------------------|
| 1            | 7         | 7                  |
| 2            | 10        | 10                 |
| 3            | 7         | 7                  |
| 4            | 8         | 8                  |
| 5            | 8         | 8                  |
| 6            | 3         | 3                  |
| 7            | 6         | 6                  |
| 8            | 5         | 5                  |
| 9            | 6         | 6                  |
| <b>Total</b> | <b>60</b> | <b>60</b>          |

\* There may be minor deviation in marks distribution.

## References

1. Van Valkenburg, M. E. (2019). Network analysis. Pearson Education.
2. Hayt, W.H., Kemmerly, J.E., Phillips, J.D., Durbin, S.M. (2019). Engineering circuit analysis. McGraw-Hill Education.
3. Ciletti, M.D. (1995). Introduction to circuit analysis and design (Latest Edition). Oxford University Press.
4. Soni, K.M. (2013). Circuits and systems. S. K. Kataria & Sons.
5. Nagrath, F.I.J., Kothari, D.P. (2017). Electric machines. McGraw Hill Education.
6. Fitzgerald, A.E., Kingsley, C. (2017). Electric machinery. McGraw Hill Education.
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8. Hussain, A. (2016). Electrical machines. Dhanpat Rai & Co.

# ENGINEERING CHEMISTRY

ENSH 153

**Lecture : 3**  
**Tutorial : 1**  
**Practical : 3**

**Year : I**  
**Part : II**

## Course Objectives:

To develop the basic concepts of physical chemistry, inorganic chemistry, analytical chemistry, environmental chemistry, green and sustainable chemistry, nano chemistry, polymer chemistry and organic chemistry relevant to the different disciplines of engineering.

### 1 Electrochemistry and Buffer

(8 hours)

- 1.1 Electrochemistry
  - 1.1.1 Introduction
  - 1.1.2 EMF of galvanic cell, Nernst equation
  - 1.1.3 Polarization and overpotential
  - 1.1.4 Butler-Volmer equation and Tafel plots
- 1.2 Electrode processes and mechanisms (Qualitative only)
  - 1.2.1 Charge transfer processes at electrodes
  - 1.2.2 Mass transfer and diffusion in electrochemical systems
- 1.3 Industrial and applied electrochemistry
  - 1.3.1 Batteries: Lead acid and lithium ion
  - 1.3.2 Solar-photovoltaic cell (With typical examples), fuel cell
  - 1.3.3 Corrosion
- 1.4 Buffer, buffer range, buffer capacity and buffer solution (Henderson-Hasselbalch equation) and its applications

### 2 Catalyst and Catalysis

(4 hours)

- 2.1 Definition and types
- 2.2 Design and criteria
  - 2.2.1 Structure-activity relationships
  - 2.2.2 Selection criteria of catalyst
- 2.3 Photocatalysis and electrocatalysis
- 2.4 Catalysis for energy and environmental applications
  - 2.4.1 Catalytic conversion of fossil fuels
  - 2.4.2 Renewable energy catalysts
  - 2.4.3 Catalyst for pollution control

- 3 Analytical Techniques and their Applications (6 hours)**
- 3.1 Chromatography
  - 3.2 Mass spectroscopy
  - 3.3 X-ray diffraction (XRD)
  - 3.4 UV-visible spectroscopy
  - 3.5 Infrared-spectroscopy (IR)
  - 3.6 Nuclear magnetic resonance spectroscopy (NMR)
- 4 Metal Complexes, Rare Earth Elements and Metal alloys (6 hours)**
- 4.1 Complexes
    - 4.1.1 Introduction and Werner's theory
    - 4.1.2 Geometry of complex by VBT and its applications
    - 4.1.3 Crystal field theory: Principle and applications
  - 4.2 Rare earth elements: Introduction and applications
  - 4.3 Metallic alloys and applications
- 5 Sustainable Chemistry (7 hours)**
- 5.1 Green chemistry: Introduction and principles
  - 5.2 Water chemistry
    - 5.2.1 Importance of water quality standards
    - 5.2.2 Degree of hardness, scale formation in boiler and softening of hard water
    - 5.2.3 Water pollution with reference to turbidity, COD, BOD, heavy metals, radioactive substances, and plastic
    - 5.2.4 Industrial wastewater and its treatment
  - 5.3 Air pollution: Particulate matter, SO<sub>x</sub>, NO<sub>x</sub>, GHGs, VOCs, their impacts and remedies
  - 5.4 Waste management
    - 5.4.1 Segregation and management of solid waste
    - 5.4.2 Management of biodegradable waste into energy
    - 5.4.3 E-waste and its management
- 6 Nanoscience and Nanotechnology (3 hours)**
- 6.1 Introduction and types of nano materials (0-, 1-, 2-, and 3- dimensional)
  - 6.2 Nanoparticles, nanofibers, nanowires, carbon nanotubes, graphene, mxene, quantum dots, and their uses
  - 6.3 Preparation of nanomaterials
- 7 Engineering Materials (7 hours)**
- 7.1 Polymers
    - 7.1.1 Natural and synthetic, organic and inorganic, conducting and non-conducting

- 7.1.2 Types of polymerizations: Addition and condensation polymerization
- 7.1.3 Preparation and applications of epoxy resin, polyurethane, Kevlar, polycarbonate, polymethyl methacrylate, polyacrylonitrile, silicones; Phosphorus based polymer, Sulphur based polymer
- 7.1.4 Conducting polymers: Synthesis and application
- 7.1.5 Composite: Fiber reinforced polymer
- 7.1.6 Natural polymers: Cellulose, chitin, chitosan, collagen
- 7.2 Cement: Hydration and setting chemistry of cement

## **8 Explosives, Lubricants and Paints**

**(4 hours)**

- 8.1 Explosives
  - 8.1.1 Types of explosives: Primary, low and high explosives
  - 8.1.2 Preparation and applications of TNT, TNG, Nitrocellulose and plastic explosives
- 8.2 Lubricants: Introduction, function and classification
- 8.3 Paints
  - 8.3.1 Introduction, requisites, types and applications
  - 8.3.2 Environmental and health impact

## **Tutorial**

**(15 hours)**

- 1. Introduction to cells, electroplating, EMF, electric double layer, problems related to buffer and Nernst equations
- 2. Types of catalyst and types of catalysis
- 3. Electromagnetic radiation, electromagnetic spectrum, electromagnetic wave, principles of spectroscopy, types of molecular spectra
- 4. Complexes, ligands, postulates, compounds with coordination number 4 and 6, splitting of octahedral and tetrahedral complexes and rare earth elements
- 5. Application of green chemistry and industrial waste management
- 6. Application of nanomaterials in pollution minimization
- 7. Introduction and stabilization of free radical, carbocation and carbanion.
- 8. Exothermic reaction of cement and its applications
- 9. Introduction of and applications of explosives, lubricants and paints

## **Practical**

**(45 hours)**

- 10. Determination of total, temporary and permanent hardness of water sample using complexometric titration
- 11. Determination of the alkalinity of water sample A and B by double indicator titration
- 12. Estimation of the amount of residual chlorine in water by iodometric titration
- 13. Preparation of the standard buffer solution (Acidic or basic) and measure the approximate pH of given unknown solution by using Universal Indicator

14. Comparison of the cleansing power of two sample of detergents by determining the reduction they cause in surface tension of water
15. Construction of Daniell cell and study of the variation of cell potential with concentration
16. Separation of the pigments through the process of paper / thin layer chromatography
17. Determination of total iron in ground water using spectrophotometer technique
18. Determination of amount of copper and iron in a given mixture solution by  $K_2Cr_2O_7$  titration
19. Preparation of cross – linked polymer by condensation polymerization method
20. Standardize potassium permanganate solution and use it to estimate the amount of Iron and determine the percentage purity in the sample of ferrous salt solution
21. Preparation of Ni-DMG complex and estimation of the amount of nickel

### Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

| Chapter | Hours | Marks Distribution* |
|---------|-------|---------------------|
| 1       | 8     | 10                  |
| 2       | 4     | 5                   |
| 3       | 6     | 5                   |
| 4       | 6     | 10                  |
| 5       | 7     | 10                  |
| 6       | 3     | 5                   |
| 7       | 7     | 10                  |
| 8       | 4     | 5                   |
| Total   | 45    | 60                  |

\*There may be minor deviation in mark distribution

### References

1. Maron, S. H., Prutton, C. F. (1965). Principles of Physical Chemistry (Latest Edition). Macmillan.
2. Lee, J.D. (2007). Concise Inorganic Chemistry. John Wiley & Sons.
3. Madan, R.D., Prakash, S. (1994). Inorganic Chemistry (Latest Edition). S. Chand & Company Ltd.
4. Bahl, S., Tuli, G.D., Bahl, A. (2009). Essentials of Physical Chemistry. S. Chand & Co. Ltd.
5. Bhagi, A. K., Morrison, G. R. T., Boyd, R. N. (2008). Organic Chemistry. Prentice-Hall of India.
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7. Vogel. (2008). Vogel's Textbook of Quantitative Chemical Analysis. Pearson Education.
8. Murthy, B. S., Shankar, P., Baldev, R., Rath, B. B., Murday, J. (2012). Textbook of nanoscience and nanotechnology. Universities Press.
9. Chatwal, G.R. (2023). Textbook of Environmental Chemistry. Himalaya Publishing House.



YEAR II, PART I

# Semester 3

## 6 COURSES IN THIS SEMESTER

|                 |                                     |           |
|-----------------|-------------------------------------|-----------|
| <b>ENSH 201</b> | Engineering Mathematics III         | <b>54</b> |
| <b>ENSH 204</b> | Communication English               | <b>57</b> |
| <b>ENCT 201</b> | Computer Graphics and Visualization | <b>60</b> |
| <b>ENEX 201</b> | Microprocessors                     | <b>64</b> |
| <b>ENEX 202</b> | Advanced Electronics                | <b>68</b> |
| <b>ENEE 204</b> | Control System                      | <b>72</b> |

3

# ENGINEERING MATHEMATICS III

ENSH 201

Lecture : 3  
Tutorial : 2  
Practical : 0

Year : II  
Part : I

## Course Objectives:

The objective of this course is to equip students with understanding and practical application of Fourier series, Fourier transform, function of complex variable, partial differential equations and obtaining mathematical models and Z- transform.

### 1 Fourier Series and Fourier Transform (12 hours)

- 1.1 Review of periodic, odd and even functions
- 1.2 Fourier series of a function over an interval of length  $2\ell$  and  $2\pi$ ; Euler's formula, Dirichlet's condition for uniform convergence of Fourier series, Fourier series of discontinuous functions
- 1.3 Half range Fourier sine and cosine series
- 1.4 Complex form of Fourier series; frequency and amplitude of a function
- 1.5 Fourier integral theorem, Fourier sine and cosine integrals, complex form of Fourier integral
- 1.6 Fourier transform, Fourier sine transform, Fourier cosine transform and their inversion formulas
- 1.7 Fourier transform of the derivative of a function
- 1.8 Relation between Fourier and Laplace transform

### 2 Functions of Complex Variable (12 hours)

- 2.1 Intuitive idea of limit, continuity and differentiability of functions of complex variable
- 2.2 Analytic functions, the Cauchy Reimann equations both in Cartesian and polar form, construction of analytic functions
- 2.3 Harmonic functions, the orthogonal system
- 2.4 Application of analytic functions in flow problems
- 2.5 Transformation (Mapping), conformal mapping, translation, rotation and magnification; inversion, bilinear transformation
- 2.6 Complex integration, simply and multiply connected regions, Cauchy's integral theorem and formula
- 2.7 Series of complex terms, power series, circle of convergence and radius of convergence, Taylor's and Laurent's series
- 2.8 Zeros, singularities, poles; residue at poles, Cauchy's residue theorem and evaluation real and improper integrals

- 3 Partial Differential Equations (5 hours)**
- 3.1 Definition and formation of partial differential equations
  - 3.2 Partial differential equations solvable by direct integration
  - 3.3 Linear partial differential equation of the first order, Lagrange's linear equations and their solution
  - 3.4 Nonlinear partial differential equation of first order; equations of the form  $f(p, q) = 0$ ,  $z = px + qy + f(p, q)$ ,  $f(z, p, q) = 0$ ,  $f_1(x, p) = f_2(y, q)$
  - 3.5 Charpit's method of solving nonlinear partial differential equations of first order
- 4 Modelling through Partial Differential Equation (10 hours)**
- 4.1 Second order partial differential equation and classification
  - 4.2 One-dimensional wave equation
  - 4.3 One-dimensional heat equation
  - 4.4 Two-dimensional heat equation, Laplace equation in Cartesian form
  - 4.5 Mass balance equation; equation of continuity in fluid dynamics, Navier-Stoke's equation
  - 4.6 Momentum balance equation; Euler's equation of motion for inviscid fluid flow
- 5 Z- transform and its Applications (6 hours)**
- 5.1 Representation of a sequence and basic operations
  - 5.2 Definition and existence of Z-transform, Z-transform of standard sequences
  - 5.3 Properties of Z-transform; linearity, change of scale, shifting properties, initial and final value theorems
  - 5.4 Differentiations of Z-transform
  - 5.5 Inverse Z-transform; partial fraction and residue methods
  - 5.6 Convolution of sequences, convolution of Z- transform
  - 5.7 Difference equations, application of Z-transform to solve difference equations and to find the sum of series
- Tutorial (30 hours)**
1. Problems related to find period and identify odd and even functions
  2. Exercises on Fourier series representation over intervals  $2l$  and generalization into  $2\pi$
  3. Exercises related to Fourier series for discontinuous functions
  4. Exercises related to half range Fourier series
  5. Exercises related to complex form of Fourier series
  6. Exercises related to Fourier integral, Fourier sine and cosine integral
  7. Exercises related to Fourier transform, Fourier sine and cosine transform and inversion
  8. Exercises related to Fourier transform of derivatives and boundary value problems.

9. Exercises on application of C-R equations and construction of analytic functions
10. Exercises on application of analytic functions to flow problems
11. Exercises on mapping covering example of each mapping
12. Exercises on application of Cauchy integral theorem and formula
13. Exercises related to expansion of a function in Taylor and Laurent series
14. Exercises related to complex integration by using Cauchy's residue theorem
15. Exercises on solution of partial differential equation by direct integration
16. Exercises related to Lagrange's equation and PDE's as mentioned in 3.4
17. Exercises related to solution of one dimensional wave equation, one dimensional heat equation, two dimensional equation
18. Exercises related to Z-transform, application of properties
19. Exercises related to inverse Z-transform
20. Exercises related to solve difference equations by Z-transform
21. Exercises related to find sum of series by Z- transform

### Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

| Chapter      | Hours     | Marks distribution* |
|--------------|-----------|---------------------|
| 1            | 12        | 18                  |
| 2            | 12        | 18                  |
| 3            | 5         | 6                   |
| 4            | 10        | 10                  |
| 5            | 6         | 8                   |
| <b>Total</b> | <b>45</b> | <b>60</b>           |

\* There may be minor deviation in marks distribution.

### References

1. Jeffery A. (2002). Advanced Engineering Mathematics (2nd edition). San Diego: Harcourt Academic Press.
2. O'Neill, P.V. (2011). Advanced Engineering Mathematics (7th edition). India: Thompsons, USA/Baba Baghanath Printers.
3. Kreyszig, A. (2020). Advanced engineering Mathematics (10th edition). USA: Wiley Publications.
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6. Dutta, D. (2006). A text book of Engineering Mathematics Vol I and II (2nd edition). India: New Age International Publishers.
7. Ogata, K. (2015). Discrete Time Control System (2nd edition). Pearson Publications.
8. Sharma, Sanjay. (2017). Signals and Systems (9th edition). India: S.K.Kataria and Sons.

# COMMUNICATION ENGLISH

## ENSH 204

**Lecture** : 3  
**Tutorial** : 0  
**Practical** : 1

**Year : II**  
**Part : I**

### Course Objectives:

The general objective of this course is to focus on English as a communication tool. Specifically, it emphasizes using English for professional communication for engineering works. It aims to increase English language ability to use appropriate research formats and methodology, develop concept papers, prepare research proposals and abstracts, set research questions, write a literature review, determine a research gap, link ideas, write technical proposals, prepare formal and informal reports and engage in project works, seminars/conferences.

- 1 Technical Communication (2 hours)**
  - 1.1 Definition, nature and scope of technical communication
  - 1.2 Professional ethics in communication (Ethical issues, plagiarism and copyright concerns, honesty, transparency and clarity)
- 2 Writing Skills (8 hours)**
  - 2.1 Principles of effective technical writing (Clarity, conciseness and coherence)
  - 2.2 Grammar (Pronoun and its antecedent, subject-verb agreement, non-finite verbs), sentence construction (Simple, compound, complex, and mixed sentences), error analysis and punctuation
  - 2.3 Bias-free language guideline, reducing bias
- 3 Technical Writing (15 hours)**
  - 3.1 Technical proposals (Purpose, types, structure, key considerations and examples)
  - 3.2 Research proposals and reports (Title page, table of contents, summary and abstract)
  - 3.3 Technical reports (Progress, feasibility and case study)
  - 3.4 Manuscript for journal (Structure, key considerations and examples)
  - 3.5 Citation and referencing (In-text citation, direct quote citations, indent citation, indirect citation, citing from books and journals, citing multiple authors in a single text, citing multiple texts from the same author, using numerical, pagination, preparing a reference page)

**4 Business Correspondence (10 hours)**

- 4.1 Writing formal letters (Applications, inquiries, complaints and orders)
- 4.2 E-mails (Structure, etiquette, and tone)
- 4.3 Notice, minutes and memos
- 4.4 Resume and cover letter
- 4.5 Press release/communique
- 4.6 Calling tender and responding to it

**5 Listening and Oral Communication (4 hours)**

- 5.1 Active listening (Barriers and strategies)
- 5.2 Effective speaking skills (Clarity, tone and pace)
- 5.3 Oral presentation skills (Structuring a presentation and handling questions)
- 5.4 Group discussions (Strategies and active participation)
- 5.5 Public speaking and speech delivery techniques

**6 Use of Visual Aids in Communication (6 hours)**

- 6.1 Tables
- 6.2 Graphs
- 6.3 Charts
- 6.4 Diagrams

**Practical (15 hours)**

- 1. Listening skill test
- 2. Visual skill test
- 3. Reading skill test
- 4. Oral communication test
- 5. Presentation skill test
- 6. Research proposals and project proposals
- 7. Team-based technical writing and presentations
- 8. Presentation on the prescribed texts
  - 8.1 "Which is More Important When Designing a Building: Beauty or Function?" from Unlock: Reading and Writing Skills by Chris Sowton
  - 8.2 On Being Modern-minded (Bertrand Russell)
  - 8.3 A Fable of Tomorrow" from The Silent Spring by Rachel Carson
  - 8.4 Religion and Science (From The World as I See It- Albert Einstein)
  - 8.5 "The Tamarisk Hunter" from Metatropolis by Paolo Bacigalupi
  - 8.6 Artificial Intelligence from The Art of Doing Science and Engineering by Richard W. Hamming
  - 8.7 Guglielmo Marconi and the History of Radio. Part II (Gerald A. Isted)
  - 8.8 Human-Centered Design (From The Design of Everyday Things- Don Norman)
  - 8.9 "The Paper Managerie" from The Paper Managerie and Other Stories by Ken Liu

8.10 "The Algorithm Will Save Us" from The New Voices of Fantasy by Sam J. Miller

8.11 "The Phantom Heart" by Laurence Yep

8.12 "Everyday Use" by Alice Walker

### Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

| Chapter      | Hours     | Marks distribution* |
|--------------|-----------|---------------------|
| 1            | 2         | 5                   |
| 2            | 8         | 10                  |
| 3            | 15        | 20                  |
| 4            | 10        | 10                  |
| 5            | 4         | 10                  |
| 6            | 6         | 5                   |
| <b>Total</b> | <b>45</b> | <b>60</b>           |

\* There may be minor deviation in marks distribution.

### References

1. Markel, M. and Selber, S. A. (2018). Technical communication (12th edition). Bedford/St. Martin's.
2. Ingre, D. (2017). Engineering communication: A practical guide to workplace communications for engineers (2nd edition). Cengage Learning.
3. Weisman, H. M. (2000). Technical communication for engineers: A handbook for engineers, scientists, and technicians. Prentice Hall.
4. Stevenson, S. and Whitmore, S. (2002). Strategies for engineering communication. John Wiley & Sons.
5. Rothwell, E. J., Cloud, M. J. (2017). Engineering writing by design: Creating formal documents of lasting value. CRC Press.
6. Blake, G., Bly, R. W. (1993). The elements of technical writing. Macmillan.
7. Beer, D., Mc Murrey, D. (2013). A guide to writing as an engineer (4th edition). John Wiley and Sons.
8. Farhathullah, T. M. (2002). Communication skills for technical students. Orient Longman.
9. Lebrun, J. L. (2007). Scientific writing: A reader and writer's guide. World Scientific Publishing.
10. Ligawa, H. (2021). Communication skills notes. Siaya Institute of Technology.
11. Katz, M. J. (2009). From research to manuscript: A guide to scientific writing (2nd edition). Springer.
12. Swales, J. M., Feak, C. B. (2012). Academic writing for graduate students: Essential tasks and skills (3rd edition). University of Michigan Press.
13. Hofmann, A. H. (2014). Scientific writing and communication: Papers, proposals, and presentations (2nd edition). Oxford University Press.

# COMPUTER GRAPHICS AND VISUALIZATION

ENCT 201

**Lecture** : 3  
**Tutorial** : 1  
**Practical** : 3

**Year** : II  
**Part** : I

## Course Objectives:

The objective of this course is to provide basic principles and their applications to computer graphics and visualization. After completion of this course, students will be able to understand geometric transformations and their applications, two-dimensional and three-dimensional object modeling techniques, rendering techniques, animation and get an overview of the latest trends in computer graphics.

## 1 Introduction and Application (4 hours)

- 1.1 History of computer graphics
- 1.2 Overview of graphic systems
  - 1.2.1 Video display devices: Raster-scan displays, random-scan displays, flat panel displays, three-dimensional viewing devices
  - 1.2.2 Graphics software and tools: Coordinate representations, graphics functions, software standards, PHIGS workstations, DirectX, OpenGL, WebGL, Maya, Blender, Unity
- 1.3 Graphics pipeline
  - 1.3.1 Two-dimensional (2D) viewing pipeline
  - 1.3.2 Three-dimensional (3D) viewing pipeline
- 1.4 Applications in various fields like medicine, engineering, art, uses in augmented and virtual realism

## 2 Raster Graphics and Algorithms (9 hours)

- 2.1 Rasterizing a point
- 2.2 Rasterizing a straight line: DDA line algorithm, Bresenham's line algorithm
- 2.3 Rasterizing a circle and an ellipse: Mid-point circle and ellipse algorithm
- 2.4 Scan-line polygon fill algorithm
- 2.5 Scan-line fill of curved boundary areas
- 2.6 Boundary-fill algorithm
- 2.7 Flood-fill algorithm
- 2.8 Point clipping

- 2.9 Line clipping
  - 2.9.1 Cohen-Sutherland line clipping
  - 2.9.2 Liang-Barsky line clipping
- 2.10 Polygon clipping: Weiler-Atherton polygon clipping
- 2.11 Text clipping

### **3 2D and 3D Coordinate Systems and Viewing Transformations (9 hours)**

- 3.1 2D transformation: Translation, rotation, scaling, reflection, shear
- 3.2 2D composite transformation
- 3.3 Window-to-viewport coordinate transformation
- 3.4 3D display methods
  - 3.4.1 Parallel projection
  - 3.4.2 Perspective projection
- 3.5 3D transformation: Translation, rotation, scaling, reflection, shear
- 3.6 3D composite transformation
- 3.7 Projection and viewing transformation

### **4 Curve Modeling and Surface Modelling (4 hours)**

- 4.1 Introduction to parametric cubic curves, splines, Bezier curves
- 4.2 Surface modeling (Polygon surface, vertex table, edge table, polygon table, surface normal and spatial orientation of surfaces)

### **5 Visible Surface Determination (4 hours)**

- 5.1 Image space and object space techniques
- 5.2 Back face detection, Z-Buffer, A-Buffer, Scan-Line method

### **6 Illumination and Surface Rendering Methods (4 hours)**

- 6.1 Algorithms to simulate ambient, diffuse and specular reflections
- 6.2 Constant, Gouraud, Phong and Fast Phong shading models

### **7 Computer Animation and Visualization (5 hours)**

- 7.1 Computer animation functions
- 7.2 Raster animations
- 7.3 Key-frame systems
- 7.4 Motion specifications
  - 7.4.1 Direct-motion specifications
  - 7.4.2 Goal-directed systems
  - 7.4.3 Kinematics and dynamics

## **8 Latest Trends in Computer Graphics**

**(6 hours)**

- 8.1 Interactive visualization
- 8.2 Distributed scene rendering
- 8.3 Augmented reality (AR), virtual reality (VR) and mixed reality (MR)
- 8.4 Game development and real-time graphics
- 8.5 Applications of AR, VR and gaming

### **Tutorial**

**(15 hours)**

1. Computations regarding raster graphics system- frame buffer size, color manipulation techniques, aspect ratio, refresh rate, resolution
2. Implementation of studied algorithms to determine points for digitizing lines, circles, and ellipses
3. Computational problems related to different clipping algorithms
4. Solution of problems related to 2D and 3D transformations and matrix compositions, including fixed-point scaling, pivot-point rotation, and reflection across an arbitrary line, among others
5. Transformation of object descriptions from the window coordinate system to the viewport coordinate system and solving problems related to parallel and perspective projection
6. Calculation of the points required to construct different curves studied using the specified set of control points and the desired number of line segments
7. Calculation of the surface normal of polygons and evaluating visibility using various visible surface determination techniques
8. Calculation of average intensity at a point on a polygon using Gouraud shading

### **Assignment**

Appropriate assignment problems are given to students after the completion of each chapter.

### **Practical**

**(45 hours)**

1. DDA line algorithm
2. Bresenham's line algorithm
3. Mid-point circle algorithm
4. Mid-point ellipse algorithm
5. Lab on 2-D transformations
6. Lab on 3-D transformations
7. Program for viewing and shading the 3D object
8. Clipping hidden surface removal
9. Implement the discrete techniques
10. Basic drawing techniques in OpenGL
11. A simple computer animation
12. A simple AR/VR scene or application using a framework (e.g., Unity, ARKit, Unreal Engine)

By the end of the practical, students required to develop a prototype project to demonstrate their understanding of computer graphics concepts. Students will work in teams and are encouraged to explore new programming languages or platforms (e.g., Unity, Unreal Engine, WebGL) to complete their project.

### Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

| Chapter      | Hours     | Marks Distribution* |
|--------------|-----------|---------------------|
| 1            | 4         | 5                   |
| 2            | 9         | 13                  |
| 3            | 9         | 13                  |
| 4            | 4         | 5                   |
| 5            | 4         | 5                   |
| 6            | 4         | 5                   |
| 7            | 5         | 7                   |
| 8            | 6         | 7                   |
| <b>Total</b> | <b>45</b> | <b>60</b>           |

\* There may be minor deviation in marks distribution.

### References

1. Hearn D., Baker, M. P. (1997). Computer Graphics C version (2nd edition), Prentice Hall.
2. Theoharis, T., Papaioannou, G., Platis, N., Patrikalakis, N. M. (2008). Graphics and Visualization: Principles & Algorithms. United States: CRC Press.
3. Foley, J. D. (1995). Computer Graphics: Principles and Practice in C (2nd edition). Germany: Addison-Wesley.

# MICROPROCESSORS

ENEX 201

**Lecture : 3**  
**Tutorial : 1**  
**Practical : 3**

**Year : II**  
**Part : I**

## Course Objectives:

The objective of this course is to familiarize students with assembly language programming, hardware and applications of microprocessors. The course provides students with a comprehensive understanding of microprocessor architecture, programming, and interfacing techniques, with a focus on the Intel 8085 and 8086 microprocessors. Students will gain theoretical and practical knowledge of microprocessor-based systems, covering essential topics such as computer organization, instruction sets, memory and I/O interfacing, interrupt mechanisms, and advanced architectural concepts.

## 1 Introduction (4 hours)

- 1.1 Introduction to microprocessors
- 1.2 History of microprocessors
- 1.3 Basic block diagram of a digital computer
- 1.4 Microcomputer and microcontroller
- 1.5 Bus organization of computer system
- 1.6 Stored program concept (Von Neumann's architecture)
- 1.7 Processing cycle of a stored program computer

## 2 Intel 8085 Microprocessor (12 hours)

- 2.1 Features of 8085
- 2.2 Internal architecture of 8085
- 2.3 Pin configurations of 8085
- 2.4 Instruction format and data format
- 2.5 Addressing modes of 8085
- 2.6 Instruction set of 8085
- 2.7 Various programs in 8085
  - 2.7.1 Simple programs with arithmetic and logical operations
  - 2.7.2 Conditions and loops
  - 2.7.3 Array and table processing
  - 2.7.4 Decimal - BCD conversion
  - 2.7.5 Multiplication and division
- 2.8 Instruction cycle, machine cycle and T-cycle
- 2.9 Timing diagrams of bus operations

### **3 Intel 8086 Microprocessor**

**(14 hours)**

- 3.1 Features of 8086
- 3.2 Internal architecture of 8086
  - 3.2.1 BIU and components
  - 3.2.2 EU and components
  - 3.2.3 EU and BIU operations
- 3.3 Segment and offset address
- 3.4 Pin configurations of 8086
- 3.5 Addressing modes of 8086
- 3.6 Assembly language programming
- 3.7 High level versus low level programming
- 3.8 Assembly language syntax
  - 3.8.1 Comments
  - 3.8.2 Reserved words
  - 3.8.3 Identifiers
  - 3.8.4 Statements
  - 3.8.5 Directives
  - 3.8.6 Operators
  - 3.8.7 Instructions
- 3.9 EXE and COM programs
- 3.10 Assembling, linking and execution
- 3.11 One pass and two pass assemblers
- 3.12 Interrupt services: INT 21H and INT 10H
- 3.13 Various programs in 8086
  - 3.13.1 Simple programs for arithmetic, logical, string and input/output
  - 3.13.2 Conditions and loops
  - 3.13.3 Array and string processing
  - 3.13.4 ASCII and decimal numbers operation
  - 3.13.5 Displaying numbers in decimal, binary and hexadecimal formats

### **4 Microprocessor System**

**(7 hours)**

- 4.1 Memory classifications and hierarchy
- 4.2 Interfacing I/O devices and memory with 8085
  - 4.2.1 Address decoding
  - 4.2.2 Unique and non-unique address decoding
  - 4.2.3 I/O mapped I/O and memory mapped I/O
  - 4.2.4 I/O address decoding with NAND and block decoders
  - 4.2.5 Memory address decoding
- 4.3 Parallel Interface
  - 4.3.1 Modes: Simple, wait, single handshaking and double handshaking
  - 4.3.2 Introduction to programmable peripheral interface (PPI)

- 4.4 Serial Interface
  - 4.4.1 Synchronous and asynchronous transmission
  - 4.4.2 Serial interface standards: RS232, USB
  - 4.4.3 Introduction to USART

## **5 Interrupt Operations (5 hours)**

- 5.1 Interrupt and its importance
- 5.2 Polling vs interrupt
- 5.3 Types of interrupts
- 5.4 Interrupts in 8085 and interrupt instructions
- 5.5 Interrupt service routine
- 5.6 Interrupt processing in 8085
- 5.7 Using programmable interrupt controllers (PIC)
- 5.8 Interrupt in 8086 and interrupt vector table
- 5.9 Interrupt processing in 8086

## **6 Advanced Topics (3 hours)**

- 6.1 Harvard architecture
- 6.2 Accumulator based and register based architecture
- 6.3 Hardwired and microprogrammed control unit
- 6.4 RISC and CISC
- 6.5 Introduction to multiprocessing/multitasking
- 6.6 Digital signal processor

## **Tutorial (15 hours)**

- 1. Assembly language programming with 8085
- 2. Assembly language programming with 8086
- 3. Input/output and memory address decoding

Problems are solved, and students are assisted by the teacher to solve additional programming problems during tutorial classes.

### **Assignment**

Appropriate assignment problems should be given to students after the completion of each chapter.

## **Practical (45 hours)**

- 1. Familiarization to programming kit and program entry/execution in kit
- 2. 8085 assembly language programming with data transfer instructions
- 3. 8085 assembly language programming with arithmetic instructions
- 4. 8085 assembly language programming with logical instructions
- 5. 8085 assembly language programming with branching and stack instructions
- 6. Miscellaneous and practical programming with 8085 such as multiplication/division

7. Familiarization with DEBUG and entry/executing programs
8. 8086 assembly language programming with simple programs and assemble link and execute programs
9. 8086 assembly language programming for input and output using INT 21H service
10. 8086 assembly language programming for display using INT 10H service
11. 8086 assembly language programs for various conditions and I/O operations
12. Lab test

### Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

| Chapter      | Hours     | Marks distribution* |
|--------------|-----------|---------------------|
| 1            | 4         | 6                   |
| 2            | 12        | 15                  |
| 3            | 14        | 18                  |
| 4            | 7         | 12                  |
| 5            | 5         | 6                   |
| 6            | 3         | 3                   |
| <b>Total</b> | <b>45</b> | <b>60</b>           |

\* There may be minor deviation in marks distribution.

### References

1. Gaonkar, R. S. (2002). Microprocessor Architecture, Programming and Applications with the 8085. United Kingdom: Prentice Hall.
2. Abel, P. (2000). IBM PC Assembly Language and Programming (5th edition). United Kingdom: Prentice Hall.
3. Hall, D. V. (1999). Microprocessors and Interfacing: Programming and Hardware (2nd Edition). Tata McGraw Hill.
4. Stalling, W. (2009). Computer Organization and Architecture. Prentice Hall.

## **ADVANCED ELECTRONICS ENEX 202**

**Lecture : 3**  
**Tutorial : 1**  
**Practical : 3/2**

**Year : II**  
**Part : I**

### **Course Objectives:**

The objective of this course is to provide fundamental understanding of operational amplifiers, including their performance, limitations, and suitability for specific applications. Students will also learn to devise efficient techniques for energy transformation and regulation in power electronic circuits, and explore the principles and components of data conversion using DAC and ADC systems.

### **1 Operational Amplifier Characterization (9 hours)**

- 1.1 Input offset voltage
- 1.2 Input bias and input offset currents
- 1.3 Output impedance
- 1.4 Differential and common-mode input impedance
- 1.5 DC gain, bandwidth, gain-bandwidth product
- 1.6 Common-mode and power supply rejection ratio
- 1.7 Higher frequency poles settling time
- 1.8 Slew rate
- 1.9 Noise in operational amplifier circuits

### **2 Digital-to-Analog and Analog-to-Digital Conversion (7 hours)**

- 2.1 Performance parameters of DAC and ADC
- 2.2 Binary weighted resistor DAC
- 2.3 The R-2R ladder DAC
- 2.4 Unipolar and bipolar D/A converters
- 2.5 Count-up and tracking A/D's based on D/A's
- 2.6 Successive approximation A/D converters
- 2.7 Integrating voltage-to-time conversion A/D converters, dual and quad slope types
- 2.8 Sigma delta A/D converters
- 2.9 Flash A/D converters

### **3 Instrumentation and Isolation Amplifiers (4 hours)**

- 3.1 One and two operational amplifier instrumentation amplifiers
- 3.2 The three operational amplifier instrumentation amplifier
- 3.3 Consideration of non-ideal properties

- 3.4 Isolation amplifier principles and realization
- 3.5 Consideration of non-ideal properties

#### **4 Operational Amplifier-Bipolar Transistor Logarithmic Amplifier (4 hours)**

- 4.1 The basic logarithmic amplifier
- 4.2 Non-ideal effects
- 4.3 Stability consideration
- 4.4 Anti-logarithmic operations

#### **5 Log-Antilog Circuit Application (4 hours)**

- 5.1 Analog multiplier based on log-antilog principles
- 5.2 The multifunction converter circuit
- 5.3 Proportional to absolute temperature (PTAT) devices
- 5.4 RMS to DC conversion

#### **6 Power Electronics (11 hours)**

- 6.1 Power diodes, power MOSFET V-I characteristics
- 6.2 Thyristor: V-I, turn on-off mechanism, protection schemes, firing circuits, series/parallel combination, self and forced commutation
- 6.3 Members of thyristor family: DIAC, TRIAC
- 6.4 Controlled rectifier circuits: single phase half wave and full wave with RLE load
- 6.5 Inverters: Fixed voltage variable frequency (half and full), variable voltage variable frequency (PWM inverters)
- 6.6 Choppers: Principle of operation, control strategies, step up chopper, classification of chopper circuits

#### **7 Switched Mode Power Supplies and Drives (6 hours)**

- 7.1 Switch mode power supply
- 7.2 Buck, boost, buck-boost regulator
- 7.3 DC drives: classification and choice of selection
- 7.4 Review of characteristics and operating modes of DC motors
- 7.5 Half wave and full wave single phase converters drives
- 7.6 Stepper motor and drives

#### **Tutorial (15 hours)**

- 1. Numerical related to input and output offset voltage, input bias current, determination of input output impedance of op-amp circuit, gain bandwidth product and slew rate limitation
- 2. Numerical related to DAC and ADC performance parameters and analog/digital conversion
- 3. Problems related to instrumentation amplifier
- 4. Problems related to log, antilog amplifiers and stability consideration

5. Application of log and antilog amplifiers and PTAT devices
6. Problems related to SCR, controlled rectifiers, inverters and choppers
7. Problems related to SMPs, BUCK-BOOST regulators, converters with DC motor and drives

### Assignment

Appropriate assignment problems are given to students after the completion of each chapter.

### Practical

**(22.5 hours)**

1. Characteristics of Operational amplifier
2. 4-bit D to A converter
3. Differential and Instrumentation amplifiers
4. Logarithmic amplifiers, multipliers, RMS to DC conversion
5. Switched voltage regulator design
6. Silicon-controlled-rectifier (SCR) circuit design
7. Stepper Motor control with driver module and arduino

### Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

| Chapter      | Hours     | Marks distribution* |
|--------------|-----------|---------------------|
| 1            | 8         | 12                  |
| 2            | 7         | 9                   |
| 3            | 4         | 5                   |
| 4            | 4         | 5                   |
| 5            | 5         | 6                   |
| 6            | 11        | 15                  |
| 7            | 6         | 8                   |
| <b>Total</b> | <b>45</b> | <b>60</b>           |

\* There may be minor deviation in marks distribution.

### References

1. Sedra, A. S., Smith, K. C. (2010). Microelectronic Circuits. United Kingdom: Oxford University Press.
2. Stanely W. (1987). Operational Amplifiers with Linear Integrated Circuits. Charles E. Merrill Publishing Company. Toronto.
3. Gayakwad, R. A. (2004). Op-amps and linear integrated circuits. 4th Edition. New Delhi: Prentice Hall.
4. P.S. Bimbhra. (2002). Power Electronics. 3rd Edition, India: Khanna Publishers.
5. Lander C.W. (1987). Power Electronics. 2nd Edition. New York: McGraw-Hill Book Company.

6. Graeme J.G. (1973). Application of Operational Amplifiers: Third Generation Techniques., New York: McGraw-Hill. The Burr-Brown Electronics Series.
7. Mohan N., Undeland T. M., Robbins W. P. (1989). Power Electronics: Converters, Applications and Design. New York: John Willey and Sons.

# CONTROL SYSTEM

## ENEE 204

**Lecture** : 3  
**Tutorial** : 1  
**Practical** : 3/2

**Year : II**  
**Part : I**

### Course Objectives:

The objective of this course is to provide foundational knowledge in control system analysis and design. It introduces essential concepts needed to understand and create control systems. Students will learn to model and analyze control mechanisms. The course emphasizes applying these principles to real-world physical processes.

- 1 Control System Background (2 hours)**
  - 1.1 History of control system and its importance
  - 1.2 Control system: Characteristics and basic features, components and variables
  - 1.3 Types of control system and their comparison
- 2 Component Modeling (6 hours)**
  - 2.1 Differential equation and transfer function notations
  - 2.2 Modeling of mechanical components: Mass, spring and damper
  - 2.3 Modeling of electrical components: Inductance, capacitance, resistance, DC and AC motor, transducers and operational amplifiers
  - 2.4 Electric circuit analogies: Force-voltage analogy and force- current analogy
  - 2.5 Linearized approximations of non-linear characteristics
- 3 System Transfer Function and Responses (10 hours)**
  - 3.1 Combinations of components to physical systems
  - 3.2 Block diagram algebra and system reduction
  - 3.3 Signal flow graphs
  - 3.4 Time response analysis
    - 3.4.1 Types of test signals: Impulse, step, ramp, parabolic
    - 3.4.2 Time response analysis of first order system
    - 3.4.3 Time response analysis of second order system
    - 3.4.4 Transient response characteristics: Rise time, peak time, delay time, settling time and maximum overshoot
  - 3.5 Static error coefficients and steady state error
  - 3.6 P, PI, PD, PID controller and derivative feedback controller

|                 |                                                                                              |                   |
|-----------------|----------------------------------------------------------------------------------------------|-------------------|
| <b>4</b>        | <b>Stability</b>                                                                             | <b>(4 hours)</b>  |
| 4.1             | Introduction of stability and causes of instability                                          |                   |
| 4.2             | Characteristic equation, root location and stability                                         |                   |
| 4.3             | Setting loop gain using Routh-Hurwitz (R-H) criterion                                        |                   |
| 4.4             | R-H stability criterion                                                                      |                   |
| 4.5             | Relative stability from complex plane axis shifting                                          |                   |
| <b>5</b>        | <b>Root Locus Technique</b>                                                                  | <b>(6 hours)</b>  |
| 5.1             | Introduction of root locus                                                                   |                   |
| 5.2             | Relationship between root loci and time response of systems                                  |                   |
| 5.3             | Rules for manual calculation and construction of root locus                                  |                   |
| 5.4             | Stability concept from Root Locus                                                            |                   |
| <b>6</b>        | <b>Frequency Response Techniques</b>                                                         | <b>(8 hours)</b>  |
| 6.1             | Frequency domain characterization of the system                                              |                   |
| 6.2             | Relationship between real and complex frequency response                                     |                   |
| 6.3             | Polar plot                                                                                   |                   |
| 6.4             | Stability analysis in frequency domain: Gain margin, phase margin                            |                   |
| 6.5             | Nyquist plot and criterion for stability analysis                                            |                   |
| 6.6             | Polar plot and Nyquist plot                                                                  |                   |
| 6.7             | Bode Plot: Significance of Bode plot, Magnitude and phase plot                               |                   |
| 6.8             | Stability analysis from Bode plot                                                            |                   |
| <b>7</b>        | <b>Performance Specifications and Compensation Design</b>                                    | <b>(6 hours)</b>  |
| 7.1             | Compensation technique and compensator                                                       |                   |
| 7.2             | Application of root locus and frequency response on control system design                    |                   |
| 7.3             | Lead, lag cascade compensation design                                                        |                   |
| 7.3.1           | Root locus method                                                                            |                   |
| 7.3.2           | Bode plot method                                                                             |                   |
| 7.4             | Concept of Lead-lag compensator                                                              |                   |
| <b>8</b>        | <b>State Space Analysis</b>                                                                  | <b>(4 hours)</b>  |
| 8.1             | Definition of state-space, state variables and state vector                                  |                   |
| 8.2             | State space representation of electrical and mechanical system                               |                   |
| 8.3             | Conversion from state space to a transfer function                                           |                   |
| 8.4             | Conversion from transfer function to state space                                             |                   |
| 8.5             | State-transition matrix                                                                      |                   |
| <b>Tutorial</b> |                                                                                              | <b>(15 hours)</b> |
| 1.              | Modeling exercises of mechanical/electrical system and analogy                               |                   |
| 2.              | Block diagram model development and reduction, SFG exercise                                  |                   |
| 3.              | Time response exercise of first order and second order system and steady state error and PID |                   |

4. RH criterion and relative stability numerical, root locus plot
5. Polar and Nyquist Plot, Bode plotting and stability analysis in frequency domain
6. Compensator design exercises from Root locus and Bode plot approach for lead and lag compensator
7. State space model development exercises from differential equation, transfer function model and vice versa and stability check

### Practical

**(22.5 hours)**

1. To study open loop and closed mode for DC motor and familiarization with different components in DC motor control module.
2. To determine gain and transfer function of different control system components
3. To study effects of feedback on gain and time constant for closed loop speed control system and position control system
4. To determine frequency response of first order and second order system and to get transfer function
5. Simulation of closed loop speed control system and position control system and verification

### Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

| Chapter      | Hours     | Marks distribution* |
|--------------|-----------|---------------------|
| 1            | 2         | 4                   |
| 2            | 6         | 8                   |
| 3            | 10        | 12                  |
| 4            | 4         | 4                   |
| 5            | 6         | 8                   |
| 6            | 8         | 12                  |
| 7            | 6         | 8                   |
| 8            | 3         | 4                   |
| <b>Total</b> | <b>45</b> | <b>60</b>           |

\* There may be minor deviation in marks distribution.

### References

1. Ogata, K. (2009). Modern Control Engineering (5th edition). Pearson
2. Gopal, M. (2009). Control Systems: Principles and Design (4th edition). Tata McGraw-Hill.
3. Kuo, B. C. (2015). Automatic Control System (9th edition). Wiley India.
4. Nagrath, I. J., Gopal, M. (2021) Modern Control Engineering (7th edition) New Age International.
5. Hassan, S. (2013). Automatic Control System (Reprint 2013). Arihant.



YEAR II, PART II

# Semester 4

## 6 COURSES IN THIS SEMESTER

|                 |                                      |           |
|-----------------|--------------------------------------|-----------|
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4

# NUMERICAL METHODS

ENSH 252

**Lecture : 3**

**Tutorial : 1**

**Practical : 3**

**Year : II**

**Part : II**

## Course Objectives:

The objective of this course is to equip students with a thorough understanding of numerical methods, focusing on their application in obtaining approximate solutions to complex mathematical problems commonly encountered in science and engineering. Emphasizing algorithm development, programming, and visualization techniques, the course enables students to apply computational approaches effectively, enhancing their problem-solving capabilities in real-world applications.

### **1 Solution of Non-Linear Equations (7 hours)**

- 1.1 Errors and accuracy in numerical computations
- 1.2 Bisection method
- 1.3 Regula Falsi method and secant method
- 1.4 Newton Raphson method
- 1.5 Fixed point iteration method
- 1.6 Comparison of the methods (Bracketing vs open-ended methods and rates of convergence)
- 1.7 Solution of system of non-linear equations
  - 1.7.1 Direct approach
  - 1.7.2 Newton Raphson method

### **2 Solution of System of Linear Algebraic Equations (8 hours)**

- 2.1 Direct methods
  - 2.1.1 Gauss Jordan method
  - 2.1.2 Gauss elimination method, pivoting strategies (Partial and complete)
  - 2.1.3 Matrix inverse using Gauss Jordan and Gauss elimination methods
  - 2.1.4 Factorization methods (Do-Little's method and Crout's method)
- 2.2 Iterative methods
  - 2.2.1 Jacobi's method
  - 2.2.2 Gauss-Seidal method
- 2.3 Determination of largest and smallest Eigen values and corresponding vectors using the power method

### **3 Interpolation (9 hours)**

- 3.1 Polynomial Interpolation
  - 3.1.1 Finite differences (Forward, backward, central and divided differences)
  - 3.1.2 Interpolation with equally spaced intervals: Newton's forward and backward difference interpolation, Stirling's and Bessel's central difference interpolation
  - 3.1.3 Interpolation with unequally spaced intervals: Newton's divided difference interpolation, Lagrange interpolation
- 3.2 Least square method of curve fitting
  - 3.2.1 Linear form and forms reducible to linear form
  - 3.2.2 Quadratic form and forms reducible to quadratic form
  - 3.2.3 Higher degree polynomials
- 3.3 Cubic spline interpolation
  - 3.3.1 Equally spaced interval
  - 3.3.2 Unequally spaced interval

### **4 Numerical Differentiation and Integration (6 hours)**

- 4.1 Numerical differentiation
  - 4.1.1 Differentiation using polynomial interpolation formulae for equally spaced intervals
  - 4.1.2 Local maxima and minima from equally spaced data
- 4.2 Numerical integration
  - 4.2.1 Newton Cote's general quadrature formula
  - 4.2.2 Trapezoidal rule, Simpson's 1/3 and 3/8 rules, Boole's rule, Weddle's rule
  - 4.2.3 Romberg integration
  - 4.2.4 Gauss-Legendre integration (up to 3-point formula)

### **5 Solution of Ordinary Differential Equations (ODE) (8 hours)**

- 5.1 Initial value problems
  - 5.1.1 Solution of first order equations: Taylor's series method, Euler's method, Runge-Kutta methods (Second and fourth order)
  - 5.1.2 Solution of system of first order ODEs via Runge-Kutta methods
  - 5.1.3 Solution of second order ODEs via Runge-Kutta methods
- 5.2 Two-point boundary value problems
  - 5.2.1 Shooting method
  - 5.2.2 Finite difference method

## **6 Solution of Partial Differential Equations**

**(7 hours)**

- 6.1 Introduction and classification
- 6.2 Finite difference approximations of partial derivatives
- 6.3 Solution of elliptic equations
  - 6.3.1 Laplace equation
  - 6.3.2 Poisson's equation
- 6.4 Solution of parabolic and hyperbolic equations
  - 6.4.1 One-dimensional heat equation: Bendre-Schmidt method, Crank-Nicolson method
  - 6.4.2 Solution of wave equation

## **Tutorial**

**(15 hours)**

- 1. Solution of non-linear equations
- 2. Solution of system of linear algebraic equations
- 3. Polynomial interpolation
- 4. Least square method of curve fitting
- 5. Cubic spline interpolation
- 6. Numerical differentiation
- 7. Numerical Integration
- 8. Solution of ordinary differential equations (Initial value problems)
- 9. Solution of ordinary differential equations (Boundary value problems)
- 10. Solution of partial differential equations

## **Practical**

**(45 hours)**

Programming language to be used: Python

Results to be visualized graphically wherever possible

Practical report contents: Working principle, Pseudocode, Source code, Test Cases

- 1. Basics of programming in Python:
  - Basic input/output
  - Basic data types and data structures
  - Control flow
  - Functions and modules
  - Basic numerical and scientific computation
  - Graphical visualization
- 2. Solution of Non-linear equations:
  - Bisection method
  - Secant method
  - Newton-Raphson
  - System of non-linear equations using Newton-Raphson method
- 3. System of linear algebraic equations:
  - Gauss Jordan Method
  - Gauss elimination method with partial pivoting
  - Gauss-Seidal method
  - Power method

4. Interpolation
  - Newton's forward difference interpolation
  - Lagrange interpolation
  - Least square method for linear, exponential and polynomial curve fitting
  - Cubic spline interpolation
5. Numerical Integration
  - Trapezoidal rule
  - Simpson's 1/3 rule or Simpson's 3/8 rule
  - Boole's Rule or Weddle's Rule
  - Gauss-Legendre integration
6. Solution of Ordinary Differential Equations:
  - Runge-Kutta fourth order method for first order ODE
  - Runge-Kutta fourth order method for system of ODEs / 2<sup>nd</sup> order ODE
  - Solution of two-point boundary value problem using Shooting method
  - Solution of two-point boundary value problem using finite difference method
7. Solution of partial differential equations using finite difference approach:
  - Laplace equation using Gauss-Seidal iteration
  - Poisson's equation using Gauss-Seidal iteration
  - One-dimensional heat equation using Bendre-Schmidt method
  - One-dimensional heat equation using Crank-Nicholson method

### Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

| Chapter      | Hours     | Marks distribution* |
|--------------|-----------|---------------------|
| 1            | 7         | 10                  |
| 2            | 8         | 10                  |
| 3            | 9         | 10                  |
| 4            | 6         | 10                  |
| 5            | 8         | 10                  |
| 6            | 7         | 10                  |
| <b>Total</b> | <b>45</b> | <b>60</b>           |

\* There may be minor deviation in marks distribution.

### References

1. Chapra, S. C., Canale, R. P. (2010). Numerical Methods for Engineers (6th edition). McGraw-Hill.
2. Kiusalaas, J. (2013). Numerical Methods in Engineering with Python 3 (3rd edition). Cambridge University Press.
3. Grewal, B. S. (2017). Numerical Methods in Engineering & Science (11th edition). India: Khanna Publishers.
4. Yakowitz, S., Szidarovszky, F. (1986). An Introduction to Numerical Computations (2nd edition). Macmillan Publishing.
5. Kong, Q., Siau T., Bayen A. (2020). Python Programming and Numerical Methods. Academic Press.

# DISCRETE STRUCTURE

ENCT 251

**Lecture : 3**  
**Tutorial : 1**  
**Practical : 0**

**Year : II**  
**Part : II**

## Course Objectives:

The objective of this course is to provide basic understanding in discrete mathematics and finite state machine. It also emphasizes to build fundamental and conceptual clarity in the area of logic, reasoning, proof, recurrence relation, graph theory, theory of automata and algorithmic analysis.

### **1 Logic and Induction (8 hours)**

- 1.1 Review of set theory, relation and function
- 1.2 Proposition, connectives in proposition, types of propositions, truth function and propositional logic
- 1.3 Expressing statements in logic propositional logic, rules of inference in propositional logic, validity of an argument, methods of tableaux
- 1.4 Predicate logic and quantification, informal deduction in predicate logic

### **2 Proof Techniques (5 hours)**

- 2.1 Formal proofs and informal proofs, mathematical reasoning- direct proof and indirect proof (Proof by contradiction and proof by contraposition)
- 2.2 Elementary induction and complete induction, strong induction
- 2.3 Proof by counter example, vacuous and trivial proofs, proof by cases, mistakes in proof

### **3 Automata Theory, Regular Language and Grammar (10 hours)**

- 3.1 Alphabet, string, string operations and language, introduction to finite automata
- 3.2 Deterministic finite automata (DFA), representation and language of DFA
- 3.3 Non deterministic finite automata (NFA), equivalence of DFA and NFA
- 3.4 Regular expressions and its characteristics, regular language and its properties
- 3.5 Equivalence of regular expression and finite automata
- 3.6 Context free grammar and context free language

#### **4 Recurrence Relation and Algorithmic Analysis (7 hours)**

- 4.1 Recurrence relations, recurrence relation for tower of Hanoi (TOH) and Fibonacci series, solving linear recurrence relations (Homogeneous and non-homogeneous)
- 4.2 Algorithm and its properties, asymptotic notation of algorithm
- 4.3 Linear and binary search and their analysis; Bubble and insertion sorting and their analysis

#### **5 Graph Theory and Tree (15 hours)**

- 5.1 Graphs basics, graph terminologies, graph types (Directed, un-directed, simple, weighted, regular, complete, bipartite, planar graph) and special graphs
- 5.2 Subgraphs, graph representation, connectivity in graphs and its components, strongly and weakly connected graphs
- 5.3 Paths and circuits, Euler path and circuit, Hamiltonian path and circuit
- 5.4 Shortest path algorithm (Dijkstra's algorithm), graph coloring and four color theorem, applications of graph coloring.
- 5.5 Graph as network, maximal flows and minimal cuts, the max flow-min cut theorem
- 5.6 Introduction and applications, tree traversals, spanning trees, minimum spanning trees (Prim's and Kruskal's algorithm)

#### **Tutorial (15 hours)**

- 1. Problem related to function, relation and validity of an arguments using rules of inference in propositional and predicate logic
- 2. Problem related to proof techniques
- 3. Design of automata, conversion from NFA to DFA, defining grammar for language and properties of regular language
- 4. Problem related to different recurrence relation including TOH, Fibonacci series and homogeneous and non-homogeneous recurrence relation
- 5. Representation of graph, finding shortest path, obtaining minimum spanning tree, problems related to planar graph, graph coloring and maximum flow
- 6. Defining the complexity of liner and binary search, problems related to bubble and insertion sorting algorithms

## Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

| Chapters     | Hours     | Marks distribution* |
|--------------|-----------|---------------------|
| 1            | 8         | 10                  |
| 2            | 5         | 7                   |
| 3            | 10        | 14                  |
| 4            | 7         | 9                   |
| 5            | 15        | 20                  |
| <b>Total</b> | <b>45</b> | <b>60</b>           |

\* There may be minor deviation in marks distribution.

## References

1. Rosen, K. H. (2019). Discrete Mathematics and Its Applications. United Kingdom: McGraw-Hill.
2. Johnsonbaugh, R. (2007). "Discrete Mathematics", Prentice Hall Inc.
3. Chartrand, G., Oellermann, O. R. (1993). Applied and Algorithmic Graph Theory. Singapore: McGraw-Hill.
4. Lewis, H. R., Papadimitriou, C. H. (1981). Elements of the Theory of Computation. United Kingdom: Prentice-Hall.
5. Cormen, T. H., Leiserson, C. E., Stein, C., Rivest, R. L. (2009). Introduction to Algorithms, Third Edition. France: MIT Press.

# INSTRUMENTATION

ENEX 252

**Lecture** : 4  
**Tutorial** : 1  
**Practical** : 3/2

**Year** : II

**Part** : II

## Course Objectives:

The objective of this course is to provide comprehensive understanding on methods and instrument for a wide range of measurement problems used in instrumentation system. It also covers application of transducers in the microprocessor, microcontroller and their interfacing to design instrumentation system.

### 1 Introduction (2 hours)

- 1.1 Analog and digital instrument: Definition, block diagram, characteristics
- 1.2 Microprocessor-based systems: Open vs closed loop, benefits, features and applications in instrumentation design
- 1.3 Microcomputer on instrumentation design

### 2 Theory of Measurement (6 hours)

- 2.1 Static performance parameters: Accuracy, precision, sensitivity, resolution and linearity
- 2.2 Dynamic performance parameters: Response time, frequency response and bandwidth
- 2.3 Error in measurement
- 2.4 Statistical analysis of error in measurement
- 2.5 Measurement of resistance (Low, medium and high)
- 2.6 DC / AC bridge (Wheatstone bridge, Maxwell's bridge, Schering bridge)

### 3 Transducer (8 hours)

- 3.1 Transducer, workflow of a transducer in typical system, transducer classification
- 3.2 Sensor and its working principle (Resistive, capacitive and piezoelectric), generation of sensor, classification of sensor (Analog sensor, digital sensor)
- 3.3 Types of sensors (Electrical sensor, chemical sensor, biological sensor, acoustic sensor, optical sensor and other motion sensor), characteristic of sensors
- 3.4 Actuator, classification of actuators (Hydraulic, pneumatic, electric and mechanical), characteristic of actuator

- 4 Interfacing of Instrumentation System (14 hours)**
- 4.1 Microprocessor and microcontroller and their selection criteria, and applications
  - 4.2 The PPI 8255 and interfacing of peripherals (LED, 7 segment, dip switch, 8-bit ADC, 8/10-bit DAC using mode 0 and mode1) with 8085 microprocessor
  - 4.3 Microcontrollers (Atmega328, STM32): Architecture, pin configuration, and their application
  - 4.4 Sensor/Actuator interfacing with Atmega328P (Arduino): Analog and digital sensors, implementation of communication protocols, interrupt based interfacing
- 5 Connectivity Technology in Instrumentation System (6 hours)**
- 5.1 Wired and wireless communication system
  - 5.2 Wired connectivity: UART, I2C, SPI, CAN
  - 5.3 Wireless sensor network and its technology
  - 5.4 RF modem, Bluetooth, WI-FI, NFC, ZIGBEE and LORA
  - 5.5 Thermal management: Heat dissipation technique, heat sink
  - 5.6 Data acquisition system (Data loggers, data archiving and storage), cloud based data acquisition system
- 6 Circuit Design (4 hours)**
- 6.1 Converting requirement into design, reliability and fault tolerance
  - 6.2 High-speed design: Bandwidth, decoupling, crosstalk, impedance matching
  - 6.3 PCB design: Component placement, trace routing, signal integrity, and ground loops
  - 6.4 Noise and noise coupling mechanism, noise prevention, filtering, ferrite beads, decoupling capacitors, and ESD & its prevention
- 7 Software for Instrumentation Application (6 hours)**
- 7.1 Overview of software engineering
  - 7.2 Types of software
  - 7.3 Software development life cycle (SDLC), software process models (Waterfall model, prototype model, incremental model, agile model)
  - 7.4 Software reliability vs hardware reliability
  - 7.5 Software bugs, software testing, different levels of testing
- 8 Electrical Equipment (6 hours)**
- 8.1 Voltmeter and ammeter: Types and working principle
  - 8.2 Energy meter: Types and working principle
  - 8.3 Frequency meter: Types and working principle
  - 8.4 Wattmeter: Types and working principle

## **9 Latest Trends**

**(3 hours)**

- 9.1 Internet of things (IoT): Simple architecture, characteristics, advantages
- 9.2 Smart sensors
- 9.3 Important of cloud computing in instrumentation system
- 9.4 Instrumentation in industry 4.0/5.0

## **10 Application of Modern Instrumentation System**

**(5 hours)**

- 10.1 Instrumentation for power station including all electrical and non-electrical parameters
- 10.2 Instrumentation for wire and cable manufacturing and bottling plant
- 10.3 Instrumentations for a beverage manufacturing and bottling plant
- 10.4 Instrumentations required for a biomedical application such as a medical clinic or hospital
- 10.5 Instrumentation system design using a processor (Microprocessor, microcontroller or others)

## **Tutorial**

**(15 hours)**

- 1. Understanding the fundamentals of Op-amps is essential since they are central to analog instrumentation.
- 2. Learn how to filter, amplify, and modify analog signals for signal conditioning
- 3. How ADCs and DACs work and how to select the right one for your application
- 4. Interfacing of ADC on any application of your interest
- 5. Application for the protocol UART, I2C, SPI in Arduino
- 6. Design a simple temperature sensing system using a thermistor or thermocouple, op-amp, and analog display.
- 7. Explain the generation of PWM signals in ATmega328P for controlling things like motor speed or LED brightness.

## **Practical**

**(22.5 hours)**

- 1. Measurement and accuracy testing: Analog and digital meters
- 2. Use of LabVIEW, Proteus, MATLAB or others for modeling instrumentation systems
- 3. Use of resistive, capacitive & inductive transducers / sensors / actuators
- 4. Review of assembly programming and simple I/O interfacing with 8085 and 8255
- 5. Interfacing of LEDs, seven segment display and motors
- 6. Interfacing of ADC and DAC

## Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

| Chapter      | Hours     | Marks distribution* |
|--------------|-----------|---------------------|
| 1            | 2         | 4                   |
| 2            | 6         | 5                   |
| 3            | 8         | 6                   |
| 4            | 14        | 12                  |
| 5            | 6         | 6                   |
| 6            | 4         | 4                   |
| 7            | 6         | 6                   |
| 8            | 6         | 6                   |
| 9            | 3         | 5                   |
| 10           | 5         | 6                   |
| <b>Total</b> | <b>60</b> | <b>60</b>           |

\* There may be minor deviation in marks distribution.

## References

1. Hall, D. V., (1999). Microprocessor and Interfacing, Programming and Hardware. Tata McGraw Hill
2. Goankar, R. S., (2000). Microprocessor Architecture, Programming and Application with 8085. Prentice Hall
3. Fowler, K. R., (1996). Electronic Instrument Design: Architecting for the Life Cycle. Oxford University Press, Inc.
4. Sawhney, A. K., (1998). A Course in Electronic Measurement and Instrumentation. Dhanpat Rai and Sons.
5. Gupta, J. B., (2008). A Course in Electrical and Electronics Measurement and Instrumentation, Kataria and Sons.
6. DE Silva C. W., Sensors and Actuators: Control System Instrumentation. CRC Press Taylor and French Group Boca Raton London New York.
7. Misra, S., Roy, C. and Mukherjee, A., (2020). Introduction to Industrial Internet of Things and Industry 4.0. CRC Press.

# COMPUTER ORGANIZATION AND ARCHITECTURE

ENEX 253

**Lecture** : 3  
**Tutorial** : 1  
**Practical** : 3/2

**Year : II**  
**Part : II**

## Course Objectives:

The objective of this course is to provide the organization, architecture and designing concept of computer system including processor architecture, computer arithmetic, memory system, I/O organization and multicore.

### 1 Introduction (6 hours)

- 1.1 Organization and architecture
- 1.2 Structure and function
- 1.3 The evolution of computer architecture (RISC, CISC, BERKELEY RISC I, overlapped register window)
- 1.4 Performance assessment
  - 1.4.1 Clock speed and instruction per second
  - 1.4.2 Instruction execution rate: CPI, MIPS Rate, MFLOPS rate, arithmetic mean, harmonic mean, speed metric, geometric mean, rate metric, Amdahl's law, speed up
- 1.5 Computer function
  - 1.5.1 Instruction fetch and execute
  - 1.5.2 Instruction cycle state diagram
- 1.6 Interconnection structure, bus interconnection, multilevel bus hierarchy, PCI

### 2 Central Processor Organization (6 hours)

- 2.1 Processor bus organization
- 2.2 ALU: Arithmetic circuit, logic circuit, one and multi-stage ALU, shifter
- 2.3 Instruction formats: CPU organization, zero and more address instruction formats
- 2.4 Addressing modes
- 2.5 Instruction set
  - 2.5.1 Data transfer instruction
  - 2.5.2 Data manipulation instruction: Arithmetic, logical and shift operations
  - 2.5.3 Program control instruction
- 2.6 Status bit conditions

### **3 Control Unit (5 hours)**

- 3.1 Definition, block diagram, control signals
- 3.2 Hardwired and microprogrammed CU
- 3.3 Microprogramming approach
  - 3.3.1 Control memory and its organization
  - 3.3.2 Computer organization
  - 3.3.3 Microprogram organization
  - 3.3.4 Address sequencing
  - 3.3.5 Mapping of microoperations
  - 3.3.6 Microinstruction formats
  - 3.3.7 Microprogramming examples
  - 3.3.8 Microprogram sequencer
  - 3.3.9 Field decoding

### **4 Memory System (8 hours)**

- 4.1 Characteristics of memory system
- 4.2 Memory classification and hierarchy
- 4.3 RAM (SRAM and DRAM) and ROM organization: Circuit level implementation
- 4.4 Locality of reference
- 4.5 Cache memory principle
  - 4.5.1 Cache and main memory
  - 4.5.2 Cache / main memory structure
  - 4.5.3 Cache read operation
  - 4.5.4 Typical cache organization
  - 4.5.5 Elements of cache design (Cache address, cache size, mapping techniques, replacement algorithms, write policy, line size, number of caches)

### **5 Computer Arithmetic (8 hours)**

- 5.1 Integer and floating-point representation
- 5.2 Integer arithmetic
  - 5.2.1 Addition and subtraction
  - 5.2.2 Multiplication
  - 5.2.3 Division
- 5.3 Floating-point arithmetic
  - 5.3.1 Addition and subtraction
  - 5.3.2 Multiplication
  - 5.3.3 Division

- 6     Pipelining and Vector Processing** **(4 hours)**
- 6.1    Pipelining concept
  - 6.2    Types of pipelining: Instruction and arithmetic pipelining
  - 6.3    The major hurdle and hazards of pipelining: Data, structure and control hazards
  - 6.4    Vector computation
    - 6.4.1    Vector computation approach
    - 6.4.2    Implementation: Pipelined ALU, parallel ALU and parallel processors
- 7     Input Output (I/O) Organization** **(4 hours)**
- 7.1    Peripheral device
  - 7.2    I/O modules
  - 7.3    I/O interface
  - 7.4    Modes of transfer
    - 7.4.1    Programmed I/O
    - 7.4.2    Interrupt driven I/O
    - 7.4.3    DMA
  - 7.5    I/O processor
  - 7.6    Data communication processor
- 8     Multicore Computer** **(4 hours)**
- 8.1    Multicore computer
  - 8.2    Hardware performance issues
    - 8.2.1    Increase in parallelism
    - 8.2.2    Power consumption
  - 8.3    Software performance issue: Software in multicore
  - 8.4    Multicore organization
- Tutorial** **(15 hours)**
- 1.    Numerical examples on performance assessment
  - 2.    Design of arithmetic circuit, logic circuit and ALU
  - 3.    Coding examples covering different instruction formats
  - 4.    Microprogramming examples in CU
  - 5.    Cache memory mapping: Hit and miss ratio
  - 6.    Numerical examples for various arithmetic algorithms
- Practical** **(22.5 hours)**
- 1.    Programming / simulation for addition and subtraction algorithm
  - 2.    Programming / simulation for multiplication algorithm
  - 3.    Programming / simulation for division algorithm
  - 4.    Programming / simulation for cache mapping techniques
  - 5.    Programming / simulation for ALU
  - 6.    Programming / simulation for vector processing

## Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

| Chapter      | Hours     | Marks distribution* |
|--------------|-----------|---------------------|
| 1            | 6         | 8                   |
| 2            | 6         | 8                   |
| 3            | 5         | 8                   |
| 4            | 8         | 10                  |
| 5            | 8         | 10                  |
| 6            | 4         | 5                   |
| 7            | 4         | 5                   |
| 8            | 4         | 6                   |
| <b>Total</b> | <b>45</b> | <b>60</b>           |

\* There may be minor deviation in marks distribution.

## References

1. Stalling, W. (2018). Computer Organization and Architecture. Pearson Education INC.
2. Mano, M. M. (2008). Computer System Architecture. Pearson Education INC.
3. Hennessy, J. L. Patterson D. A., (2000). Computer Architecture - A Quantitative Approach. Harcourt Asia PTE Ltd.

# ELECTROMAGNETICS

ENEX 254

**Lecture : 3**  
**Tutorial : 1**  
**Practical : 3/2**

**Year :II**  
**Part : II**

## Course Objectives:

The objective of this course is to provide students with a basic mathematical concepts related to electromagnetic time invariant and time variant fields including electromagnetic wave and their transmission on different media

### 1 Introduction (4 hours)

- 1.1 Scalar and vector fields
- 1.2 Operations on scalar and vector fields
- 1.3 Co-ordinate systems (Cartesian, cylindrical and spherical) and conversions

### 2 Electric Field (15 hours)

- 2.1 Coulomb's law
- 2.2 Electric field intensity
- 2.3 Electric flux density
- 2.4 Gauss's law and applications
- 2.5 Physical significance of divergence, divergence theorem
- 2.6 Electric potential, potential gradient
- 2.7 Energy density in electrostatic field
- 2.8 Electric properties of material medium
- 2.9 Free and bound charges, polarization, relative permittivity, electric dipole electric boundary conditions
- 2.10 Current, current density, conservation of charge, continuity equation, relaxation time
- 2.11 Boundary value problems, Laplace and Poisson equations and their solutions, uniqueness theorem

### 3 Magnetic Field (9 hours)

- 3.1 Biot-Savart's law
- 3.2 Magnetic field intensity
- 3.3 Ampere's circuital law and its application
- 3.4 Magnetic flux density
- 3.5 Physical significance of curl, Stoke's theorem
- 3.6 Scalar and magnetic vector potential
- 3.7 Magnetic properties of material medium

- 3.8 Magnetic force, magnetic torque, magnetic moment, magnetic dipole, magnetization
- 3.9 Magnetic boundary condition

#### **4 Time Varying Fields (4 hours)**

- 4.1 Faraday's law, transformer EMF, motional EMF
- 4.2 Displacement current
- 4.3 Maxwell's equations in integral and point forms

#### **5 Plane Waves (9 hours)**

- 5.1 Wave propagation in lossless and lossy dielectric
- 5.2 Plane waves in free space, lossless dielectric, good conductor
- 5.3 Power and Poynting theorem average power density
- 5.4 Reflection of plane wave at normal incidence
- 5.5 Standing wave and SWR
- 5.6 Input intrinsic impedance

#### **6 Transmission Lines (4 hours)**

- 6.1 Transmission line equations (Taking analogy from wave equations)
- 6.2 Lossless, lossy and distortionless transmission lines
- 6.3 Input impedance, reflection coefficient, standing wave ratio

#### **Tutorial (15 hours)**

1. Conversion of coordinate systems (Cartesian to cylindrical /spherical and vice versa, cylindrical to spherical and vice versa)
2. Electric field intensity and flux density (Coulomb's law, Gauss law, divergence, electric potential and energy density)
3. Boundary condition, electric dipole, and boundary value problems
4. Magnetic fields (Biot-Savart law, Ampere circuit law, Stoke's theorem, magnetic force and torque)
5. Time varying fields (Transformer/motional EMF, displacement current)
6. Wave propagation equations in lossy and lossless medium (Poynting theorem, standing wave ratio and intrinsic impedance)
7. Transmission line (Lossless, lossy and distortionless)

#### **Practical (22.5 hours)**

1. Teledeltos (Electro-conductive) paper mapping of electrostatic fields
2. Determination of dielectric constant, display of a magnetic hysteresis loop
3. Studies of wave propagation on a lumped parameter transmission line
4. Microwave sources, detectors, transmission lines
5. Standing wave patterns on transmission lines, reflections, power patterns on transmission lines, reflections, power measurement
6. Familiarizations of electric and magnetic field measurements using simulation tool

## Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

| Chapter      | Hours     | Marks distribution* |
|--------------|-----------|---------------------|
| 1            | 4         | 5                   |
| 2            | 15        | 20                  |
| 3            | 9         | 12                  |
| 4            | 4         | 6                   |
| 5            | 9         | 12                  |
| 6            | 4         | 5                   |
| <b>Total</b> | <b>45</b> | <b>60</b>           |

\* There may be minor deviation in marks distribution.

## References

1. Hayt, W. H. (2001). Engineering Electromagnetics. McGraw-Hill Book Company.
2. Kraus, J. D. (1973). Electromagnetics. McGraw-Hill Book Company.
3. Rao, N. N. (1990). Elements of Engineering Electromagnetics. Prentice Hall.
4. Devid K. Cheng, (1989). Field and Wave Electromagnetics. Addison-Wesley.
5. Sadiku, M. N. O. (2010). Elements of Electromagnetics. Oxford University Press.

# SIGNALS AND SYSTEMS

ENEX 255

**Lecture** : 3  
**Tutorial** : 1  
**Practical** : 3/2

**Year** : II  
**Part** : II

## Course Objectives:

The objective of this course is to provide students with a fundamental understanding of how signals are represented, analyzed, and processed in various systems. Students will grasp essential concepts such as signal classification, time and frequency domain analysis, convolution and Fourier analysis. By the end of the course, students should be proficient in solving problems related to signal processing and system analysis, enabling them to design and optimize systems effectively.

## 1 Signal and its Types

(7 hours)

- 1.1 Introduction to signal and signal processing
- 1.2 Classification of signal based on dimension
- 1.3 Classification of one-dimensional signal (CT and DT) and properties
- 1.4 Fundamental signals: Delta function, unit step, ramp, rectangular pulse, signum function
- 1.5 Relationship between unit step and delta function
- 1.6 Signal classification based on causality
- 1.7 Classification of signals based on periodicity (CT and DT)
- 1.8 Transformation of the independent variable
- 1.9 Energy and power signals
- 1.10 Even and odd signals
- 1.11 System, types of systems: Linear and non-linear, causal and non-causal, time-invariant and time-variant

## 2 Fourier Series

(9 hours)

- 2.1 Introduction to Fourier series
- 2.2 Fourier series representation of continuous time periodic signal
- 2.3 Properties of continuous time Fourier series: Linearity, time shifting, time scaling, time reversal, convolution, multiplication, frequency shifting, conjugate symmetry, Parseval's relation
- 2.4 Fourier series representation of discrete time periodic signal
- 2.5 Properties of discrete time Fourier series: Linearity, time shifting, time scaling, time reversal, convolution, modulation, conjugate symmetry, Parseval's relation
- 2.6 Applications of Fourier series

- 3      Fourier Transform      (9 hours)**
- 3.1 Introduction to Fourier transform
  - 3.2 Continuous time Fourier transform
  - 3.3 Properties of continuous time Fourier transform: Linearity, time shifting, frequency shifting, time scaling, time reversal, convolution, multiplication, duality, conjugation, Parseval's relation
  - 3.4 Discrete time Fourier transform
  - 3.5 Properties of discrete time Fourier transform: Linearity, time shifting, frequency shifting, time reversal, convolution, modulation, conjugation, Parseval's relation
  - 3.6 Fourier transform for periodic signals
  - 3.7 Applications of Fourier transform
- 4      Linear Time Invariant (LTI) System      (7 hours)**
- 4.1 Linear time invariant (LTI) system
  - 4.2 Convolution integral properties of LTI system
  - 4.3 Representation of discrete-time signals in terms of impulses
  - 4.4 Convolution sum
  - 4.5 Representation of continuous-time signals in terms of impulses
  - 4.6 Convolution integral
  - 4.7 Practical applications of convolution
- 5      Sampling      (6 hours)**
- 5.1 Introduction to sampling
  - 5.2 Sampling theorem
  - 5.3 Practical consideration of sampling and impulse-train sampling
  - 5.4 Signal reconstruction from sampled version
  - 5.5 Aliasing
  - 5.6 Band limited signals
- 6      Frequency Response of Continuous and Discrete Time Systems      (7 hours)**
- 6.1 Frequency response of continuous time systems
  - 6.2 Transfer function of continuous time system
  - 6.3 Impulse response of ideal low-pass, band-pass and high-pass filter
  - 6.4 Response of ideal low pass filter to a step function input
  - 6.5 Frequency and Impulse response of RC filter
  - 6.6 Frequency response of discrete time systems: Transfer function
  - 6.7 Impulse response of low-pass, band-pass and high-pass filter
- Tutorial      (15 hours)**
- 1. Numerical related to signal construction and periodicity
  - 2. Numerical related to extraction of even and odd part of both continuous and discrete time signals

3. Numerical to calculate the energy and power of both continuous and discrete time signals
4. Numerical related to Fourier series and its properties
5. Numerical related to Fourier transform and its properties
6. Numerical exercise to compute convolution sum and convolution integral
7. Numerical related to sampling and aliasing and signal reconstruction

### Practical

**(22.5 hours)**

1. Generation of continuous time sinusoidal signal, continuous time unit step signal, discrete time unit step signal, continuous time ramp signal, continuous time sinc function, discrete time sinusoidal signal, discrete time unit step signal, discrete time unit impulse signal, continuous time exponential signals, discrete time exponential signals, continuous time complex exponentials and discrete time complex exponentials
2. Convolution: Square wave with odd symmetry
3. Magnitude and phase of rational signal
4. Fourier series
5. Fourier transform

### Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

| Chapter      | Hours     | Marks distribution* |
|--------------|-----------|---------------------|
| 1            | 7         | 10                  |
| 2            | 9         | 12                  |
| 3            | 9         | 12                  |
| 4            | 7         | 10                  |
| 5            | 6         | 7                   |
| 6            | 7         | 9                   |
| <b>Total</b> | <b>45</b> | <b>60</b>           |

\* There may be minor deviation in marks distribution.

### References

1. Oppenheim, A.V., Willsky, A.S., Nawab, S.H. (2013). Signals and Systems. Pearson education second edition.
2. Oppenheim, A., Schafer, R. W. (2013). Discrete-Time Signal Processing: Pearson New International Edition. United Kingdom: Pearson Education.
3. Ingle, V. K., Proakis, J. G. (2000). Digital signal processing using MATLAB. United Kingdom: Brooks/Cole.
4. Lathi, B. P. (2010). Linear Systems and Signals. United Kingdom: Oxford University Press.



YEAR III, PART I

# Semester 5

6 COURSES IN THIS SEMESTER

|                     |                            |            |
|---------------------|----------------------------|------------|
| <b>ENSH 304</b>     | Probability and Statistics | <b>98</b>  |
| <b>ENCT 305</b>     | Artificial Intelligence    | <b>101</b> |
| <b>ENEX 301</b>     | Filter Design              | <b>104</b> |
| <b>ENEX 302</b>     | Embedded Systems           | <b>108</b> |
| <b>ENEX 303</b>     | Propagation and Antenna    | <b>112</b> |
| <b>ENEX 325-344</b> | Elective I                 | <b>115</b> |

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# PROBABILITY AND STATISTICS

ENSH 304

**Lecture** : 3  
**Tutorial** : 1  
**Practical** : 0

**Year : III**  
**Part : I**

## Course Objectives:

The objective of this course is to equip students with foundational knowledge in probability and statistics, focusing on core concepts essential for engineering applications. Students will develop essential skills in statistical data analysis, enabling them to apply various statistical techniques to address real-world engineering challenges. Additionally, the course emphasizes the interpretation and effective communication of statistical results, preparing students to make informed, data-driven decisions in their professional practice.

- 1 Descriptive Statistics and Basic Probability (6 hours)**
  - 1.1 Introduction to statistics and its importance in engineering
  - 1.2 Measure of central tendency and measure of variation
  - 1.3 Graphical representation of data: Histograms, box plots and scatter plots
  - 1.4 Basic probability concepts, additive law, multiplicative law
  - 1.5 Conditional probability and Bayes' theorem
- 2 Probability Distributions and Sampling Distribution (14 hours)**
  - 2.1 Random variables: Discrete and continuous
  - 2.2 Expectation and variance of discrete and continuous random variables
  - 2.3 Discrete probability distributions: Binomial, Poisson, negative Binomial
  - 2.4 Continuous probability distributions: Normal, Gamma, Chi-Square
  - 2.5 Population and sample
  - 2.6 Sampling distribution of mean and proportion
  - 2.7 Central limit theorem
- 3 Statistical Inference (14 hours)**
  - 3.1 Point estimations and properties of estimators
  - 3.2 Confidence intervals for mean and proportions
  - 3.3 Hypothesis testing, parametric and non-parametric tests, procedure of hypothesis
  - 3.4 Hypothesis testing of mean (Single mean, two means, paired t-test and one-way)
  - 3.5 Goodness of fit tests and independence of attributes (Chi-square and Kolmogorov–Smirnov test)

#### **4 Correlation and Regression (6 hours)**

- 4.1 Correlation analysis and test of linear correlation
- 4.2 Simple regression analysis, the concept of explained, unexplained, and total
- 4.3 Multiple regression analysis

#### **5 Statistical Quality Control (5 hours)**

- 5.1 Quality control and its importance in engineering
- 5.2 Control charts for variables (X-bar, R-chart, P-chart)
- 5.3 Six sigma concepts

#### **Tutorial (15 hours)**

1. Visualize data, compute central tendency, and variance in engineering problems using computer software
2. Solve different engineering problems involving probability
3. Solve different engineering problems involving discrete probability distribution and its interpretation
4. Solve different engineering problems involving continuous probability distribution and its interpretation
5. Analyze numerical engineering datasets, perform normality tests, confidence intervals, significance tests of means, and ANOVA
6. Analyze categorical engineering datasets, perform crosstabulation, proportion tests, Chi-Square tests, and draw conclusions using computer software
7. Calculate the correlation coefficient and perform correlation tests on engineering data
8. Fit and interpret simple/multiple regression models on engineering data using computer software
9. Use control charts for process monitoring on sample engineering data.
10. Create control charts using computer software

#### **Final Exam**

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

| Chapter      | Hours     | Marks distribution* |
|--------------|-----------|---------------------|
| 1            | 6         | 10                  |
| 2            | 14        | 15                  |
| 3            | 14        | 20                  |
| 4            | 6         | 10                  |
| 5            | 5         | 5                   |
| <b>Total</b> | <b>45</b> | <b>60</b>           |

\* There may be minor deviation in marks distribution.

## References

1. Ronald, E.W., Raymond, H.M., Sharon, L.M. (2012). Probability & Statistics for Engineers & Scientists (9th edition). Boston USA: Prentice Hall.
2. Richard A.J. (2018). Probability and Statistics for Engineers (9th edition). Edinburgh Gate: Pearson Education Limited
3. Sheldon M.R. (2009). Introduction to Probability and Statistics for Engineers and Scientists (4th edition). London: Elsevier Inc.
4. Jay L.D. (2012). Probability and Statistics for Engineering and Sciences. Boston: Thomson Brooks/Cole
5. Brian S.E., Ibrsten H. (2010). A Handbook of Statistical Analyses Using R (2nd edition). London: CRC Press Taylor & Francis Group
6. Andy F. (2018). Discovering Statistics Using IBM SPSS Statistics (5th edition). London: SAGE Publications.

# ARTIFICIAL INTELLIGENCE

ENCT 305

**Lecture** : 3  
**Tutorial** : 1  
**Practical** : 3/2

**Year : III**  
**Part : I**

## Course Objectives:

The objective of this course is to build a strong foundation in Artificial Intelligence (AI), covering intelligent agents, search techniques, knowledge representation, machine and learning. It aims to equip students with both theoretical knowledge and practical skills to apply AI techniques in solving real-world problems, while also fostering awareness of the ethical considerations associated with AI applications.

### 1 Introduction (4 hours)

- 1.1 Definition, foundation, history of AI
- 1.2 AI tree: Branches and interdisciplinary nature
- 1.3 Definition and importance of knowledge and learning
- 1.4 Human intelligence and machine intelligence
- 1.5 Intelligent agents and types

### 2 Problem Solving and Search (9 hours)

- 2.1 Formal problem definition: States, actions, transitions, well-defined problems
- 2.2 Constraint satisfaction problems: Node consistency, path consistency, backtracking
- 2.3 Search algorithms, strategies, and evaluations
- 2.4 Uninformed: BFS, DFS, iterative deepening
- 2.5 Informed search: Best first search, greedy search, A\* algorithm
- 2.6 Adversarial search: Minimax algorithm, alpha-beta pruning
- 2.7 Local search and optimization: Hill climbing, simulated annealing
- 2.8 Evolutionary optimization: Genetic algorithm

### 3 Knowledge Representation and Probabilistic Reasoning (7 hours)

- 3.1 Knowledge-based agent
- 3.2 Knowledge representation techniques and issues in representation
- 3.3 Propositional and predicate logic
- 3.4 Semantic networks and frames
- 3.5 Probabilistic reasoning, inference using Bayes' theorem
- 3.6 Fuzzy logic: Membership functions, fuzzy inference systems

- 4 Machine Learning Fundamentals (10 hours)**
- 4.1 Forms of learning: Supervised, unsupervised, semi-supervised, reinforcement learning
  - 4.2 Machine learning pipeline
    - 4.2.1 Preprocessing and cleaning
    - 4.2.2 Model development
    - 4.2.3 Training, testing, and hyperparameter tuning
  - 4.3 Overfitting, underfitting, bias-variance tradeoff
  - 4.4 Regression and classification with linear model
  - 4.5 Classification using decision tree and Naive Bayes
  - 4.6 Evaluation with confusion matrix
- 5 Neural Networks and Deep Learning Algorithms (6 hours)**
- 5.1 Neural networks: Structures and activation functions
  - 5.2 Perceptron, multilayer perceptron, and backpropagation
  - 5.3 Introduction to deep learning
  - 5.4 Concepts on recurrent and generative neural networks
- 6 AI Applications (7 hours)**
- 6.1 Expert systems: Characteristics, architecture, development and various applications
  - 6.2 NLP: Level of analysis and application
  - 6.3 Robotics and computer vision: Fundamental, components and applications
  - 6.4 VLSI testing, fault diagnosis, and sustainable systems
- 7 AI Ethics and Recent Trends (2 hours)**
- 7.1 Responsible AI: Bias, fairness, explainability
  - 7.2 Ethical and societal considerations
  - 7.3 Privacy and security in AI
  - 7.4 Emerging trends: Federated learning, embedded AI
- Tutorial (15 hours)**
- 1. Design a simple agent model (Vacuum cleaner, chess player)
  - 2. Formulate a route-finding problem using states, actions, and transitions
  - 3. Solve the problem with uninformed strategies
  - 4. Apply the A\* algorithm with the given heuristic values
  - 5. Solve the minimax tree and demonstrate alpha-beta pruning
  - 6. Solve a CSP like map coloring or mini-sudoku
  - 7. Perform one iteration of the genetic algorithm (Selection, crossover, mutation)
  - 8. Represent facts using semantic networks and frames
  - 9. Solving the problem related to linear and logistic regression
  - 10. Solving problems related to Bayes' theorem and fuzzy logic

11. Understanding machine learning basics through model training, cross-validation, and performance evaluation
12. Apply the Naive Bayes theorem to classify an instance
13. Model evaluation: Build a confusion matrix. Calculate sensitivity, specificity, precision, recall, and F1-score
14. Solve perceptron weight updates for a small dataset
15. Derive forward and backward propagation numerically for a 2-layer NN
16. Case study: Identify ethical risks in real-world AI use. Responsible AI in Nepal's context

### Practical

**(22.5 hours)**

1. Knowledge-based agents and search
2. Adversarial search and CSP
3. Symbolic and probabilistic reasoning
4. Machine learning – Supervised and unsupervised
5. Neural networks basics
6. Mini project and AI applications

### Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

| Chapters     | Hours     | Marks distribution* |
|--------------|-----------|---------------------|
| 1,6 and 7    | 13        | 16                  |
| 2            | 9         | 12                  |
| 3            | 7         | 10                  |
| 4            | 10        | 12                  |
| 5            | 6         | 10                  |
| <b>Total</b> | <b>45</b> | <b>60</b>           |

\* There may be minor deviation in marks distribution.

### References

1. Russell, S., Norvig, P. (2020). Artificial intelligence: A modern approach. Pearson.
2. Rich, E., Knight, K., Nair, S. B. (2009). Artificial intelligence. McGraw-Hill.
3. Bishop, C. M. (2006). Pattern recognition and machine learning. Springer.
4. Deisenroth, M. P., Faisal, A. A., Ong, C. S. (2020). Mathematics for machine learning. Cambridge University Press.

# **FILTER DESIGN**

## **ENEX 301**

**Lecture : 3**  
**Tutorial : 1**  
**Practical : 3/2**

**Year : III**  
**Part : I**

### **Course Objectives:**

The objective of this course is to provide a comprehensive understanding of analog filters and their applications. It focuses on analog filter circuits and developing skills required to design both passive and active filters based on given specifications.

## **1 Introduction (6 hours)**

- 2.1 Filter, its evolution and importance
- 2.2 Lowpass, highpass, bandpass, bandstop, allpass, passive and active filters
- 2.3 Filter response: Ideal (Brick wall) response and practical response
- 2.4 Filter parameters: Gain, attenuation, passband, stopband and transition band
- 2.5 Filter transfer function, frequency response, poles, zeros and their roles
- 2.6 Normalization and de-normalization in filter design
- 2.7 Impedance (Magnitude) scaling and frequency scaling

## **2 Approximation Methods (9 hours)**

- 2.1 Approximation and its importance in filter design
- 2.2 Low pass approximations methods
- 2.3 Butterworth approximation
- 2.4 Chebyshev (Chebyshev type I) approximation
- 2.5 Inverse Chebyshev (Chebyshev type II) approximation
- 2.6 Cauer (Elliptic) approximation
- 2.7 Bessel-Thomson response
- 2.8 Delay equalization

## **3 Frequency Transformation (2 hours)**

- 3.1 Frequency transformation and its importance in filter design
- 3.2 Low pass to high pass transformation
- 3.3 Low pass to band pass transformation
- 3.4 Low pass to band stop transformation

- 4 Properties and Synthesis of Passive Networks (8 hours)**
- 4.1 One-port passive circuits
    - 4.1.1 Properties of passive circuits, positive real functions
    - 4.1.2 Properties of lossless function
    - 4.1.3 Synthesis of LC one-port circuits, Foster and Cauer realization
    - 4.1.4 Properties and synthesis of RC one-port circuits
  - 4.2 Two-port passive circuits
    - 4.2.1 Properties of passive two-port circuits, residue condition, transmission zeros
    - 4.2.2 Synthesis of two port LC and RC ladder circuits based on zero shifting by partial removal of a pole
- 5 Design of Resistively-Terminated Lossless Filters (4 hours)**
- 5.1 Properties of resistively-terminated lossless ladder circuit, transmission and reflection coefficients
  - 5.2 Synthesis of LC ladder circuits to realize all-pole low pass functions and functions with finite transmission zeros
- 6 Design of Active Filters (12 hours)**
- 6.1 First order active filters (Bilinear)
    - 6.1.1 Review of op-amp characteristics
    - 6.1.2 First order active filters using inverting and non-inverting op-amp configurations
  - 6.2 Second order active filters (Biquads)
    - 6.2.1 Tow-Thomas biquad circuit, design of lowpass active filter using Tow-Thomas biquad circuit
    - 6.2.2 Highpass, bandpass, bandstop and allpass filter using Tow-Thomas biquad circuit
    - 6.2.3 Sallen-key biquad circuit
    - 6.2.4 Gain reduction and gain enhancement
    - 6.2.5 RC-CR transformation
  - 6.3 Higher order active filters
    - 6.3.1 Cascade of biquads
    - 6.3.2 Active simulation of passive filters: Using simulated inductor and FDNR; Using Leapfrog simulation of LC ladders
- 7 Sensitivity (2 hours)**
- 7.1 Sensitivity and importance of sensitivity analysis
  - 7.2 Single parameter sensitivity
  - 7.3 Centre frequency and Q-factor sensitivity
  - 7.4 Sensitivity of biquads and passive filters

## 8 Other Filters

(2 hours)

- 8.1 Switched capacitor filters
- 8.2 Current mode filters
- 8.3 Adaptive filters
- 8.4 Current conveyors

### Tutorial

(15 hours)

- 1. Magnitude and frequency scaling: Design of a filter at required frequency with practically realizable elements from normalized filter using scaling
- 2. Calculation of order and transfer function using Butterworth, Chebyshev, inverse Chebyshev filter for given lowpass specifications
- 3. Design of filter at required frequency range from normalized filter using frequency transformation
- 4. Synthesis of one port LC and RC functions
- 5. Synthesis of two port LC and RC ladder
- 6. Synthesis of resistively terminated lossless filters
- 7. Synthesis of first order active filters
- 8. Synthesis of second order active filters using Tow-Thomas biquad circuit and Sallen-Key biquad circuit
- 9. Synthesis of higher order active filters using cascade of biquads, simulated inductors, FDNR and Leapfrog simulation
- 10. Sensitivity analysis of active and passive filters

### Practical

(22.5 hours)

- 1. Analysis of passive and active filter circuits
- 2. Design of passive filters at required frequency with practically realizable values from a normalized filter circuit
- 3. Design of active filters using Tow-Thomas biquad circuit
- 4. Design of active filters using Sallen-Key biquad circuit
- 5. Design of higher order active filters using simulated inductors and FDNR
- 6. Design of higher order active filters using Leapfrog simulation

### Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

| Chapters     | Hours     | Marks distribution* |
|--------------|-----------|---------------------|
| 1            | 6         | 9                   |
| 2            | 9         | 12                  |
| 3 and 5      | 6         | 9                   |
| 4            | 8         | 9                   |
| 6            | 12        | 15                  |
| 7 and 8      | 4         | 6                   |
| <b>Total</b> | <b>45</b> | <b>60</b>           |

\* There may be minor deviations in marks distribution.

## References

1. Raut, R., Swamy, M. N. S. (2010). Modern analog filter analysis and design. Wiley-VCH.
2. Schaumann, R., Van Valkenburg, M. E. (2001). Design of analog filters. Oxford University Press.
3. Su, K. L. (2002). Analog filters. Springer.
4. Chen, W.-K. (2009). Passive, active and digital filters. CRC Press.
5. Thede, L. D. (2004). Practical analog and digital filter design. Artech House.

# EMBEDDED SYSTEMS

## ENEX 302

**Lecture** : 3  
**Tutorial** : 1  
**Practical** : 3/2

**Year : III**

**Part : I**

### Course Objectives:

The objective of this course is to provide a comprehensive understanding of the design and development of embedded hardware and firmware, their integration and management of embedded system development process focusing on RTOS, microcontroller and VHDL.

### 1 Introduction (2 hours)

- 1.1 Definition of embedded system
- 1.2 Embedded system vs. general purpose computing system
- 1.3 Characteristics, classification and purposes of embedded system
- 1.4 Major application areas of embedded systems

### 2 Core of Embedded System (6 hours)

- 2.1 Elements and core of embedded system
  - 2.1.1 General purpose and domain specific processors: Microprocessor, microcontroller, digital signal processor (DSP)
  - 2.1.2 Application specific integrated circuits (ASICs)
  - 2.1.3 Programmable logic devices (PLDS)
  - 2.1.4 Commercial off-the-shelf components (COTS)
- 2.2 Sensors and actuators: LED, 7 segment display, optocoupler, stepper motor, relay, Piezo buzzer, push button switch, keyboard, PPI
- 2.3 Communication interface: I2C, SPI bus, UART, 1 – wire interface, parallel interface, IEEE 1394 (Firewire), Wi-Fi, Zigbee, Bluetooth
- 2.4 Embedded firmware, real-time clock (RTC) and watchdog timer
- 2.5 Quality attributes of embedded systems
  - 2.5.1 Operational quality attributes: Response, throughput, reliability, maintainability, security and safety
  - 2.5.2 Non-operational quality attributes: Testability and debug-ability, evolvability, portability, time to prototype and market and per unit cost and NRE cost

### 3 Hardware Design Issues (6 hours)

- 3.1 Transistors and logic gates: Logic gates implementation using CMOS
- 3.2 Review of combinational logic

- 3.3 Review if sequential logic
- 3.4 Design of custom single/dual purpose processor design
- 3.5 Optimization of custom single/dual purpose processor design

#### **4 Designing Embedded System with Microcontroller (10 hours)**

- 4.1 Microprocessor versus microcontroller
- 4.2 Factors for selecting a microcontroller (Overview of 8051/AVR/PIC/ARM cortex microcontroller)
- 4.3 Pin description of 8051
- 4.4 Designing with 8051
  - 4.4.1 8051 architecture
  - 4.4.2 Memory organization: Program and data memory, external program and data memory interfacing
  - 4.4.3 Registers
  - 4.4.4 Interrupt and interrupt systems
- 4.5 Timer units
- 4.6 Addressing modes and instruction set of 8051
- 4.7 Assembly programming

#### **5 Embedded System Development Environment (4 hours)**

- 5.1 Integrated development environment (IDE)
- 5.2 Keil µVision 3/4 IDE for 8051
- 5.3 An overview of IDEs for embedded system development
- 5.4 Files generated on cross – compilation: List file (.lst), preprocessor output file, object file (.obj), map file (.map), hex file (.hex)
- 5.5 Simulators, emulators and debugging

#### **6 RTOS Based Embedded System Design (10 hours)**

- 6.1 OS basics
  - 6.1.1 Definition and primary functions
  - 6.1.2 Kernel and its services: Process management, primary and secondary management, file system management, I/O devices management, protection, interrupt handler
  - 6.1.3 Kernel space and user space: Monolithic and micro kernels
- 6.2 Types of OS: General purpose and real time OS
- 6.3 RT kernel and its basic functions
  - 6.3.1 Task / process management
  - 6.3.2 Task / process scheduling
  - 6.3.3 Task / process synchronization
  - 6.3.4 Error / exception handling
  - 6.3.5 Memory management
  - 6.3.6 Interrupt handling
  - 6.3.7 Time management

- 6.4 Hard real time and soft real time
- 6.5 Process: Structure of process, process state and transition and PCB
- 6.6 Threads
  - 6.6.1 Concept of multithreading
  - 6.6.2 Thread standards: POSIX threads, Win32 threads, java threads
  - 6.6.3 Thread preemption: User level thread, kernel/system level thread, many – to – one model, one – to – one model, many – to – many model
  - 6.6.4 Thread vs. process
- 6.7 Multiprocessing and multitasking: preemptive, non – preemptive and cooperative
- 6.8 Task scheduling
  - 6.8.1 Factors for selecting a scheduling criterion
  - 6.8.2 Non – preemptive scheduling: FCFS/FIFO, LCFS/LIFO, SJF, priority based
  - 6.8.3 Preemptive scheduling: SRTF, RR, priority based
- 6.9 Deadlock
  - 6.9.1 Conditions for deadlock
  - 6.9.2 Deadlock handling: Ignore deadlocks, detect and recover, avoid deadlocks, prevent deadlocks, livelock and starvation
- 6.10 How to choose an RTOS
  - 6.10.1 Functional requirements
  - 6.10.2 Non – functional requirements

## **7 VHDL Coding and Logic Synthesis (4 hours)**

- 7.1 Introduction, features, application, design flow and code structure
- 7.2 VHDL modeling styles: Behavioral model, dataflow model and structural model
- 7.3 Lexical elements: Library and packages, identifiers, keywords, numbers, character, string, data objects, data types, operator, data type conversion
- 7.4 Dataflow model: Concurrent statements
- 7.5 Behavioral modeling: Sequential statements
- 7.6 Structural modeling
- 7.7 Finite state machine (FSM) design using VHDL: Coding of counter, register, sequence detector and custom single/dual purpose processor

## **8 IC Technology (3 hours)**

- 8.1 Introduction
- 8.2 Full-custom (VLSI) IC technology
- 8.3 Semi-custom (ASIC) IC technology
- 8.4 Programmable logic devices (PLD) IC technology

**Tutorial****(15 hours)**

1. Design of custom single/dual purpose processor
2. Programming examples in 8051 microcontroller
3. Numerical examples based on different scheduling algorithms
4. Programming examples in VHDL

**Practical****(22.5 hours)**

1. Programming with data transfer, arithmetic and logical instruction in 8051
2. Programming with branching and bit manipulation operations in 8051
3. Programming with timers for delay and wave pulse generation in 8051
4. Coding with VHDL for combinational and sequential logic in dataflow model
5. Coding with VHDL for combinational and sequential logic in behavioral model
6. Coding with VHDL for combinational and sequential logic in structural model

The simulator like Xilinx ISE design suite, keil, proteus and other tools can be used for programming in 8051 using assembly and C level and VHDL coding.

**Final Exam**

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

| Chapter      | Hours     | Marks distribution* |
|--------------|-----------|---------------------|
| 1            | 2         | 2                   |
| 2            | 6         | 8                   |
| 3            | 6         | 8                   |
| 4            | 10        | 14                  |
| 5            | 4         | 6                   |
| 6            | 10        | 12                  |
| 7            | 4         | 6                   |
| 8            | 3         | 4                   |
| <b>Total</b> | <b>45</b> | <b>60</b>           |

\* There may be minor deviation in marks distribution.

**References**

1. Shibu, K. V. (2012). Introduction to embedded systems. Tata McGraw Hill Education.
2. Vahid, F., Givargis, T. (2011). Embedded system design: A unified hardware/software introduction. Wiley India.
3. Lee, W. F. (2000). VHDL coding and logic synthesis with Synopsis. Academic Press.
4. Neupane, M., Shrestha, S. (2020). Embedded system design principles and practice (1st ed.). Pratibha Pustak Sadan and Stationery.

# PROPAGATION AND ANTENNA

ENEX 303

**Lecture** : 3  
**Tutorial** : 1  
**Practical** : 3/2

**Year : III**  
**Part : I**

## Course Objectives:

The objective of this course is to provide a comprehensive understanding of electromagnetic wave propagation and the working principles of various types of antennas. It emphasizes their characteristics, design considerations, and applications in modern communication systems.

## 1 Introduction (6 hours)

- 1.1 Radiation phenomena in a conductor
- 1.2 Function of antenna
- 1.3 Retarded potentials: EM wave generation and propagation
- 1.4 Radiated electric and magnetic fields in EM wave
- 1.5 Radiation patterns and input impedance of very short dipole, short dipole and long dipoles
- 1.6 Antenna theorems
  - 1.6.1 Reciprocity theorem
  - 1.6.2 Superposition theorem
  - 1.6.3 Thevenin theorem
  - 1.6.4 Maximum power transfer theorem
  - 1.6.5 Compensation theorem
  - 1.6.6 Equality of directional patterns
  - 1.6.7 Equivalence of receiving and transmitting impedances

## 2 Basic Antenna Parameters and Arrays (7 hours)

- 2.1 Antenna parameters
- 2.2 Pattern multiplications
- 2.3 Two dimensional antenna arrays
  - 2.3.1 Broadside arrays
  - 2.3.2 End fire arrays
  - 2.3.3 Parasitic arrays
  - 2.3.4 Collinear arrays
- 2.4 Arrays of two point sources
  - 2.4.1 With equal amplitude and same phase
  - 2.4.2 With equal amplitude and opposite phase
  - 2.4.3 With equal amplitude and quadrature phase
  - 2.4.4 With any amplitude and any phase

### **3      Antenna Classifications      (12 hours)**

- 3.1 Electromagnetic spectrum
- 3.2 Criteria for antenna design
- 3.3 Isotropic antenna
- 3.4 Omnidirectional antennas
- 3.5 Directional antennas
- 3.6 Travelling and standing wave antennas: Long wire antenna, vee antennas, rhombic antenna
- 3.7 Wired antennas: Monopole and dipole antennas, Yagi-Uda antenna, log-periodic antenna, loop antenna, helix antenna
- 3.8 Reflector antennas: Small plane sheet and large plane sheet; Linear and corner types
- 3.9 Aperture antennas: Horn antennas types, parabolic antenna types
- 3.10 Advanced antennas: Microstrip antenna and smart antennas

### **4      Propagation and Radio Frequency Spectrum      (7 hours)**

- 4.1 Radio frequency spectrum
- 4.2 Ground wave
- 4.3 Ground reflected wave and duct propagation
- 4.4 Space wave
- 4.5 Sky wave and ionospheric layers
- 4.6 Maximum usable frequency (MUF)
- 4.7 Critical frequency and skip distance

### **5      Propagation between Antennas      (6 hours)**

- 5.1 Propagation of radio waves
- 5.2 Propagation characteristics of different band of frequencies
- 5.3 MW, SW, VHF, UHF and SHF band characteristics
- 5.4 Propagation models: Free space, two-ray and multi-path models
- 5.5 Free space propagation
- 5.6 Fresnel zones and knife edge diffraction

### **6      Link Budget      (7 hours)**

- 6.1 Introduction
- 6.2 Friis transmission equation
- 6.3 EIRP and free space loss calculation
- 6.4 Link budget calculations
  - 6.4.1 Uplink calculation
  - 6.4.2 Down-link calculation

### **Tutorial      (15 hours)**

- 1. Realization of different antenna theorems
- 2. To realize properties of EM waves: Refraction, diffraction, polarization

3. Two experiments in radiation patterns of various types of antennas
4. Calculation of mono-pole and dipole antenna of various frequencies
5. Calculation of Yagi-Uda antenna in VHF frequencies
6. Calculation of Yagi-Uda antenna in UHF frequencies
7. Antenna parameters numerical
8. Broad side and end fire antenna design concepts
9. Application and design concepts of different bands' antennas
10. Link budget calculation numerical

### Practical

**(22.5 hours)**

1. To realize and polar plots of dipole antenna, dipole with directors and reflector
2. To realize and polar plots of long wire and vee antenna
3. To realize and polar plots of rhombic antenna
4. To realize and polar plots of Yagi-Uda antenna
5. To realize and polar plots of horn antenna
6. To realize and polar plots of reflector antenna
7. Visual presentation/observation of radio, TV stations and cable operators/ISPs

### Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

| Chapter      | Hours     | Marks distribution* |
|--------------|-----------|---------------------|
| 1            | 6         | 8                   |
| 2            | 7         | 9                   |
| 3            | 12        | 16                  |
| 4            | 7         | 9                   |
| 5            | 6         | 8                   |
| 6            | 7         | 10                  |
| <b>Total</b> | <b>45</b> | <b>60</b>           |

\* There may be minor deviation in marks distribution.

### References

1. Kraus, J. D. (1950). Antenna (Latest Edition). McGraw-Hill.
2. Balanis, C. A. (2016). Antenna theory: Analysis and design. John Wiley & Sons.
3. Collins, R. E. (1985). Antennas and radiowave propagation (Latest Edition). McGraw-Hill.
4. Gautam, A. K. (2010). Antenna and wave propagation. S. K. Kataria & Sons.

# BIOMEDICAL INSTRUMENTATION

## ENEX 325

**Lecture** : 3  
**Tutorial** : 2  
**Practical** : 1

**Year : III**  
**Part : I**

### Course Objectives:

The objective of this course is to provide a comprehensive understanding of the principles, methodologies, and instrumentation used in biomedical engineering. It emphasizes the design, operation, and maintenance of various biomedical instruments, along with their applications in medical diagnosis, monitoring, and therapy.

#### **1 Fundamental of Medical Instrumentation (2 hours)**

- 1.1 Biomedical engineering and scope
- 1.2 Biometrics and design consideration factors
- 1.3 Man instrument system and their objectives
- 1.4 Components of man instrument system

#### **2 Bioelectric Signals and Electrodes (2 hours)**

- 2.1 Body system and bioelectric phenomenon
- 2.2 Sources of bioelectric signals
- 2.3 Resting and action potentials
- 2.4 Electrode theory and their equivalent circuits
- 2.5 Types of biopotential electrodes
- 2.6 Application of electrodes in medical instrumentation

#### **3 Physiological Transducers (2 hours)**

- 3.1 Classification of transducers
- 3.2 Performance characteristics of transducers
- 3.3 Active transducers and their application in medical instruments
- 3.4 Passive transducers and their types used in medical instruments

#### **4 Bioelectric Signals Measurement and Recording System (5 hours)**

- 4.1 Aspects of bioelectric signals
- 4.2 Electrocardiography (ECG)
  - 4.2.1 Normal characteristics of electrocardiogram
  - 4.2.2 ECG lead configuration and recording techniques
  - 4.2.3 Computer aided electrocardiograph analysis
- 4.3 Electroencephalography (EEG)
  - 4.3.1 Electroencephalogram and evoked potential

- 4.3.2 EEG preamplifier design
- 4.3.3 EEG electrode configuration and recording techniques
- 4.3.4 Practical details of EEG
- 4.4 Electromyography (EMG)
  - 4.4.1 Electromyography recording technique
  - 4.4.2 Applications of EMG

## **5 Non- Invasive Diagnostic Instruments (10 hours)**

- 5.1 Blood flow measurement
  - 5.1.1 Magnetic blood flow meter
  - 5.1.2 Ultrasonic blood flow meter
  - 5.1.3 Blood flow measurement by radiographic method
- 5.2 Diagnostic medical imaging system
  - 5.2.1 Radiographic imaging system: principle of generation of X-rays and its medical properties; Functional X-ray machine; Biological effects of X-rays
  - 5.2.2 Ultrasonography imaging system
  - 5.2.3 Computer tomography (CT-Scan) system
  - 5.2.4 Magnetic resonance imaging system (MRI)
  - 5.2.5 Nuclear medicine machine

## **6 Therapeutic Instruments (4 hours)**

- 6.1 Cardiac pacemaker
- 6.2 Defibrillator machine
- 6.3 Function of kidneys
- 6.4 Principle of artificial kidneys
- 6.5 Hemodialysis machine
- 6.6 Lithotripter machine and its principle

## **7 Biomedical Telemetry and Telemedicine (2 hours)**

- 7.1 Wireless telemetry
- 7.2 Single channel telemetry system
- 7.3 Multi channel telemetry
- 7.4 Telemedicine using mobile communication equipment

## **8 Ventilators (15 hours)**

- 8.1 Mechanism of respiration
  - 8.1.1 Types and classification of ventilators
  - 8.1.2 Artificial ventilation
  - 8.1.3 ICU ventilators
  - 8.1.4 Types of ventilators
  - 8.1.5 Ventilators terms
  - 8.1.6 Modern ventilators

- 8.2 Anesthesia machines
  - 8.2.1 Need for anesthesia
  - 8.2.2 Anesthesia machine, its types and electronics
- 8.3 Blood gas analyzers and blood cell counters
  - 8.3.1 Principle of measurements of blood gas analyzers, circuit diagram and clinical applications
  - 8.3.2 Micro cell counters and its types
- 8.4 Patient monitoring systems
  - 8.4.1 Overview and system concept
  - 8.4.2 Cardiac monitor
  - 8.4.3 Bed side ICU patient monitoring systems
  - 8.4.4 Central monitors

## **9 Electrical Safety of Medical Equipment**

**(3 hours)**

- 9.1 Physiological effects of electricity
- 9.2 Leakage currents and methods of accident prevention
- 9.3 Micro shocks and macro shocks hazards
- 9.4 Electrical safety codes and standards
- 9.5 Special safety measures for electrical susceptible patients
- 9.6 Power distribution and protection system of the hospital

## **Tutorial**

**(30 hours)**

- 1. Description study of mechanism of respiration
- 2. Aspects of ICU ventilator and modern ventilators
- 3. Anesthesia machines and their electro-mechanical aspects.
- 4. Practical aspects and applications of life saving equipment
- 5. Study of diagnostic medical imaging system
- 6. Radiographic imaging system
- 7. Principle of generation of X-rays and its medical properties
- 8. Study of functional X-ray machine
- 9. Biological effects of X-rays
- 10. Study of Ultrasonography imaging system
- 11. Practical aspects and applications of us machine
- 12. Study of computer tomography (CT-Scan) system
- 13. Practical aspects and applications of ct scan machine
- 14. Study of magnetic resonance imaging system (MRI)
- 15. Practical aspects and applications of MRI machine
- 16. Study of nuclear medicine machine, Cath lab
- 17. Blood gas analyzers and blood cell counters, study of lab equipment and applications
- 18. Design study of 4 beds ICU patient monitoring system
- 19. Study of bioelectric signals measurement and recording system
- 20. Aspects of bioelectric signals and their recorders: Applications of electrocardiography (ECG), electroencephalography (EEG), electromyography (EMG)

**Practical****(15 hours)**

1. Laboratory/ practical exercises based on portable medical devices (Sensors/transducers)
2. Practical on medical instruments Pulse Oximeter, ECG Machine, clinical based equipment in the lab
3. Practical on medical instruments patient monitor and devices, clinical based equipment in the lab
4. Observation and Inspection visit of different medical equipment to medical institution or hospitals and submission of inspection report

**Final Exam**

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

| Chapters     | Hours     | Marks distribution* |
|--------------|-----------|---------------------|
| 1, 2 and 3   | 6         | 10                  |
| 4            | 5         | 6                   |
| 5            | 10        | 10                  |
| 6 and 7      | 6         | 10                  |
| 8            | 15        | 20                  |
| 9            | 3         | 4                   |
| <b>Total</b> | <b>45</b> | <b>60</b>           |

\* There may be minor deviation in marks distribution.

**References**

1. Webster, J.G. (1997). Medical instrumentation: Application and design (Latest edition). John Wiley & Sons.
2. Cromwell, L., Weibell, F.J., Pfeiffer, E.A. (1980). Biomedical instrumentation and measurements (Latest edition). Prentice-Hall.
3. Khandpur, R.S. (2004). Biomedical instrumentation: Technology and applications. McGraw-Hill.
4. Paul, S., Saikia, A., Majhi, V., Pandey, V.K. (2022). Introduction to biomedical instrumentation and its applications. Academic Press.

# JAVA PROGRAMMING

ENCT 327

**Lecture** : 3  
**Tutorial** : 2  
**Practical** : 1

**Year** : III

**Part** : I

## Course Objectives:

The objective of this course is to equip students with comprehensive knowledge and practical skills in Java programming, enabling them to design and develop robust, modern applications. Emphasis is placed on using the Spring Boot framework to build scalable, production-ready enterprise solutions.

### 1 Java Fundamentals (7 hours)

- 1.1 Overview of Java ecosystem (JDK, JVM, JRE)
- 1.2 Evolution of Java
- 1.3 Modern development tools (Maven, Gradle, IntelliJ, VS Code)
- 1.4 Review of core Java OOP, collections and exception handling
- 1.5 Functional programming: Lambda, expressions and streams API
- 1.6 Introduction to modern features like records and sealed classes

### 2 Java I/O and Data Handling (6 hours)

- 2.1 Streams and file handling
  - 2.1.1 Byte and character streams
  - 2.1.2 Reading/writing text files
  - 2.1.3 Object streams and serialization
  - 2.1.4 New I/O (NIO.2) file operations
- 2.2 JSON and data Interchange
  - 2.2.1 Handling JSON data with libraries like Jackson or Gson
  - 2.2.2 JSON vs. XML in REST APIs

### 3 Database and Web Communication (10 hours)

- 3.1 Java database connectivity (JDBC)
  - 3.1.1 JDBC architecture and drivers
  - 3.1.2 Connection, statement, and result set management
  - 3.1.3 Prepared statements for secure and efficient queries
- 3.2 Network programming and rest
  - 3.2.1 Client-server model and basics of socket communication
  - 3.2.2 Consuming restful APIs using the HttpClient from Java 11+
  - 3.2.3 Overview of microservices architecture

## **4 Spring Boot and Modern Web Development (16 hours)**

- 4.1 Spring Boot fundamentals; Dependency injection and inversion of control; Creating RESTful APIs with Spring Boot
- 4.2 Data Access with Spring
  - 4.2.1 Overview of ORM and JPA
  - 4.2.2 Building a repository layer with spring data JPA
  - 4.2.3 CRUD operations and transactional management
- 4.3 API Development and Security
  - 4.3.1 REST API design principles
  - 4.3.2 Handling exceptions in spring boot
  - 4.3.3 Overview of spring security for authentication and authorization
- 4.4 Deployment and Project Work
  - 4.4.1 Docker and containerization
  - 4.4.2 Packaging and deploying a Spring Boot application

## **5 Concurrency and Performance (6 hours)**

- 5.1 Overview of multithreading
- 5.2 Thread lifecycle and synchronization
- 5.3 Executor framework and thread pools
- 5.4 Completable future and parallel streams
- 5.5 Best practices for thread-safe programming
- 5.6 Performance of multi-threaded program

## **Tutorial (30 hours)**

- 1. Practice Lambda expressions and Stream API operations
- 2. Implement functional interfaces and method references
- 3. Perform file I/O operations and object serialization
- 4. Implement multithreading and synchronization mechanisms
- 5. Develop a Java program for CRUD operations using JDBC
- 6. Create and configure a Spring Boot project using Spring Initializer
- 7. Implement dependency injection using constructor, setter, and field injection
- 8. Develop restful CRUD APIs using Spring Boot and JPA
- 9. Create custom database queries using derived methods and the @query annotation
- 10. Implement centralized exception handling and API error responses
- 11. Configure authentication and authorization using Spring Security
- 12. Consume third-party rest APIs using WebClient or RestTemplate
- 13. Configure environment-specific properties and external database connections
- 14. Containerize and deploy a spring boot application using Docker
- 15. Write and execute unit and integration tests using JUnit 5 and MockMvc
- 16. Project work: Apply learned concepts by building a small, secure, full-stack REST service

**Practical****(15 hours)**

1. Programs using Lambda expressions and Streams API
2. Implementation of file I/O operations
3. Development of a simple client-server application
4. Implementation of a Spring Boot application with a data access layer
5. Containerization of a Spring Boot application using Docker

**Final Exam**

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

| Chapter      | Hours     | Marks distribution* |
|--------------|-----------|---------------------|
| 1            | 7         | 8                   |
| 2            | 6         | 8                   |
| 3            | 10        | 14                  |
| 4            | 16        | 22                  |
| 5            | 6         | 8                   |
| <b>Total</b> | <b>45</b> | <b>60</b>           |

\* There may be minor deviation in marks distribution.

**References**

1. Bloch, J. (2017). Effective Java. Addison-Wesley Professional.
2. Schildt, H. (2024). Java: The Complete Reference. McGraw-Hill Education.
3. Goetz, B., Peierls, T., Bloch, J., Bowbeer, D., Holmes, J., Lea, D. (2006). Java Concurrency in Practice. Addison-Wesley Professional.
4. Walls, C. (2016). Spring Boot in Action. Manning Publications.

# QUANTUM COMPUTING

ENCT 328

**Lecture** : 3  
**Tutorial** : 2  
**Practical** : 1

**Year : III**

**Part : I**

## Course Objectives:

The objective of this course is to introduce the principles, mathematical foundations, and computational models of quantum computing. It emphasizes on algorithmic insights, and offer practical experience with quantum programming environments. By the end of the course, students will be able to represent and manipulate quantum states and gates, design and simulate basic quantum circuits, implement fundamental quantum algorithms and their speedup mechanisms, and explore applications of quantum machine learning (QML) techniques.

- 1 Fundamentals of Quantum Concepts (6 hours)**
  - 1.1 Classical versus Quantum computation
  - 1.2 Qubits, superposition, measurement
  - 1.3 Postulates of quantum mechanics
  - 1.4 Dirac notation and Bloch sphere
- 2 Quantum Gates and Circuits (6 hours)**
  - 2.1 Quantum gates (X, Y, Z, H, Phase, CNOT)
  - 2.2 Unitary operations and reversibility
  - 2.3 Multi-qubit systems and tensor products
  - 2.4 Circuit design and visualization
- 3 Entanglement and Quantum Communication (5 hours)**
  - 3.1 Entangled states and Bell theorem
  - 3.2 EPR paradox
  - 3.3 Quantum teleportation and superdense coding
  - 3.4 Quantum key distribution protocols: BB84, E91
- 4 Quantum Algorithms (10 hours)**
  - 4.1 Quantum parallelism
  - 4.2 Deutsch and Deutsch–Jozsa algorithms
  - 4.3 Bernstein–Vazirani
  - 4.4 Grover's algorithm
  - 4.5 Shor's algorithm

- |                 |                                                                                                                |                   |
|-----------------|----------------------------------------------------------------------------------------------------------------|-------------------|
| <b>5</b>        | <b>Quantum Hardware and NISQ Era</b>                                                                           | <b>(6 hours)</b>  |
|                 | 5.1 Physical realization (Ion trap, superconducting, photonic)                                                 |                   |
|                 | 5.2 Noise, decoherence, and qubit metrics                                                                      |                   |
|                 | 5.3 NISQ model and limitations                                                                                 |                   |
|                 | 5.4 Quantum circuit execution on IBM quantum simulators                                                        |                   |
| <b>6</b>        | <b>Quantum Error and Correction</b>                                                                            | <b>(4 hours)</b>  |
|                 | 6.1 Bit-flip and phase-flip errors                                                                             |                   |
|                 | 6.2 Simple quantum error detection                                                                             |                   |
|                 | 6.3 Shor's 9-qubit code                                                                                        |                   |
|                 | 6.4 Surface code overview                                                                                      |                   |
| <b>7</b>        | <b>Quantum Annealing, Optimization Algorithms</b>                                                              | <b>(4 hours)</b>  |
|                 | 7.1 Principles of quantum annealing                                                                            |                   |
|                 | 7.2 Relationship with adiabatic quantum computation                                                            |                   |
|                 | 7.3 Optimization problem formulation (QUBO, Ising models)                                                      |                   |
|                 | 7.4 Quantum annealer architecture                                                                              |                   |
| <b>8</b>        | <b>Quantum Machine Learning</b>                                                                                | <b>(4 hours)</b>  |
|                 | 8.1 Introduction to QML and its importance                                                                     |                   |
|                 | 8.2 Quantum data representation and feature encoding                                                           |                   |
|                 | 8.3 Variational Quantum Circuits (VQC)                                                                         |                   |
|                 | 8.4 Simple quantum classifiers and QNN concepts                                                                |                   |
|                 | 8.5 Hybrid quantum-classical learning models                                                                   |                   |
| <b>Tutorial</b> |                                                                                                                | <b>(30 hours)</b> |
|                 | 1. Classical versus quantum computation; Qubit basics, superposition, and measurement                          |                   |
|                 | 2. State vectors, normalization and probability amplitudes                                                     |                   |
|                 | 3. Dirac notation and Bloch sphere representation with simple simulations                                      |                   |
|                 | 4. Single-qubit gates (X, Y, Z, H, Phase); Matrix representation and simulation                                |                   |
|                 | 5. Multi-qubit systems and two-qubit gates such as CNOT; Tensor product exercises and simulation               |                   |
|                 | 6. Entanglement and Bell states; Measurement correlation analysis                                              |                   |
|                 | 7. Simulation of quantum key distribution protocols, including BB84                                            |                   |
|                 | 8. Quantum algorithms I: Deutsch and Deutsch–Jozsa; Algorithm formulation and coding                           |                   |
|                 | 9. Quantum algorithms II: Bernstein–Vazirani and Grover search; Coding and simulation exercises                |                   |
|                 | 10. Introduction to quantum hardware; Physical qubit types, noise, and decoherence; Basic modeling             |                   |
|                 | 11. NISQ devices; Build and execute simple circuits on IBM Quantum or equivalent simulator and analyze results |                   |

12. Quantum error modeling including bit-flip and phase-flip; Simple error detection and correction exercises
13. Quantum annealing and optimization; Formulation of QUBO and Ising problems
14. Quantum machine learning and variational circuits; Data encoding, simple VQC construction

### Practical

**(15 hours)**

1. IBM qiskit / quantum composer labs
2. Implement Grover's or teleportation circuit
3. Implement Shor's algorithm
4. Applications in combinatorial optimization (E.g., scheduling, routing, network optimization)
5. Hands-on simulation using quantum annealers
6. Mini-project demonstration

### Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

| Chapter      | Hours     | Marks distribution* |
|--------------|-----------|---------------------|
| 1            | 6         | 8                   |
| 2            | 6         | 8                   |
| 3            | 5         | 7                   |
| 4            | 10        | 12                  |
| 5            | 6         | 8                   |
| 6            | 4         | 6                   |
| 7            | 4         | 5                   |
| 8            | 4         | 6                   |
| <b>Total</b> | <b>45</b> | <b>60</b>           |

\* There may be minor deviation in marks distribution.

### References

1. Nielsen, M. A., Chuang, I. L. (2002). Quantum computation and quantum information. Cambridge University Press.
2. Bernhardt, C. (2019). Quantum computing for everyone. MIT Press.
3. Schuld, M., Petruccione, F. (2021). Machine learning with quantum computers. Springer.
4. Sahni, V. (2007). Quantum computing. Tata McGraw-Hill Publishing Company.
5. Akama, S. (2014). Elements of quantum computing: History, theories and engineering applications. Springer International Publishing.
6. Wichert, A. (2014). Principles of quantum artificial intelligence. World Scientific Publishing Co.

# PYTHON PROGRAMMING FOR DATA SCIENCE

ENCT 329

**Lecture** : 3  
**Tutorial** : 2  
**Practical** : 1

**Year : III**  
**Part : I**

## Course Objectives:

The objective of this course is to develop a fundamental understanding of Python programming and its applications in data science. It covers Python basics including syntax, variables, data types, and control structures, and provides hands-on experience with essential libraries such as NumPy, Pandas, Matplotlib, and Seaborn for data manipulation, analysis, and visualization. By the end of the course, students will be able to work with real-world datasets and apply Python programming to solve data-driven problems effectively.

### **1 Introduction (8 hours)**

- 1.1 Overview of Python and its role in data science
- 1.2 Setting up Python environment (Anaconda, Jupyter Notebook)
- 1.3 Basic syntax, variables, keywords, and expressions
- 1.4 Data types: Numeric, string, boolean, and type conversion
- 1.5 Input/output operations and basic file handling

### **2 Control Structures and Functions (8 hours)**

- 2.1 Conditional statements (if, elif, else)
- 2.2 Looping constructs (for, while, nested loops)
- 2.3 Loop control statements (break, continue, pass)
- 2.4 Functions – Definition, arguments, return values, lambda functions
- 2.5 Scope and lifetime of variables, error, and exception handling

### **3 Data Structures and Collections (8 hours)**

- 3.1 Lists, tuples, sets, and dictionaries – Creation and manipulation
- 3.2 List comprehensions and dictionary comprehensions
- 3.3 Working with nested data structures
- 3.4 Introduction to Python modules and importing libraries

### **4 NumPy for Numerical Computing (5 hours)**

- 4.1 Introduction to NumPy and array creation
- 4.2 Indexing, slicing, and reshaping arrays
- 4.3 Array operations and broadcasting

- 4.4 Mathematical, statistical, and aggregate functions
- 4.5 Practical applications in scientific computing

## **5 Data Manipulation with Pandas (8 hours)**

- 5.1 Introduction to Series and DataFrame
- 5.2 Data import/export (CSV, Excel, JSON)
- 5.3 Data cleaning: handling missing values, filtering, sorting
- 5.4 Data transformation: grouping, merging, joining, and aggregation
- 5.5 Descriptive statistics and data summarization

## **6 Data Visualization with Matplotlib and Seaborn (8 hours)**

- 6.1 Importance of visualization in data science
- 6.2 Plotting basics using Matplotlib (Line, bar, scatter, histogram)
- 6.3 Customizing plots: Titles, labels, legends, colors, subplots
- 6.4 Seaborn for statistical visualization: Boxplot, heatmap, pairplot, distplot
- 6.5 Creating visual stories using combined plots

## **Tutorial (30 hours)**

- 1. Practice on Python syntax, variables, data types, and expressions
- 2. Exercises on conditional statements, loops, and writing small programs
- 3. Practice creating and manipulating lists, tuples, sets, and dictionaries
- 4. Problem-solving using functions, arguments, return values, and lambda functions
- 5. Exercises on file input/output operations and handling exceptions
- 6. Numerical computation problems using NumPy arrays and vectorized operations
- 7. Data manipulation problems using Pandas: Filtering, grouping, merging, and summarization
- 8. Visualization exercises using Matplotlib and Seaborn for different chart types
- 9. Discussion and review of mini-project design and dataset selection
- 10. Mini project: Complete a small end-to-end data analysis task: Importing a dataset, cleaning and processing it using Pandas, performing numerical analysis with NumPy, and visualizing insights using Matplotlib and Seaborn

## **Practical (15 hours)**

- 1. Environment setup: Installation and configuration of Python, Anaconda, and Jupyter Notebook
- 2. Basic programming tasks: Writing simple Python programs involving variables, expressions, loops, and conditional statements
- 3. Functions and data structures: Implementing Python functions, list and dictionary operations, and comprehension techniques
- 4. File handling: Reading and writing text and CSV files using Python's built-in libraries

5. NumPy practice: Creating, reshaping, and manipulating NumPy arrays; Performing vectorized mathematical operations
6. Data manipulation with pandas: Loading real datasets, handling missing values, filtering, sorting, and aggregating data
7. Data summarization and descriptive statistics: Using Pandas to compute mean, median, standard deviation, correlation, and other statistics
8. Visualization using Matplotlib: Plotting line graphs, bar charts, histograms, and scatter plots; Customizing labels, titles, and legends
9. Statistical visualization using Seaborn: Creating advanced visualizations such as boxplots, heatmaps, and pairplots

### Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

| Chapter      | Hours     | Marks distribution* |
|--------------|-----------|---------------------|
| 1            | 8         | 10                  |
| 2            | 8         | 12                  |
| 3            | 8         | 10                  |
| 4            | 5         | 8                   |
| 5            | 8         | 10                  |
| 6            | 8         | 10                  |
| <b>Total</b> | <b>45</b> | <b>60</b>           |

\* There may be minor deviation in marks distribution.

### References

1. VanderPlas, J. (2016). Python data science handbook. O'Reilly Media.
2. McKinney, W. (2018). Python for data analysis. O'Reilly Media.
3. Gaddis, T. (2018). Starting out with Python. Pearson Education.
4. Matthes, E. (2023). Python crash course. No Starch Press.

# WEB PROGRAMMING

ENCT 330

**Lecture : 3**  
**Tutorial : 2**  
**Practical : 1**

**Year : III**  
**Part : I**

## Course Objectives:

The objective of this course is to provide comprehensive understanding of web technologies for developing responsive and interactive web applications. The course emphasizes the use of modern front-end frameworks and tools, as well as techniques for integrating front-end interfaces with back-end APIs and databases. By the end of the course, students will be able to design, implement and evaluate contemporary applications while exploring current trends and future directions in web development.

## 1 Introduction (6 hours)

- 1.1 Overview of web applications and evolution of web architecture
- 1.2 Client-server architecture, HTTP, HTTPS, URLs, DNS, web browsers
- 1.3 Html basics: Syntax, tags, attributes, forms and inputs, tables, lists, multimedia, semantic HTML5 elements
- 1.4 CSS basics: Selectors, properties, values, box model
- 1.5 CSS framework: Bootstrap

## 2 JavaScript and Client-Side Programming (12 hours)

- 2.1 JavaScript essentials
  - 2.1.1 Data types, variables, control structures, functions
  - 2.1.2 Dom manipulation, events, and form validation
  - 2.1.3 Local storage and session storage
  - 2.1.4 GUI interactions
  - 2.1.5 JavaScript library: jQuery
- 2.2 Modern JavaScript (ES6+)
  - 2.2.1 Arrow functions, destructuring, spread/rest operators
  - 2.2.2 Callbacks, promises, async/await
  - 2.2.3 Modules and imports
- 2.3 Client-side applications
  - 2.3.1 Client-side web application development using React JS library
  - 2.3.2 Traditional multi-page apps vs. single-page apps (SPAs)
  - 2.3.3 Component-based UI and props
  - 2.3.4 State management and data flow
  - 2.3.5 Client-side routing and navigation without reloads
  - 2.3.6 Fetch API: Fetching, displaying data, handling errors and loading states

### 2.3.7 Comparison of modern JavaScript libraries: React, Angular, Vue

## **3 Server-Side Web Programming (9 hours)**

- 3.1 MVC architecture in web development
- 3.2 Role of backend in web applications
- 3.3 Backend web framework: Django
- 3.4 Handling requests and responses
- 3.5 Form data handling and sessions
- 3.6 Routing, middleware, templating concepts
- 3.7 Overview and comparison of backend frameworks: Django, flask, fastapi, dot NET MVC framework, ruby on rails, java spring boot, node.js
- 3.8 Database integration: Relational versus NoSQL, CRUD operations, ORM concept
- 3.9 Authentication and authorization: Cookies, sessions, JWT
- 3.10 Middleware for logging, error handling, and security

## **4 Web Services and APIs (7 hours)**

- 4.1 API basics: Role in web applications
- 4.2 REST principles and design, RESTful APIs
- 4.3 JSON versus XML data exchange
- 4.4 Data validation and serialization
- 4.5 Microservices

## **5 Web Application Security (6 hours)**

- 5.1 Common vulnerabilities: XSS, SQL injection, CSRF
- 5.2 Security best practices: Input validation, sanitization, https, secure cookies, env variables
- 5.3 Authentication practices and token handling
- 5.4 Security in full-stack apps: CORS, safe sessions

## **6 Web Application Deployment and Modern Trends (5 hours)**

- 6.1 Full-stack development
- 6.2 Testing and QA
- 6.3 DevOps, continuous integration (CI) and continuous delivery (CD)
- 6.4 Progressive web apps (PWAs), responsive design and usability

## **Tutorial (30 hours)**

- 1. Walkthrough of client-server request flow (DNS→HTTP/HTTPS→ Browser)
- 2. Guided coding: HTML page with semantic tags, styled with CSS grid/flexbox
- 3. JavaScript and client-side programming
- 4. Hands-on exercises with DOM manipulation, event handling
- 5. Form validation and local storage demo

6. Guided task: Small SPA with component-based UI and fetch API integration
7. Discuss request/response cycle with server framework
8. Guided coding: Simple CRUD using Django/Flask (e.g., library system)
9. Session handling and authentication example
10. REST principles with examples
11. Hands-on exercise: Build a simple REST API endpoint and test with fetch/postman
12. Demonstration of XSS and SQL Injection vulnerabilities
13. Guided exercise: Secure login form with input validation and session/token handling
14. Discussion on PWAs, serverless, microservices
15. Develop a comprehensive project that encompasses the complete process of front-end and back-end web application development and deployment. The project should be carried out over at least six to seven lab sessions, covering the following stages: Project proposal, front-end UI/UX design, back-end and database design, API design and integration, testing and deployment, and culminating in a final presentation and demonstration

## Practical

**(15 hours)**

1. Build a responsive personal portfolio page using semantic HTML5, CSS grid/flexbox, and media queries
2. Create a dynamic to-do list app with DOM events, local storage, and JavaScript event handling (using jQuery)
3. Develop a CRUD application (e.g., library system) using a server-side framework (Django/Flask/FastAPI)
4. Create a frontend in React that fetches data from your backend API and displays it dynamically.
5. Extend the CRUD app with user authentication (Login/logout), form validation, and secure token/session handling

## Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

| Chapter      | Hours     | Marks distribution* |
|--------------|-----------|---------------------|
| 1            | 6         | 8                   |
| 2            | 12        | 16                  |
| 3            | 9         | 12                  |
| 4            | 7         | 9                   |
| 5            | 6         | 8                   |
| 6            | 5         | 7                   |
| <b>Total</b> | <b>45</b> | <b>60</b>           |

\* There may be minor deviation in marks distribution.

## References

1. Copes, F. (2019). The JavaScript Handbook. (<https://flaviocopes.com/the-javascript-handbook-2019-edition/>)
2. Nixon, R. (2025). Learning PHP, MySQL & JavaScript: A Step-by-Step Guide to Creating Dynamic Websites. O'Reilly Media.
3. Vincent, W. S. (2025). Django for Beginners: Build websites with Python and Django.
4. Richardson, L., & Amundsen, M. (2013). RESTful Web APIs: Services for a Changing World. O'Reilly Media.
5. Hoffman, A. (2024). Web Application Security: Exploitation and Countermeasures for Modern Web Applications (2nd ed.). O'Reilly Media.

# OPERATING SYSTEM (OS)

ENCT 331

**Lecture** : 3  
**Tutorial** : 2  
**Practical** : 1

**Year** : III  
**Part** : I

## Course Objectives:

The objective of this course is to provide a comprehensive understanding of the principles, design, and functionality of operating systems. It focuses on core concepts such as process management, inter-process communication and synchronization, input/output management and file system organization. The course also introduces essential aspects of system security, administration, and virtualization, equipping students with both theoretical knowledge and practical skills in modern operating system design.

## 1 Introduction (6 hours)

- 1.1 History of operating systems (OS)
- 1.2 OS as an extended machine and resource manager
- 1.3 Type of operating system: Mainframe, server, personal, smartphone and handheld, IoT and embedded, real-time, smart-card
- 1.4 Operating system components: Kernel, shell, utilities, applications
- 1.5 Types of OS kernel: Monolithic, micro, nano, layered, hybrid, Exo Kernel
- 1.6 System calls, shell commands, shell programming
- 1.7 POSIX standard
- 1.8 Bootloader, MBR/GPT, UEFI and legacy boot

## 2 Process Management (7 hours)

- 2.1 Introduction to process
  - 2.1.1 Process description
  - 2.1.2 Process states
  - 2.1.3 Process control
- 2.2 Scheduling algorithms
  - 2.2.1 First come first serve (FCFS)
  - 2.2.2 Shortest job first (SJF)
  - 2.2.3 Shortest remaining time (SRT)
  - 2.2.4 Round robin (RR)
  - 2.2.5 Highest response ratio next (HRNN)
  - 2.2.6 Completely fair scheduler (CFS) used in Linux
- 2.3 Threads and thread scheduling

- 3 Process Communication and Synchronization (10 hours)**
- 3.1 Principles of concurrency, race condition, critical region
  - 3.2 Mutual exclusion, semaphores, and Mutex
  - 3.3 Message passing and monitors
  - 3.4 Classical problems of synchronization: Readers-writers problem, producer-consumer problem, dining philosopher problem
  - 3.5 Deadlock: Prevention, ignorance, avoidance, detection, and recovery
- 4 I/O and Memory Management (9 hours)**
- 4.1 I/O management
    - 4.1.1 Principles of I/O hardware and software
    - 4.1.2 I/O software layer
    - 4.1.3 Disk technologies: magnetic disk, SSD, NVMe storage
    - 4.1.4 RAID
    - 4.1.5 Concept of stable storage, cost per bit comparison
  - 4.2 Memory management
    - 4.2.1 Memory address, swapping, and managing free memory space
    - 4.2.2 Virtual memory management; Paging; Segmentation
    - 4.2.3 Page replacement algorithms (FIFO, LRU, LFU, optimal), page fault, and hit ratio
    - 4.2.4 Allocation of frames
    - 4.2.5 Thrashing
- 5 File Systems (3 hours)**
- 5.1 File concepts: Name, structure, types, access, attributes, operations
  - 5.2 Directory structures: Paths and hierarchies (Linux/Windows)
  - 5.3 File system implementation: Inodes, allocation methods (Contiguous, linked, indexed)
  - 5.4 File system performance: Factors affecting efficiency
  - 5.5 Example file systems: NTFS, EXT4, FAT32, NFS
- 6 Security and System Administration Tools (3 hours)**
- 6.1 OS security: Cryptography, multi-factor authentication (MFA), secure boot, and sandboxing
  - 6.2 Access control: Policies, lists, and OS support
  - 6.3 System administration: User management, environment setup, and tools (AWK, shell scripts, Make)
- 7 Hypervisors and Virtual Systems (4 hours)**
- 7.1 Hypervisors: Type 1 and type 2
  - 7.2 Virtual machines: Creating a virtual machine in Qemu/VirtualBox/VMWare
  - 7.3 Container virtualization: Docker and Kubernetes

- 7.4 Powershell and windows subsystem for Linux(WSL)
- 7.5 Performance optimization and security in virtualized environments

## **8 Recent Development (3 hours)**

- 8.1 Role of operating systems in embedded and communication systems
- 8.2 Synchronization in real-time communication and IoT systems
- 8.3 Memory and I/O management in embedded communication devices
- 8.4 File systems used in mobile, IoT, and communication devices (YAFFS, F2FS)
- 8.5 Securing communication-oriented OS and networked embedded devices
- 8.6 Application of virtualization in IoT gateways and communication systems

## **Tutorial (30 hours)**

- 1. Introduction to operating systems and kernel types
- 2. Unix shell programs to perform a variety of tasks
- 3. Problems on process states and scheduling algorithms (FCFS, SJF, RR, HRRN, CFS)
- 4. Thread and concurrency concepts with numerical and conceptual problems
- 5. Problems on semaphores and classical synchronization (Readers–writers, producer–consumer, dining philosophers)
- 6. Problems on deadlock prevention, avoidance, and recovery
- 7. Study on I/O hardware–software interface and stable storage
- 8. Comprehensive study on storage technologies with cost/bit and speed comparisons
- 9. Problems on memory allocation, fragmentation, and swapping
- 10. Problems on paging and segmentation
- 11. Problems on page replacement algorithms (FIFO, LRU, LFU, optimal)
- 12. Study on file system implementation and directory structures
- 13. Study on OS security concepts (MFA, secure boot, sandboxing)
- 14. Study on virtualization and containerization (Hypervisors, Docker, WSL)
- 15. Study on OS components and performance in IoT and embedded systems

## **Practical (15 hours)**

- 1. Basic Unix commands and shell programming
- 2. Implementation of the ls and grep commands
- 3. Programs using the I/O system calls of the Unix operating system
- 4. Implementation of scheduling algorithms (FCFS, round robin) and the producer-consumer problem using semaphores
- 5. Implementation of some memory management schemes, such as paging and segmentation
- 6. Project work

## Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

| Chapter      | Hours     | Marks distribution* |
|--------------|-----------|---------------------|
| 1            | 6         | 8                   |
| 2            | 7         | 10                  |
| 3            | 10        | 13                  |
| 4            | 9         | 12                  |
| 5            | 3         | 4                   |
| 6            | 3         | 4                   |
| 7            | 4         | 5                   |
| 8            | 3         | 4                   |
| <b>Total</b> | <b>45</b> | <b>60</b>           |

\* There may be minor deviation in marks distribution.

## References

1. Tanenbaum, A. S., Bos, H. (2009). Modern operating systems. PHI Learning.
2. Stallings, W. (2012). Operating systems: Internals and design principles. Pearson Education.
3. Chaturvedi, A., Rai, B. L. (2011). Unix and shell programming. University Science Press.



YEAR III, PART II

# Semester 6

6 COURSES IN THIS SEMESTER

|                     |                                         |            |
|---------------------|-----------------------------------------|------------|
| <b>ENCT 355</b>     | ICT Project Management                  | <b>137</b> |
| <b>ENCE 356</b>     | Engineering Economics                   | <b>141</b> |
| <b>ENEX 351</b>     | Communication Systems                   | <b>144</b> |
| <b>ENEX 352</b>     | Telecommunication and Computer Networks | <b>148</b> |
| <b>ENEX 353</b>     | Minor Project                           | <b>152</b> |
| <b>ENEX 385-399</b> | Elective II                             | <b>154</b> |

6

# ICT PROJECT MANAGEMENT

ENCT 355

**Lecture : 3**

**Tutorial : 1**

**Practical : 0**

**Year : III**

**Part : II**

## Course Objectives:

The objective of this course is to provide knowledge of fundamental concepts and practices of project management in ICT environments. It focuses on project planning, scheduling, cost estimation, quality assurance, risk assessment, procurement, and stakeholder management. Upon completion, students will be able to apply project management tools, methodologies, and ethical practices to plan, execute, monitor, and control ICT-based projects effectively.

### **1 Introduction (5 hours)**

- 1.1 Definition of project and project management
- 1.2 Project objectives
- 1.3 Classification of projects
- 1.4 Advantages of project management
- 1.5 Project management context as per project management institute (PMI)
- 1.6 ICT product life cycle and its characteristics
- 1.7 Overview of system development methodologies

### **2 Project Management Body of Knowledge (6 hours)**

- 2.1 Project environment
- 2.2 Managerial skills: Conceptual, technical, human-relation
- 2.3 Role and responsibilities of key project members
- 2.4 Problem solving using problem trees
- 2.5 Project and organizational structure
  - 2.5.1 System view of project management
  - 2.5.2 Functional organization
  - 2.5.3 Projectized organization
  - 2.5.4 Matrix organization
  - 2.5.5 Organizational structure influences on projects

### **3 Portfolio and Project Management Framework (2 hours)**

- 3.1 PMI framework
- 3.2 Program management
- 3.3 Portfolio management
- 3.4 Project management office

- 3.5 Drivers of project success
- 3.6 Inhibitors of project success

#### **4 Project Management Process Groups (2 hours)**

- 4.1 Project management processes
- 4.2 Overlaps of process groups in a phase
- 4.3 Mapping of project management process groups to area of knowledge

#### **5 Project Integration Management (2 hours)**

- 5.1 Develop project charter
- 5.2 Develop project management plan
- 5.3 Direct and manage project execution
- 5.4 Monitor and control project work
- 5.5 Integrated change control
- 5.6 Close project or phase

#### **6 Project Scope Management (2 hours)**

- 6.1 Develop preliminary project scope statement
- 6.2 Create work break down structure
- 6.3 Scope verification
- 6.4 Scope control

#### **7 Project Time Management (6 hours)**

- 7.1 Activity definition, decomposition of activities, activity attributes
- 7.2 Activity sequencing, precedence relationship, network diagram, precedence diagram method, arrow diagramming method
- 7.3 Activity resources estimating, determining resource requirements
- 7.4 Schedule development and control, principles of scheduling, milestones, forward pass, backward pass, critical path method (CPM), critical chain technique, Gantt chart, schedule control

#### **8 Project Cost Management (5 hours)**

- 8.1 Cost and project cost management
- 8.2 Cost estimates, types, process and accuracy; Enterprise environmental factors, organizational process assets, cost estimating tools
- 8.3 Cost budgeting, cost aggregation, deriving budget from activity cost
- 8.4 Cost control process, cost control methods
- 8.5 Earned value management, EVM benefits, variance analysis

#### **9 Project Quality Management (2 hours)**

- 9.1 Quality theories
- 9.2 Quality planning and requirements, cost of quality, quality management plan

- 9.3 Quality assurance, quality audit, approach to a quality audit
- 9.4 Quality control process, control chart, Pareto charts
- 9.5 Testing of IT system, the test life cycle

**10 Project Communication Management (2 hours)**

- 10.1 Importance of communication management
- 10.2 Communications planning process, communication requirement analysis, organizing and conducting effective meeting
- 10.3 Information distribution process
- 10.4 Performance reporting process, integrated reporting system

**11 Project Risk Management (3 hours)**

- 11.1 Understanding project risks
- 11.2 Risk management plan and planning process
- 11.3 Risk identification techniques
- 11.4 Qualitative risk analysis process
- 11.5 Quantitative risk analysis process, modeling techniques
- 11.6 Risk response planning, resolution of risk, strategies for negative risks or threats, strategies for positive risks or opportunities
- 11.7 Risk monitoring and control process

**12 Project Procurement Management (3 hours)**

- 12.1 Procurement management process flow
- 12.2 Plan purchases and acquisition process, enterprise environmental factor, organizational process assets
- 12.3 Plan contracting process, standard forms, evaluation criteria
- 12.4 Request seller response process; Select seller process
- 12.5 Contract administration process
- 12.6 Contract closure process

**13 Project Resource and Stakeholder Management (3 hours)**

- 13.1 Developing the resource management plan and team charter
- 13.2 Estimating activity resources
- 13.3 Acquiring resources
- 13.4 Developing the project team
- 13.5 Managing the project team
- 13.6 Monitoring and controlling resources
- 13.7 Identifying stakeholders
- 13.8 Planning, managing and monitoring stakeholder engagement

**14 Trends in ICT Project management (2 hours)**

- 14.1 Agile project management

- 14.2 Balanced scorecard and ICT project management
- 14.3 Project management maturity models
- 14.4 Certification process flow
- 14.5 Code of ethics
- 14.6 Future trends

## Tutorial

**(15 hours)**

1. Analysis of local project management case studies
2. Evaluation of global project failures and lessons learned
3. IT project scope definition and requirement validation
4. Development of work breakdown structures and project scheduling
5. Agile planning and comparison of scheduling approaches
6. Project cost estimation and budget management using earned value techniques
7. Quality assurance, testing, and project communication planning
8. Project risk identification and procurement management
9. Preparation and documentation of IT project deliverables
10. Project presentation and team-based capstone defense

## Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

| Chapters     | Hours     | Marks distribution* |
|--------------|-----------|---------------------|
| 1            | 5         | 7                   |
| 2            | 6         | 8                   |
| 3, 4, 5, 6   | 8         | 11                  |
| 7            | 6         | 8                   |
| 8            | 5         | 7                   |
| 9, 10, 11    | 7         | 9                   |
| 12, 13, 14   | 8         | 10                  |
| <b>Total</b> | <b>45</b> | <b>60</b>           |

\* There may be minor deviation in marks distribution.

## References

1. Schwalbe, K. (2019). Information technology project management. Cengage Learning.
2. Gray, C. F., Larson, E. W. (2021). Project management: The management process. McGraw-Hill Education.
3. Project Management Institute. (2021). The standard for project management and a guide to the project management body of knowledge (PMBOK® guide). Project Management Institute.
4. Jenkins, N. (2012). A project management primer.
5. Young, T. L. (2013). The handbook of project management. Kogan Page.
6. Kelkar, S. A. (2015). IT project management. PHI Learning.

# ENGINEERING ECONOMICS

ENCE 356

**Lecture : 3**  
**Tutorial : 1**  
**Practical : 0**

**Year : III**

**Part : II**

## Course Objectives:

The objective of this course is to provide concept of economic principles and the economic environment at the project, firm, societal, and national levels, enabling them to analyze cause-and-effect relationships. The course aims to equip students with the ability to apply economic theories and tools for project selection, equipment replacement, property valuation, and price variation. By the end of the course, students will be able to evaluate alternatives and make informed, economically sound decisions in engineering and business contexts.

### **1 Introduction (2 hours)**

- 1.1 Micro, macro and engineering economics (History, fundamental principle and application)
- 1.2 Terminology related to engineering economics
- 1.3 Economic decision and role of engineers in decision making
- 1.4 Cash flow and cash flow diagram

### **2 Market Economics (3 hours)**

- 2.1 Market, demand, supply and relationship
- 2.2 Elasticity, application of elasticity and government policies
- 2.3 Externality and market inefficiency
- 2.4 Market failure and firm behavior

### **3 Cost (8 hours)**

- 3.1 Cost classification
  - 3.1.1 Total, average, fixed, variable, and marginal costs
  - 3.1.2 Direct, indirect, and standard costs
  - 3.1.3 Cash versus book cost, manufacturing and non-manufacturing cost
  - 3.1.4 Sunk cost, opportunity cost, element of cost, life-cycle cost
- 3.2 Cost estimation and control

### **4 Time Value of Money (6 hours)**

- 4.1 Money (Type, functions and time value of money)
- 4.2 Simple and compound interests (Nominal, effective and continuous compounding)

- 4.3 Economic equivalence
- 4.4 Cash flow types (Single, uniform, linear gradient, geometric gradient and irregular)

## **5 Methods of Economic Analysis (12 hours)**

- 5.1 Capital budgeting
- 5.2 Minimum attractive rate of return (MARR)
- 5.3 Economic analysis of single and multiple projects
  - 5.3.1 Payback period (Simple and discounted)
  - 5.3.2 Equivalent worth (Net present, annual, future and capitalized)
  - 5.3.3 Rate of return (Internal and external)
  - 5.3.4 Public Sector economic analysis (Benefit cost analysis)
  - 5.3.5 Financial and economic analysis
- 5.4 Weighted average cost of capital (WACC)
- 5.5 Repeatability assumption and co-Terminated assumptions
- 5.6 Multiple investment project alternatives (Dependent, independent and contingent)

## **6 Replacement Analysis (5 hours)**

- 6.1 Replacement strategies (Asset life and selection of challengers over defenders)
- 6.2 Economic service life of an asset
- 6.3 Replacement strategy for asset (Project with finite and infinite planning horizon)

## **7 Risk Analysis (5 hours)**

- 7.1 Origin of risk in projects
- 7.2 Risk analysis of projects (Sensitivity, breakeven and scenario analyses)
- 7.3 Decision tree

## **8 Depreciation and Taxes (5 hours)**

- 8.1 Concept and terminology
- 8.2 Depreciation calculation (Straight line, declining balance, sinking fund, sum of the year digit and modified accelerated cost recovery methods)
- 8.3 Tax and corporate income tax
- 8.4 Economic analysis (After-tax cash flow)

## **9 Measurement of Nation Income (5 hours)**

- 9.1 Gross domestic product (Components, real and nominal gross domestic product)
- 9.2 Unemployment (Measurement, job search, minimum wage law)

- 9.3 Inflation
  - 9.3.1 Causes, effects and measurement of inflation
  - 9.3.2 Constant and current cash flow
  - 9.3.3 Equivalence calculation under inflation
  - 9.3.4 Inflation controlling measures
- 9.4 Real and nominal exchange rates, fiscal budget and monetary policy
- 9.5 Financial statement

### **Tutorial**

**(15 hours)**

1. Cash flow diagram construction, apply and analyze it for different projects
2. Problems related to market equilibrium, elasticity, and government policies
3. Exercises on calculating interests, and analyze cash flows with economic equivalence
4. Application of capital budgeting techniques for given cash flows
5. Selection of best replacement strategies and also, apply risk analysis for real case
6. Computation of after-Tax cash flow for economic analysis
7. Calculation and analysis of gross domestic product, performing equivalence calculations under different inflation scenarios, analyze real and nominal exchange rates
8. Calculation of price variation and price escalation
9. Summarize the fiscal budget

### **Final Exam**

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

| <b>Chapter</b> | <b>Hours</b> | <b>Mark distribution*</b> |
|----------------|--------------|---------------------------|
| 1              | 2            | 3                         |
| 2              | 3            | 5                         |
| 3              | 2            | 3                         |
| 4              | 6            | 8                         |
| 5              | 12           | 16                        |
| 6              | 5            | 6                         |
| 7              | 5            | 6                         |
| 8              | 5            | 8                         |
| 9              | 5            | 5                         |
| <b>Total</b>   | <b>45</b>    | <b>60</b>                 |

\* There may be minor deviation in marks distribution.

### **References**

1. Mankiw, N. G. (2017). Principles of economics (8th ed.). Cengage Learning.
2. Park C.S. (2016). Contemporary Engineering Economics: Prentice Hall, Inc.
3. McConnell, C. R., Brue, S. L., Flynn, S. M. (2020). Economics: Principles, problems, and policies (22nd ed.). McGraw-Hill Education.

# COMMUNICATION SYSTEMS

ENEX 351

**Lecture : 4**  
**Tutorial : 1**  
**Practical : 3**

**Year : III**

**Part : II**

## Course Objectives:

The objective of this course is to provide a foundation in analog and digital communication systems. It focuses on modulation and demodulation techniques, system performance analysis in the presence of noise, and fundamental concepts of multiplexing, multiple access, switching, and error control coding.

### **1 Introduction (5 hours)**

- 1.1 Review of signals and systems
- 1.2 Block diagram of analog and digital communication systems
- 1.3 System needs and requirements
- 1.4 Noise, attenuation, and interference

### **2 Amplitude Modulation (8 hours)**

- 2.1 Time domain expressions, frequency domain representation, modulation index, signal bandwidth of amplitude modulated signal
- 2.2 AM for single and double tone message, carrier and sideband components, power in carrier and sideband components, bandwidth and power efficiency, Hilbert transform
- 2.3 Double sideband AM (DSB-FC), generation (Square law), detection (Envelope and square law method)
- 2.4 Double sideband suppress carrier (DSB-SC), Generation (Linear modulator, balance modulator), Synchronous detection method
- 2.5 Overview of SSB, VSB, and ISB modulations
- 2.6 Phase locked loop (PLL), demodulation of AM using PLL
- 2.7 Super-heterodyne AM receiver

### **3 Angle Modulation (7 hours)**

- 3.1 Basic definition, time domain expression for frequency modulation (FM) and phase modulation (PM)
- 3.2 Time domain expression for single tone, modulated FM signals, spectral representation
- 3.3 Bandwidth of FM, Carson's rule, narrow and wideband FM
- 3.4 Generation of FM: Direct and indirect

- 3.5 Demodulation of FM signals: Non-synchronous (Limiter discriminator) and synchronous (PLL)
- 3.6 Stereo FM, spectral details, pre-emphasis and de-emphasis network
- 3.7 Super-heterodyne Radio receiver for FM

#### **4 Pulse Modulation (8 hours)**

- 4.1 Sampling theorem, ideal sampling, practical sampling, aliasing effect, aperture effect, signal reconstruction
- 4.2 Fundamentals of PAM, PWM, and PPM, time domain representation
- 4.3 Pulse coded modulation (PCM), quantization, quantization error, quantization noise
- 4.4 Signal to quantization noise ratio (SQNR) in uniform quantization, SQNR improvements, non-uniform quantization, companding techniques (A-law,  $\mu$ -Law)
- 4.5 DPCM, DM: Encoder, decoder, advantage, disadvantage, noise in DM

#### **5 Multiplexing Techniques (3 hours)**

- 5.1 Multiplexing fundamentals: FDM, TDM, WDM and applications
- 5.2 T1 and E1 TDM PCM telephony hierarchy
- 5.3 Multiple access fundamentals: FDMA, TDMA, CDMA, SDMA

#### **6 Baseband Digital Data Transmission (8 hours)**

- 6.1 Information theory, measurement of information, entropy, symbol rates and data rates
- 6.2 Shannon Hartley channel capacity theorem, implication of theorem, and theoretical limits
- 6.3 Compression techniques: Shannon-Fano, Huffman codes
- 6.4 Line coding schemes: Unipolar, polar, bipolar
- 6.5 RZ, NRZ, AMI, Manchester, differential Manchester, B8ZS, HDB3 for digital data transmission
- 6.6 ISI, Nyquist criteria, pulse shaping for zero ISI

#### **7 Digital Modulation Techniques (8 hours)**

- 7.1 Binary digital modulation (ASK, FSK, PSK), generation, properties, constellation diagram and detections
- 7.2 QPSK generation, properties, constellation diagram, and detections
- 7.3 M-ARY modulation techniques, M-PSK versus M-QAM

#### **8 Error Detection and Correction Coding (7 hours)**

- 8.1 Hamming weight, hamming distance, code vectors, constraint length, code rate, syndromes

- 8.2 Error detection and correction
  - 8.2.1 Error detection codes: Checksum, CRC
  - 8.2.2 Error correction codes: Linear block codes, hamming codes
- 8.3 Cyclic codes (Generator polynomial, parity-check polynomial)

## **9 Noise in Communication Systems (6 hours)**

- 9.1 Definition, white noise, AWGN channel, PSDF, and AC function of white noise
- 9.2 Ideal low-pass and RC filtering of white noise, noise equivalent bandwidth of a filter
- 9.3 Optimum detection of a pulse in additive white noise, the matched filter, realization of matched filters (Time correlators), the matched filter for a rectangular pulse
- 9.4 Overview of error probability function in digital communication (ASK, FSK, and PSK)

## **Tutorial (15 hours)**

- 1. Differences between analog and digital communication systems, with their advantages and disadvantages
- 2. Comparison of FM and AM in terms of bandwidth, power, and noise performance
- 3. Quantization error and its mathematical expression
- 4. Entropy in information theory and relation to channel capacity
- 5. Importance of the line coding mechanism, highlighting its typical characteristics
- 6. Differences between FDM and TDM techniques
- 7. Importance of the constellation diagram in the digital modulation method
- 8. Derivation of the time domain and frequency domain expressions for different sampling methods
- 9. Error detection (Checksum, CRC)
- 10. Error correction (Linear block codes, hamming codes)

## **Practical (45 hours)**

- 1. Review of different Signals using MATLAB
- 2. Amplitude modulation generation and reconstruction
- 3. Frequency modulation generation and reconstruction
- 4. Pulse modulation generation and reconstruction
- 5. Digital modulation ASK generation and reconstruction
- 6. Digital modulation FSK generation and reconstruction
- 7. Conversion of the given binary sequence into different line coding
- 8. PCM generation and reconstruction
- 9. DPCM and DM: Generation and detection
- 10. FDM and TDM: Multiplexing and demultiplexing

## Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

| Chapter      | Hours     | Marks distribution* |
|--------------|-----------|---------------------|
| 1            | 5         | 5                   |
| 2            | 8         | 8                   |
| 3            | 7         | 7                   |
| 4            | 8         | 8                   |
| 5            | 3         | 3                   |
| 6            | 8         | 8                   |
| 7            | 8         | 8                   |
| 8            | 7         | 7                   |
| 9            | 6         | 6                   |
| <b>Total</b> | <b>60</b> | <b>60</b>           |

\* There may be minor deviation in marks distribution.

## References

1. Haykin, S. (2009). Communication systems. John Wiley & Sons.
2. Lathi, B. P., Ding, Z. (2018). Modern digital and analog communication systems. Oxford University Press.
3. Proakis, J. G., Salehi, M. (2008). Communication systems engineering. Prentice Hall.
4. Forouzan, B. A. (2012). Data communications and networking. McGraw-Hill Education.
5. Sharma, S. (2017). Analog and digital communication systems. Katson Books.
6. Sharma, S., Sharma, D. K. (2019). Digital communication. Katson Books.

# TELECOMMUNICATION AND COMPUTER NETWORKS

ENEX 352

**Lecture** : 3  
**Tutorial** : 1  
**Practical** : 3

**Year** : III  
**Part** : II

## Course Objectives:

The objective of this course is to provide students with a foundational understanding of telecommunications and computer networking, including data communication principles, network architectures, and communication protocols. The course aims to develop the ability to analyze network models, routing, congestion control, and security mechanisms, and apply key networking concepts in designing and evaluating modern communication systems.

### **1 Introduction (3 hours)**

- 1.1 Definition and evolution of telecommunications
- 1.2 Elements of telecommunication
- 1.3 Transmission media and modes

### **2 Switching and Multiplexing (5 hours)**

- 2.1 Switching systems: Manual, mechanical, electromechanical
- 2.2 Analog and digital multiplexing for telecommunications
- 2.3 FDM and TDM hierarchies
- 2.4 Space and time switching (ST, TS, TST, STS)
- 2.5 Signaling: Subscriber, interswitch, audible-visual, supervisory, address

### **3 Telephone Traffic (4 hours)**

- 3.1 Network traffic load and parameters
- 3.2 Loss systems
- 3.3 Delay systems
- 3.4 Routing in telecommunication
- 3.5 Numbering plans and charging plans

### **4 Network Models (5 hours)**

- 4.1 Basics of computer networks
- 4.2 Layered protocols
- 4.3 OSI reference model
- 4.4 TCP/IP protocol suite
- 4.5 Encapsulation and decapsulation
- 4.6 Protocols, standards, and services

4.7 Network devices and working layers (Repeater, hub, bridge, switch, router)

## **5 Physical and Data Link Layer (6 hours)**

- 5.1 Multiplexing, switching techniques: Circuit, packet, datagram, virtual circuit
- 5.2 Data encoding techniques: Manchester, NRZI, MLT3, and their uses
- 5.3 Data link layer functions: Framing, error control, flow control, access control
- 5.4 Media access control (MAC) protocols: ALOHA, CSMA/CD, CSMA/CA
- 5.5 Ethernet standards and wireless LAN (Wi-Fi) basics

## **6 Network Layer (9 hours)**

- 6.1 Network layer functions and services
- 6.2 Logical addressing and its importance
- 6.3 IPv4 addressing and classes, private and public IP addresses, subnetting and supernetting, VLSM, CIDR
- 6.4 Routing and types of routing
- 6.5 Routing algorithms: Distance vector (RIP), link state (OSPF), and BGP
- 6.6 Protocols and header structure: IPv4, ICMP, ARP
- 6.7 Network address translation (NAT)
- 6.8 IPv6 addressing, SLAAC, ICMPv6
- 6.9 IPv6 transition strategies

## **7 Transport Layer (4 hours)**

- 7.1 Transport layer functions and services
- 7.2 Transport protocol: TCP and UDP
- 7.3 TCP state transition diagram
- 7.4 Traffic shaping and congestion control

## **8 Application Layer (5 hours)**

- 8.1 Functions and services of application layer
- 8.2 Upper layer protocols: DHCP, HTTP, FTP, SMTP, POP, IMAP
- 8.3 Domain name system (DNS), its function, and queries
- 8.4 Network management tools and protocols (SNMP)
- 8.5 Proxy server and its use
- 8.6 VoIP, FoIP, and IP interconnection

## **9 Advanced Topics (4 hours)**

- 9.1 Network security and its importance
- 9.2 Principles of cryptography
- 9.3 Basics of IoT, WSN, and SDN
- 9.4 5G/6G network fundamentals
- 9.5 Network virtualization
- 9.6 Future trends in networking

**Tutorial****(15 hours)**

1. Communication models, basic components of data communication systems, and overview of signal types and transmission
2. Switching techniques including circuit, packet, and message switching, and multiplexing techniques such as TDM and FDM with applications
3. Telephone traffic concepts including traffic intensity, Erlang theory, and basic quality of service considerations
4. OSI reference model in detail, functions of each layer, and mapping of network devices (hubs, switches, routers, and gateways) to OSI layers
5. Digital encoding techniques and medium access control protocols including CSMA/CD and CSMA/CA
6. IP addressing, subnetting, VLSM, and CIDR with numerical problem-solving
7. Routing concepts, TCP vs UDP comparison, DNS operation, and HTTP request-response mechanism

**Practical****(45 hours)**

1. Telecommunication lab illustrating course principles
2. Network simulation using Cisco Packet Tracer or NS2/NS3/Mininet
3. Network commands and their uses
4. IP address configuration and subnetting
5. Router configurations
6. Static routing configurations
7. Dynamic routing configurations
8. VLAN configurations and Inter-VLAN routing
9. Packet analysis using Wireshark
10. Web and DNS server configurations
11. Implementation of client-server models
12. Proxy server configuration

**Final Exam**

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

| Chapter      | Hours     | Marks distribution* |
|--------------|-----------|---------------------|
| 1            | 3         | 4                   |
| 2            | 5         | 7                   |
| 3            | 4         | 5                   |
| 4            | 5         | 7                   |
| 5            | 6         | 8                   |
| 6            | 9         | 12                  |
| 7            | 4         | 5                   |
| 8            | 5         | 7                   |
| 9            | 4         | 5                   |
| <b>Total</b> | <b>45</b> | <b>60</b>           |

\* There may be minor deviation in marks distribution.

## References

1. Freeman, R. L. (2004). Telecommunication system engineering. Wiley.
2. Forouzan, B. A. (2013). Data communications and networking. McGraw-Hill Education.
3. Tanenbaum, A. S., Wetherall, D. J. (2011). Computer networks. Pearson.
4. Kurose, J. F., Ross, K. W. (2021). Computer networking: A top-down approach. Pearson.
5. Flood, J. E., Gnanasivam, P. (2007). Telecommunication switching and networks. Wiley.

# MINOR PROJECT

ENEX 353

**Credit :1**

**Year: III**

**Part: II**

## **Course Objectives:**

The objective of this course is to enable students to carry out a small-scale engineering research- or product-based project in the field of electronics, communication, and information engineering, thereby developing practical skills and hands-on experience in system design, implementation, and testing.

## **General Procedures**

Under the supervision of the assigned supervisor, students will be organized into groups of 3–4 members. Each group will select a project topic related to electronics, communication, and information engineering, with emphasis on areas such as embedded systems (Arduino, Raspberry Pi, and microcontrollers), Internet of Things (IoT) systems and applications, FPGA hardware and software platforms, signal and image processing (MATLAB, Simulink, and Python libraries such as NumPy, SciPy, and OpenCV), communication systems (GPS, GSM, Bluetooth, Wi-Fi, and network simulators), instrumentation and data acquisition (sensors, DAQ systems, and LabVIEW), and circuit design (PCB fabrication, simulation, and prototyping). Students may conduct field visits or collect real-world datasets where appropriate. Each group will systematically complete the project through stages including topic selection, planning, development, testing, documentation, and final presentation. Continuous guidance, monitoring, and feedback will be provided by the supervisor throughout the course.

## **1 Project Selection and Planning**

- 1.1 Selection of minor project based on theory/practical subject studied or as per the research or industry needs
- 1.2 Problem identification and scope definition
- 1.3 Approval of project by the department

## **2 Literature Review and Proposal**

- 2.1 Basic literature review and background study, study of existing systems in case of product based project
- 2.2 Preparation of brief project proposal including objective and methodology
- 2.3 Selection of hardware/software tools, technologies, and resources (Development board, simulation software, hardware components, sensors, embedded programming languages, embedded IDEs)

### 3 Design, Development and Project Management

- 3.1 Design and development (Software/hardware/hybrid system)
- 3.2 Application of programming, circuit design, and hardware design skills
- 3.3 Integration of concepts from different subjects (Signals and systems, communication system, instrumentation system, microprocessor, computer organization and architecture, embedded system, electronic devices and circuits)
- 3.4 Applications of project management skills such as work division, time management, leadership

### 4 Implementation and Testing

- 4.1 Implementation and deployment of the project
- 4.2 Testing and validation of the developed system (Unit testing, integration testing, and user testing)
- 4.3 Performance evaluation and improvement

#### Timeline of the defense

- i. Proposal submission and defense: A group of students shall submit the proposal in the prescribed format to the concerned department within two weeks after the commencement of the sixth semester
- ii. Mid-term defense: The mid-term defense of the minor project shall be conducted one month prior to the final defense
- iii. Final defense: The final defense shall be conducted two weeks prior to the board examination

#### Evaluation

The final evaluation of the minor project shall be based on assessments from the supervisor, the proposal defense, mid-term defense, final defense, and the internal examiner. The respective weightage and total marks are presented in the following table:

| Supervisor | Defense  |          |       | Internal Examiner | Total Marks |
|------------|----------|----------|-------|-------------------|-------------|
|            | Proposal | Mid-Term | Final |                   |             |
| 25         | 5        | 5        | 5     | 10                | 50          |

# SOFTWARE SYSTEMS ENGINEERING

ENEX 386

**Lecture : 3**  
**Tutorial : 2**  
**Practical : 1**

**Year : III**  
**Part : II**

## Course Objectives:

The objective of this course is to introduce the fundamental concepts of software engineering in the context of engineering systems. It focuses on the development of structured software solutions involving system modeling, architectural design, implementation, and testing. The course emphasizes the role of software as part of larger systems, considering integration, constraints, reliability, and real-world applications.

### **1 Introduction (4 hours)**

- 1.1 Software and its role in engineering systems
- 1.2 Nature and characteristics of software
- 1.3 Software application domains
- 1.4 Legacy software
- 1.5 Software crisis and myths
- 1.6 Fundamental principles of software engineering

### **2 Software Development Process (6 hours)**

- 2.1 Overview of the software development lifecycle
- 2.2 Process models
  - 2.2.1 Waterfall model and its extensions
  - 2.2.2 Incremental process model
  - 2.2.3 Evolutionary process models (Prototyping, spiral)
- 2.3 Introduction to agile concepts
- 2.4 Selection of an appropriate development approach

### **3 Software Requirements Engineering (6 hours)**

- 3.1 Requirement engineering process
- 3.2 Functional and non-functional requirements
- 3.3 Software requirement specification
- 3.4 Use case-based requirements analysis
- 3.5 System scope, constraints, and assumptions

### **4 System Modeling for Engineering Applications (9 hours)**

- 4.1 System modeling and its importance

- 4.2 Use-case descriptions and diagrams
- 4.3 Activity diagrams
- 4.4 Sequence diagrams for interaction modeling
- 4.5 State-based modeling
- 4.6 Basics of class diagram

## **5 System Design and Architecture (4 hours)**

- 5.1 Concept of system design
- 5.2 High-level system architecture
- 5.3 Modular design, cohesion, and coupling
- 5.4 Basics of hardware-software interaction architecture

## **6 Implementation Practices (3 hours)**

- 6.1 Coding standards and good practices
- 6.2 Code readability and documentation
- 6.3 Version control (Git basics)

## **7 System Testing (5 hours)**

- 7.1 Importance of testing
- 7.2 Types of testing
- 7.3 Verification and validation in system testing
- 7.4 Black-box and white-box testing approach
- 7.5 Basics of hardware-software integration testing
- 7.6 Writing basic test cases

## **8 Software Quality and Maintenance (4 hours)**

- 8.1 Quality concepts
- 8.2 Software maintenance and its types
- 8.3 Maintenance effort and lifecycle considerations
- 8.4 Common software issues and improvements

## **9 Software in Engineering Systems (4 hours)**

- 9.1 Software in embedded and communication systems
- 9.2 Introduction to IoT-based applications
- 9.3 System constraints and reliability considerations
- 9.4 Case studies of engineering systems

## **Tutorial (30 hours)**

- 1. Problem understanding, scope definition, and feasibility analysis
- 2. Selection and justification of the development process
- 3. Identification of functional and non-functional requirements
- 4. Preparation of initial SRS
- 5. Refinement of SRS with constraints and assumptions

6. Identification of actors and use cases
7. Use case diagram and descriptions
8. Activity diagram for system workflow
9. Sequence diagram for interaction modeling
10. Introduction to basic class diagram
11. High-level architectural design
12. Modular design and module interaction
13. Coding standards and code structure discussion
14. Design of basic test cases
15. Final documentation and integration of system artifacts

### Practical

**(15 hours)**

1. Preparation of the system requirements document using a standard SRS template
2. Construction of use case and activity diagrams using CASE tools
3. Construction of a sequence diagram and a basic class diagram using CASE tools
4. Development of system architecture and module structure using CASE tools
5. Implementation of a functional module following coding standards
6. Execution of test cases, application of version control (Git)

### Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

| Chapters     | Hours     | Marks distribution* |
|--------------|-----------|---------------------|
| 1            | 4         | 5                   |
| 2            | 6         | 9                   |
| 3            | 6         | 8                   |
| 4            | 9         | 13                  |
| 5            | 4         | 5                   |
| 6, 7         | 8         | 10                  |
| 8, 9         | 8         | 10                  |
| <b>Total</b> | <b>45</b> | <b>60</b>           |

\* There may be minor deviation in marks distribution.

### References

1. Pressman, R. S., Maxim, B. R. (2019). Software engineering: A practitioner's approach. McGraw-Hill Education.
2. Kossiakoff, A., Biemer, S. M., Seymour, S. J., Sweet, W. N. (2011). Systems engineering: Principles and practice. Wiley.
3. Sommerville, I. (2026). Software engineering. Pearson.
4. Mall, R. (2009). Fundamentals of software engineering. PHI Learning.
5. Pfleeger, S. L., Atlee, J. M. (2009). Software engineering: Theory and practice. Pearson

# ANALYSIS OF ALGORITHMS

ENCT 388

**Lecture : 3**

**Tutorial : 2**

**Practical : 1**

**Year : III**

**Part : II**

## Course Objectives:

The objective of this course is to provide students with a strong foundation in the analysis of algorithm efficiency and computational complexity. It aims to develop understanding of key algorithm design paradigms, including divide-and-conquer, greedy methods, dynamic programming, and backtracking, and covers fundamental concepts of NP-completeness and approximation algorithms.

### 1 Introduction to Algorithm Analysis (5 hours)

- 1.1 Algorithm and its properties, RAM model, time and space complexity, detailed analysis of algorithms, Concept of Aggregate Analysis
- 1.2 Asymptotic notations (Big-O, Big-Ω and Big-Θ), their geometrical interpretations and examples
- 1.3 Concept of best case, average case and worst case performance of an algorithm
- 1.4 Modeling algorithms by recurrence relation
- 1.5 Solving recurrence relation for evaluating computational complexity
  - 1.5.1 Recursion tree method
  - 1.5.2 Substitution method
  - 1.5.3 Using masters theorem

### 2 Iterative and Numeric Algorithms (8 hours)

- 2.1 Algorithm for GCD and Fibonacci number
- 2.2 Sequential search
- 2.3 Review of bubble sort, selection sort, and insertion sort algorithms
- 2.4 Number theoretic notations
- 2.5 Euclid's and Extended Euclid's algorithms
- 2.6 Solving modular linear equations using Chinese remainder theorem
- 2.7 Fermat's theorem
- 2.8 Miller-Rabin randomized primality test and algorithm

### 3 Divide and Conquer Algorithms (8 hours)

- 3.1 Binary search, min max finding algorithm
- 3.2 Analysis of sorting algorithms
  - 3.2.1 Merge sort

- 3.2.2 Heap sort
- 3.2.3 Quick sort
- 3.2.4 Randomized quick sort
- 3.3 Order statistics
  - 3.3.1 Selection in expected linear time
  - 3.3.2 Selection in worst case linear time

#### **4 Greedy Algorithms (7 hours)**

- 4.1 Basic concepts
- 4.2 Fractional knapsack problem
- 4.3 Job sequencing with deadlines
- 4.4 Analysis of minimum spanning trees related algorithms
- 4.5 Analysis of single source shortest path algorithm

#### **5 Dynamic Programming (8 hours)**

- 5.1 Basic concepts
- 5.2 All pair shortest path algorithm
- 5.3 Travelling salesperson problem
- 5.4 String editing
- 5.5 0/1 knapsack problem using dynamic programming
- 5.6 Matrix chain multiplication
- 5.7 Flow shop scheduling

#### **6 Backtracking Techniques (4 hours)**

- 6.1 Basic concepts
- 6.2 The N-Queen problem
- 6.3 Sum of subsets
- 6.4 Graph coloring
- 6.5 Hamiltonian cycles
- 6.6 0/1 knapsack problem using backtracking approach

#### **7 NP-Hard and NP-Complete Problems (5 hours)**

- 7.1 Basic concepts
- 7.2 Cook's theorem
- 7.3 NP-Hard graph problems
- 7.4 NP-Hard scheduling problems
- 7.5 NP-Hard code generation problems
- 7.6 Simplified NP-hard problems
- 7.7 Approximation algorithms:  $\epsilon$ - approximation, polynomial time approximation scheme, probabilistically good algorithms
- 7.8 Vertex cover problem, subset sum problem

**Tutorial****(30 hours)**

1. Algorithm analysis
2. Iterative and numeric algorithms
3. Divide and conquer algorithms
4. Greedy algorithms
5. Dynamic programming
6. Backtracking techniques
7. NP-Hard and NP-complete problems

**Practical****(15 hours)**

1. Implementation and complexity analysis of iterative, numeric and recursive algorithms
2. Implementation and complexity analysis of greedy algorithms
3. Implementation and complexity analysis of algorithms involving divide and conquer strategy
4. Implementation and complexity analysis of algorithms based on dynamic programming
5. Implementation and complexity analysis of algorithms using backtracking concept

**Final Exam**

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

| Chapter      | Hours     | Marks distribution* |
|--------------|-----------|---------------------|
| 1            | 5         | 6                   |
| 2            | 8         | 10                  |
| 3            | 8         | 11                  |
| 4            | 7         | 9                   |
| 5            | 8         | 12                  |
| 6            | 4         | 5                   |
| 7            | 5         | 7                   |
| <b>Total</b> | <b>45</b> | <b>60</b>           |

\* There may be minor deviation in marks distribution.

**References**

1. Horowitz, E., Sahni, S., Rajasekaran, S. (2007). Fundamentals of computer algorithms. Universities Press.
2. Cormen, T. H., Leiserson, C. E., Rivest, R. L., Stein, C. (2022). Introduction to algorithms. MIT Press.
3. Kleinberg, J., Tardos, É. (2006). Algorithm design. Pearson.
4. Skiena, S. S. (2020). The algorithm design manual. Springer.
5. Dasgupta, S., Papadimitriou, C. H., Vazirani, U. V. (2006). Algorithms. McGraw-Hill Education.

# AUDIO PROCESSING

ENCT 389

**Lecture : 3**

**Tutorial : 2**

**Practical : 1**

**Year : III**

**Part : II**

## Course Objectives:

The objective of this course is to develop competency in analyzing and processing audio signals in time and frequency domains. It covers fundamentals of acoustics, digital audio representation, spectral analysis and audio effects, along with practical skills in feature extraction and Music Information Retrieval (MIR). Hands-on use of Digital Audio Workstations (DAWs), MIDI, and plugins enables application of audio signal processing techniques in multimedia, speech processing, music technology and emerging digital audio applications.

- 1 Fundamental of Sound and Audio Signal (7 hours)**
  - 1.1 Physical acoustic: Wave propagation, frequency, amplitude, phase
  - 1.2 Psycho acoustic: Pitch, loudness, timbre, dynamics and intensity
  - 1.3 Fundamental of digital audio
  - 1.4 Audio file format: WAV, AIFF, FLAC, ALAC, MP3
  - 1.5 Practical audio quality: Sample rates (44.1khz, 48khz, 96khz) and bit depths
- 2 Time Domain Audio Processing (8 hours)**
  - 2.1 Discrete time audio signal, basic signal operations, system in time domain
  - 2.2 Convolution and impulse response
  - 2.3 Analog and digital filters in audio systems
  - 2.4 Temporal feature extraction
- 3 Spectral Representation (7 hours)**
  - 3.1 DFT and FFT: Derivation and computational complexity
  - 3.2 Windowing function in audio
  - 3.3 Short time Fourier transform: Frame size, hop size and overlap
  - 3.4 Spectrograms: Reading and interpreting time-frequency representation,
  - 3.5 Mel spectrogram: Reading and interpreting; Mel frequency representation
  - 3.6 Constant Q transform and its relevance to music analysis
- 4 Frequency Domain and Non-Linear Effects (10 hours)**
  - 4.1 Sinusoidal model
  - 4.2 Deterministic plus residual model
  - 4.3 Deterministic plus stochastic model

- 4.4 Basis of non-linear effects
- 4.5 Dynamic range control: Envelop follow, compressor and limiting, expansion and gating, ADSR, modulation effect
- 4.6 Time segment process: Time scratching and pitch shifting

## **5 Music Information Retrieval (6 hours)**

- 5.1 MIR overview: Types of music data, challenges, application
- 5.2 Spectral centroid and roll off
  - 5.2.1 Basics of spectral centroid and spectral roll
  - 5.2.2 Comparison between centroid and roll off
  - 5.2.3 Application (Timbre analysis, music/ speech classification)
- 5.3 Mel frequency cepstral coefficient (MFCC)
  - 5.3.1 Motivation for cepstral features
  - 5.3.2 Steps in MFCC
  - 5.3.3 Interpretation of coefficient
  - 5.3.4 Application (Speech recognition, music classification)
- 5.4 Chroma
  - 5.4.1 Concept of pitch classes (12- tone system) mapping
  - 5.4.2 Chromagram representation,
- 5.5 Onset and tempo and their applications

## **6 Audio system and DAW Integration (4 hours)**

- 6.1 Digital audio workstation (DAW)
  - 6.1.1 Role in audio production
  - 6.1.2 History and evolution of DAW
- 6.2 DAW available in market, DAW interface, timeline and arrangement view
- 6.3 MIDI: Basics, MIDI message structure, VSTi basics,
- 6.4 Common plugin: Equalizer, compressor, reverb, delay

## **7 Recent Trend (3 hours)**

- 7.1 Machine learning in audio
- 7.2 Audio foundation models for bioacoustic and healthcare
- 7.3 Spatial audio
- 7.4 Audio DSP ICs
- 7.5 Generative AI in music

## **Tutorial (30 hours)**

1. Discuss lossless versus lossy compression in the context of audio
2. Derive the convolution sum for a linear time-invariant (LTI) system and explain its physical significance in audio signal processing.
3. Discuss different types of analog filter. Write an advantage of FIR and IIR filter in audio processing
4. Case study discussion
5. Explain the various steps involved in MFCC

6. State the Nyquist theorem and find the Nyquist rate for a signal with maximum frequency 8 kHz.
7. Explain the concept of a chromagram in music information retrieval
8. Explain binaural rendering using head-related transfer functions (HRTFs) and identify one application domain for dedicated audio DSP hardware
9. Music feature analyzer: Input (Audio file), output (Spectrogram, MFCC, tempo)
10. Mini DAW project: Record and edit audio using DAW, apply multiple effects, mix a short track
11. Music classifier: Genre basis classifier

### Practical

(15 hours)

1. Generate sinusoids; Downsample to observe aliasing
2. Measure file size, SNR, and spectral differences between WAV, MP3 (128k/320k), and FLAC
3. Temporal features extraction
4. Spectrogram and STFT
5. Mel spectrogram and CQT
6. MIR features: MFCC
7. DAW: Implement basic features
8. DAW integration and MIDI, VSTi implementation

### Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

| Chapter      | Hours     | Marks distribution* |
|--------------|-----------|---------------------|
| 1            | 7         | 9                   |
| 2            | 8         | 11                  |
| 3            | 7         | 9                   |
| 4            | 10        | 13                  |
| 5            | 6         | 8                   |
| 6            | 4         | 6                   |
| 7            | 3         | 4                   |
| <b>Total</b> | <b>45</b> | <b>60</b>           |

\* There may be minor deviation in marks distribution.

### References

1. Christensen, M. G. (2019). Introduction to audio processing. Springer.
2. Smith, J. O. (2011). Spectral audio signal processing. W3K Publishing.  
Zölzer, U. (Ed.). (2011). DAFX: Digital audio effects. Wiley.
3. Müller, M. (2015). Fundamentals of music processing: Audio, analysis, algorithms, applications. Springer.
4. Lyons, R. G. (2011). Understanding digital signal processing. Pearson Education.



## YEAR IV

# Final year

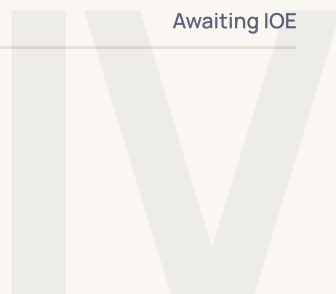
IOE has named these courses in the curriculum structure but has not yet published their syllabi. They will be added to this handbook once released.

**Semester 7** YEAR IV, PART I

|              |                              |              |
|--------------|------------------------------|--------------|
| ENEX 411     | RF and Microwave Engineering | Awaiting IOE |
| ENEX 412     | Robotics                     | Awaiting IOE |
| ENEX 413     | Digital Signal Processing    | Awaiting IOE |
| ENEX 435-444 | Elective III                 | Awaiting IOE |
| ENEX 414     | Project I                    | Awaiting IOE |
| ENEX 415     | Wireless Communication       | Awaiting IOE |

**Semester 8** YEAR IV, PART II

|              |                                            |              |
|--------------|--------------------------------------------|--------------|
| ENEX 463     | Energy, Environment and Social Engineering | Awaiting IOE |
| ENEX 462     | Internship                                 | Awaiting IOE |
| ENEX 465-484 | Elective IV                                | Awaiting IOE |
| ENEX 461     | Project II                                 | Awaiting IOE |





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