DEPARTMENT OF ELECTRONICS AND TELECOMMUNICATIONS ENGINEERING
AHMADU BELLO UNIVERSITY, ZARIA

POSTGRADUATE STUDIES BY COURSEWORK AND RESEARCH LEADING TO THE
AWARD OF M.Sc.
TELECOMMUNICATIONS ENGINEERING

4.0 DURATION OF THE PROGRAMME

The duration of the full-time M.Sc program will be for a minimum period of three (3) semesters and a maximum period of six (6) semesters while for the full-time M.Phil/Ph.D program, it will be for a minimum period of four (4) semesters and a maximum period of six (6) semesters. For the part-time M.Phil/Ph.D program, it will be for a minimum period of six (6) semesters and a maximum period of ten (10) semesters.

5.0 GRADUATION REQUIREMENTS:

To graduate at the M.Sc level, a student must complete all PG and Departmental requirements. In addition, a student must satisfy the following:

a) Satisfactory completion of coursework requirements (at least 30 credit units)
b) Presentation of a Research Proposal
c) Presentation of the required number of seminars on the research
d) Completion and defence of dissertation to the satisfaction of internal and external examiners as well as satisfying the requirements of the School of Postgraduate Studies and Senate of the University.
e) Any additional requirements as may be specified from time to time.

The total minimum requirement for the Master's degree comprises **30 credit units** for coursework and **4 credit units** for seminars and **8 credit units** for dissertation, making a total of **42 credit units**.

NOTE: A candidate can be presented for examination for the M.Sc after a minimum of 18 months if he/she has satisfied all the above requirements**.**

To graduate at the M.Phil/Ph.D level, a student must complete all PG and Departmental requirements. In addition, a student must satisfy the following:

a) Satisfactory completion of coursework requirements (at least 45 credit units)
b) Presentation of a Research Proposal
c) Presentation of the required number of seminars on the research
d) Completion and defence of thesis to the satisfaction of internal and external examiners as well as satisfying the requirements of the School of Postgraduate Studies and Senate of the University.
e) Any additional requirements as may be specified from time to time.

The total minimum requirement for a M.Phil/Ph.D. degree comprises **12 credits units** for the thesis in addition to satisfying the coursework credit load of 45 credit units (Coursework credit units earned for the M.Sc inclusive). The candidate graduating for the M.Phil must satisfy the minimum coursework requirements for the M.Sc in addition to the thesis requirement.

NOTE: A candidate can be presented for examination for the M.Phil/Ph.D (as the case might be) after a minimum of 24 months if he/she has satisfied all the above requirements**.**

6.0 COURSE REQUIREMENTS:

For any of the options selected at the M.Sc Level:

a) A student must score a minimum of 50% in all courses taken towards the degree:
b) Each student will be expected to pass the entire **COMMON** courses, **CORE** and a specified minimum number (1) of **ELECTIVE** (3 Credits) courses depending on the specialization.
c) A student wishing to pursue a Ph.D degree in the Department upon completion of the M.Sc degree is advised to consider offering more elective courses (coursework requirement for PhD is 45CUs inclusive of MSc CUs)

For any of the options selected at the M.Phil/Ph.D:

a) A student must make up the minimum coursework credit units (45) if he/she has not acquired such at the M.Sc or Masters level.
b) A student must offer a course on Research Methodology or show evidence of having taken and passed the course at the M.Sc or Masters level
c) A student must score a minimum of 50% in all courses taken towards the degree:

7.0 TELECOMMUNICATIONS ENGINEERING OPTION

7.1 COURSE OUTLINE

COMMON COURSES

S/N	CODE	TITLE	CU
1	CMEN802	RESEARCH METHODOLOGY	**3**
2	CMEN803	ADVANCED ENGINEERING MANAGEMENT AND DECISION MAKING	**3**
3	CMEN821	DIGITAL SIGNAL PROCESSING	**3**
4	CMEN834	MICROWAVE ENGINEERING AND DEVICES	**3**
5	CMEN836	NETWORK MANAGEMENT AND ANALYSIS	**3**
6	CMEN837	ANTENNA THEORY AND EMC	**3**
7	CMEN839	ADVANCED ELECTROMAGNETICS	**3**
8	CMEN850	ADVANCED ANALYTICAL TECHNIQUES FOR COMMUNICATIONS ENGINEERING	**3**
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CORE COURSES

S/N	CODE	TITLE	CU
1	CMEN831	DATA COMMUNICATIONS	**3**
2	CMEN832	OPTICAL COMMUNICATIONS	**3**
3	CMEN833	DIGITAL COMMUNICATIONS	**3**
4	CMEN835	WIRELESS AND MOBILE COMMUNICATIONS	**3**
5	CMEN838	SATELLITE COMMUNICATIONS	**3**
			15

ELECTIVE COURSES

S/N	CODE	TITLE	CU
1	CMEN822	EMERGING WIRELESS TECHNOLOGIES	**3**
2	CMEN824	SECURE COMMUNICATIONS	**3**
3	CMEN825	WIRELESS MOBILE Ad-Hoc AND SENSOR NETWORKS	**3**
4	CMEN827	ADVANCED ELECTROMAGNETIC FIELD AND COMPATIBILITY	**3**
5	CMEN847	ENGINEERING PRODUCT DESIGN AND INNOVATION	**3**
6	CMEN851	ELECTRONICS COMMUNICATIONS SYSTEMS MODELLING AND SIMULATION	**3**
7	CMEN858	INTELLIGENT NETWORK AND SENSOR	**3**
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RESEARCH

S/N	CODE	TITLE	CU
1	CMEN881/882	SEMINAR I	**2**
2	CMEN883/884	SEMINAR II	**2**
3	CMEN891/892 893/894	M.Sc. RESEARCH THESIS	**8**
			12

7.3 COURSE CONTENTS

CMEN802: RESEARCH METHODOLOGY– 3 CREDITS

OBJECTIVES:

1. To understand the meanings of research and project management.
2. To understand the basic concepts of research and types of research.
3. To describe the research process and understand its key components.
4. To understand the meaning and need for literature review as well as its structure.
5. To identify the main sources of literature.
6. To understand the meaning and types of academic plagiarism.
7. To understand the main elements and structures of MSc Dissertation and PhD Thesis.
8. To learn the techniques for successful oral presentation at the Viva Voce.
9. To learn different work plan techniques for effective project management
10. To learn and apply the techniques of risk management in project implementation

COURSE OUTLINE

MODULE I: FOUNDATION CONCEPTS

Definition of research, Objectives of research: diagnostic, hypothesis-testing Classifications of research based on objectives: descriptive, correlational, explanatory, exploratory. Characteristics of research: critical, empirical, valid and verifiable, controlled, rigorous, systematic Types of research: qualitative, quantitative, conceptual, empirical, fundamental, applied, descriptive, analytical

MODULE II: THE RESEARCH PROCESS

Types of process: linear process, circular or iterative process. Block diagrams showing key stages in the process; problem definition, literature review, formulation of hypothesis, research design, execution, data analysis, interpretation, report writing, viva voce. Description of these stages and their inter-relationships.

MODULE III: LITERATURE REVIEW

Definition and meaning of literature review. Distinguish between literature review and literature survey. Ways of finding relevant material. Types of literature review: systematic review,

quantitative or qualitative meta-analysis review, narrative review, critical review, scoping review. Conceptual review, state-of-the-art review. Critical review: meaning and purpose, structure of critical review; introduction, summary, conclusion, references, critique. Selecting and defining a research problem

MODULE IV: SELECTING AND DEFINING A RESEARCH PROBLEM

Problem formulation. Criteria for selecting a problem. Identifying variables. Evaluating problems. Functions of a hypothesis

MODULE V: CITATION AND PLAGIARISM

Plagiarism: Definition and meaning of plagiarism. Common forms of plagiarism; copying, inappropriate paraphrasing, collusion, inappropriate citation, self-plagiarism. Characteristics of key citation styles: American Psychological Association APA) format. Harvard citation format. Footnote/Bibliography referencing format. IEEE referencing format. Types of anti-plagiarism software and their characteristics.

MODULE VI: WRITING THE RESEARCH REPORT

Structure: the format and sequence in which the research proposal/Dissertation/Thesis is to be written as specified by the University. Key elements of the report: abstract, introduction, aim, objectives, problem definition, significance of research, material and method, results and discussion, significant contributions, conclusion, limitations and recommendations, references

MODULE VII: THE VIVA VOCE

Design of presentation slides: number of slides, font type, font size, using colors and animation, presentation of graphs and tables. Structure: Outline introduction, literature review, research problem definition, material and method, results, significant contributions, limitations and recommendations, references.

MODULE VIII: RESEARCH PROJECT MANAGEMENT

Principles of Research Project management. Project plan: Use of Gantt charts and tables. Project Management Tools. Microsoft Project; (project Management software), Prince2. Work Breakdown Structure (WBS), milestones, deliverables, critical path, decision tree.

MODULE IX: MANAGING RISKS IN RESEARCH PROJECTS

Risk management planning. Risk identification. Qualitative risk analysis. Quantitative risk analysis. Risk response planning. Risk concepts, Sources of risk, Risk Assessment; PERT. Time Management: (a) Activity definition; (b) Activity sequencing; (c) Activity resource estimating; (d) Activity duration estimating, and (e) Schedule development

Learning Outcomes

By the end of this course, students should have understood:

1. The different types of research and the research process.
2. How to conduct critical literature review.
3. How to identify research gaps from which a research problem could be defined.
4. The various forms and implications of plagiarism.
5. The structure and techniques of writing good Dissertation and Thesis proposals/reports
6. The principles and applications of research project management.

Grading

1. Continuous assessment: Reports/Presentation, Written test (40%)
2. Semester Examination (60%)

CMEN 821: ADVANCED DIGITAL SIGNAL PROCESSING (3 CREDIT UNITS)

OBJECTIVES:

1. To understand the main types and characteristics of discrete signals
2. To understand the characteristics of, and analyse main types of discrete systems
3. To understand the concept of convolution and correlation as well as applying them in the analysis of discrete-time signals.
4. To understand the fundamentals of the z- transform, DFT and DFT transform methods and how to apply them in the analysis of LTI systems.
5. To understand the Nyquist sampling theorem and its application in single rate and multi rate systems
6. To understand and, apply, different methods of designing IIR and FIR filters
7. To understand the concept of random signals and random process

COURSE OUTLINE

MODULE I: GENERAL OVERVIEW AND DISCRETE-TIME SIGNALS

Definitions of signal and system. Describe elements of digital signal processing. Advantages and disadvantages of digital signal processing compared with analogue signal processing. Describe major signal processing methods: transform methods, model based, Bayesian statistical, Neural networks. Methods of representing discrete-time signals: graphical, functional, tabular, sequential. Characteristics of Elementary discrete-time signals: unit impulse, unit step, unit ramp, complex exponential, real exponential, sinusoidal. Basic Operations on Sequences: time shifting, time reversal, time scaling, amplitude scaling, signal addition, signal multiplication.

Classifications of discrete-time signals: deterministic and random, energy and power, bounded and unbounded, causal and non-causal, even and odd.

MODULE II: DISCRETE SYSTEMS

Define discrete-time system. Classifications of discrete time systems and their properties: Static(memoryless) and dynamic(memory) systems, Causal and Non-causal systems Linear and non-linear systems, Time-invariant and time-variant systems, Stable and unstable systems, Invertible and non-invertible systems, FIR and IIR systems.

MODULE III: DISCRETE CONVOLUTION AND CORRELATION

Impulse response and convolution sum. Methods to evaluate convolution sum: analytical, tabular array, tabula method, matrices method. **Types of discrete correlation**s; cross correlation, autocorrelation. Analyses and applications.

MODULE IV: SAMPLING AND RECONSTRUCTION

Describe the concepts of analogue-digital conversion; sampling, quantization, encoding. State the Nyquist sampling theorem. Proof of Nyquist theorem using ideal sampling technique. Practical sampling; falt top sampling, the aperture effect, natural sampling. Reconstruction techniques; ideal reconstruction filter, interpolation methods; zero-order hold (ZOH), linear interpolator, first-order hold (FOH).

MODULE V: Z - TRANSFORM

Definition. Region of convergence and its properties. Types and properties of z-transform. Relationship between z-transform and discrete Fourier transform. Inverse z-transform methods: power series method, convolution integral method, partial fraction expansion method. Z-transform analysis of LTI sytems; solution of difference equation using z-transfor method. stability and causality.

MODULE VI: DISCRETE FOURIER TRANSFORM (DFT)

Definition. Existence of DFT. Inverse DFT. Transfer function. Frequency of discrete-time systems. Comparison between discrete-time Fourier transform (DTFT) and discrete Fourier transform (DFT). The twiddle factor and its properties. Matrix formulations of DFT and IDFT.

MODULE VII: FAST FOURIER TRANSFORM (FFT)

Definition. Existence of FFT. Direct computation of DFT and comparison with FFT. Algorithms for efficient computation of FFT; decimation in time, decimation in frequency, comparison between the two. Graphical representation of FFT; the butterfly diagram.

MODULE VIII: DIGITAL FILTER DESIGN

Concept of digital filters. IIR filter design techniques: approximation of derivative method, impulse invariant transformation method, bilinear transformation method. FIR filter design techniques: Fourier Series Method, frequency sampling method, Window Method; rectangular,

blackman, Hanning, Barlett, Kaiser, hamming windows. Comparison between IIR and FIR filters.

MODULE IX: ADAPTIVE FILTERS

Principles of adaptive filters. Adaptive estimation methods: state-space Kalman filters, Recursive Least-Squared (RLS) filters, Wiener filters, Least mean squared (LMS) filtersTypes and applications of adaptive filters. Applications of adaptive filters.

MODULE X: MULTIRATE SIGNAL PROCESSING

Concept of multirate signal processing, down sampling technique. Up sampling technique. Applications. Aliasing effect and anti-aliasing filter. Applications of multirate signal processing.

MODULE XI: RANDOM SIGNAL PROCESSING

Concept of random variable. Examples of random variables. Definition of a random process or stochastic process. Examples of random processes. Ergodic, wide sense stationary, Systems with random signal excitations. Formation of cells. Propagation impairments.

MODULE XII: DISCRETE-TIME LTI SYSTEM REALISTION

Concept of discrete-time LTI system realization using z-transform. The basic elements; adder, constant multiplier, unit delay element. Structures for realization of IIR systems: direct form-I structure, direct form-II structure. Structures for the realization of FIR filters: direct form-I structure, direct form-II structure.

Learning Outcomes

By the end of this course students should have understood:

1. The main types discrete signal synthesis and their characteristics.
2. The charateristics and analysis of LTI system in both frequency and z-domain.
3. The principles and analyses of z-transform and DTFT transform methods.
4. The principles and analyses of DFT and FFT transform methods
5. Different techniques for increasing cell capacity
6. The concept and design of digital filters; IIR, FIR, and adaptive.
7. The concept of random signal processing and multirate signal processing and their applications
8. How to realize discrete-time LTI systems using z-transfom.

Grading

1. Continuous assessment: Reports/Presentation, Written test (40%)
2. Semester Examination (60%)

CMEN 827: ADVANCE ELECTROMAGNETIC FIELDS AND ELECTROMAGNETIC COMPATIBILITY (3 CREDIT UNITS)

Aim: To learn properties of advance electromagnetic fields, waves and EMC in an engineering context.

OBJECTIVES:

1. Students shall understand the concept of electromagnetics laws and describe electromagnetic phenomena.
2. Students shall be able to state and explain the laws and principles of electric, magnetic, and electromagnetic fields.
3. Students will be introduced to some fundamental concept of electricity and magnetism to form a bridge between circuit theory to the transmission lines, waves and wireless systems, in order to solve problems in electrostatic, magnetostatic, and electromagnetic fields, that describe the principles of operation of several electrical, magnetic, and electromagnetic devices.
4. Students will be introduced to some areas of applications of electromagnetic fields and waves.
5. Understand the principles and applications of time - varying electro-magnetic Fields
6. Understand the principles of Electromagnetic compatibility in electronics devices

MODULE I: REVIEW OF EM LAWS

Gauss law. Ampere's law and Faraday's law; Review of EM laws in static and dynamic states. Quasi-stationary magnetic fields. Electric and magnetic problems and solutions. Derive Maxwell's equations in both differential and integral forms. Apply EM laws and Maxwell's equation to solve wave equations in free space and in lossless medium. Explain practical applications of these laws

MODULE II: UNIFORM EM PLANE WAVES:

Magnetic fields in and around current carrying conductors. Conduction and displacement currents. Derivation of Maxwell's equation in curl form from Faraday's and Ampere's laws; Time varying electric and magnetic fields in free space; The wave equation; Plane waves in vacuum, dielectric conducting and lossy media; Skin effect; Polarization of waves; Poynting's vector and energy propagation in free space; Discuss Electric fields of two-electrode configurations. Explain Field distribution in air-gaps Boundary conditions; Plane waves in unbounded dielectric media; Reflection and transmission of plane waves. Eddy currents and braking power.

MODULE III: EM RADIATING SYSTEMS

Antennae: isotropic antenna, elementary dipole near the far fields; Antenna parameters; Half-wave antenna; Practical antenna e.g. loop, horn and parabolic.

MODULE IV: WAVE-GUIDES
Wave-guides: E and H wave modes. Field patterns in rectangular wave-guides. Propagation characteristics. Modes in Rectangular Waveguides, energy flow and attenuation
Explain resonant cavities and Optical Fibers**:** Field at the surface and within a conductor, cylindrical cavities and waveguides

MODULE V:
The concept of Electromagnetic Compatibility. Numerical analysis and Simulation.

Learning Outcomes
Students that successfully complete this course should be able to:

1. Understand how vector analysis can be used to facilitate the analysis of Electric and Magnetic fields.
2. Describe laws that govern Electromagnetic fields and waves.
3. Apply the laws and principles of electricity and magnetism in solving practical problems in electromagnetic fields.
4. Explain some areas of applications of electromagnetic fields and waves.
5. Understand the principles and applications of time - varying electro-magnetic Fields and be familiar with Maxwell's equations
6. Understand Poynting's theorem and the conservation energy and momentum
7. Understand the principles of propagation of waves in a guided media
8. Expose students to some EM simulations software
9. To understand EMC phenomena

GRADING

Method	**Weight**
Report/presentation	20%
Written CA Test	20%
Written Exams	60%

CMEN831: DATA COMMUNICATIONS (3 Credit Units)

OBJECTIVES:
1. To know the different types of data media, modes of transmission (flow), and communication modes.
2. To know the different categories of data networks as well as support standards and reference models.
3. To understand digital-to-digital conversion, switching (circuit, message, and packet), and routing (unicast, broadcast, multicast, and anycast) of data packets, as well as support algorithms.

4. To understand the functions of Modems and DSS and how different techniques (FDM, TDM, WDM, CDM) multiplex data packets onto a single high-speed line.
5. To know the different types of data networks (PAN, LAN, MAN, WAN, INTERNET) and internetworking.
6. To know the different fundamentals architectures of data networks, their associated problems, and their applications.

MODULE I: INTRODUCTION TO DATA COMMUNICATIONS

Concepts of data communications, protocol (elements, tasks, control information) & information transmission process, components of data communications system, attributes of data communications, data network issues, data communications terminologies.

MODULE II: DATA FLOW, NETWORK TOPOLOGIES, AND COMMUNICATIONS CODES

Data (information) flow (simplex, half-duplex, full duplex), data communications frameworks (osi tcp/ip), data rate limits, data network topologies (bus, star, mesh, ring) & goals (high throughput and low latency), data communications codes (morse, baudot, ebcdic, ascii), data network classifications (lan, man, wan) & network devices (modem, hub, switch, router).

MODULE III: DATA FLOW, STANDARDS, AND COMMUNICATIONS REFERENCE MODELS

History Of Data Flow, Transmission Techniques, And Data Transmission (Parallel & Serial And Asynchronous & Synchronous), Standards, Osi Reference Model, Functions Of Osi Reference Model, Inter-Layer Data Communications, Osi Layers (Physical, Datalink, Network, Transport, Session, Presentation, Application), Tcp/Ip Reference Model, Broadband Isdn Reference Model, Service Types In Layered Network Structures, Communication Services Implementation.

MODULE IV: DATA NETWORK TRANSMISSION MEDIA

Transmission medium and physical layer, classes of transmission media (guided and unguided), types of transmission media (twisted pair, coaxial cable, optical fiber and their categories), electromagnetic spectrum and wireless transmission waves (for wireless communications)

MODULE V: DIGITAL-TO-DIGITAL DATA CONVERSION

Techniques of digital-to-digital conversion (definition and techniques), line coding (mapping data elements into signal levels, data rate and signal rate relationship, etc), criteria for choosing good signal element (baseline wandering, dc components, self-synchronization, error detection, noise and interference, etc), line coding schemes (unipolar, polar, bi-polar, multi-level, multi-transition).

MODULE VI: SWITCHING, ROUTING & ALGORITHMS

Switching techniques (connectionless and connection oriented) circuit switching, message switching, packet switching (delay in packet switching, routing in packet-switched network), network routing (unicast, broadcast, multicast, anycast routings), routing algorithms (flooding and shortest path).

MODULE VII: DATA LINE DEVICES

Modulator demodulator (modem) system (types: directional capability, line connection mode, transmission mode), digital subscriber line (dsl) system (xdsl technologies).

MODULE VIII: DATA MULTIPLEXING TECHNIQUES

Concept of multiplexing, data multiplexers, types of multiplexing techniques (frequency division multiplexing - fdm: fdm multiplexers, hierarchy), time division multiplexing (tdm multiplexers, hierarchy, and types of techniques), data rate management (data rate matching, pulse stuffing multiplexing technique), data synchronization process, wavelength division multiplexing (wdm), code division multiplexing (cdm), inverse multiplexing technique.

MODULE IX: DIFFERENT DATA NETWORKS

Types of data networks (storage network, pan, lan: wired and wireless, man: fixed and mobile, wan: cellular and satellite, internet: mix of all networks), networks hardware (broadcast + point-to-point).

MODULE X: BUILDING BLOCKS OF DATA NETWORK TOPOLOGIES

Wireless pan (bluetooth, infrared, ism wireless), wired lan (fast and giga ethernet), wireless lan or wireless fidelity (different ieee standards) wireless man (fixed and mobile wimax), wireless wan (cellular and satellite systems).

MODULE XI: ARCHITECTURE AND APPLICATION OF DATA NETWORKS

Wired lan (ethernet- ieee 802.3), wireless lan (wifi – 802.11: standards, types, protocol, hidden/exposed terminal problems), wlan problem, wlan (maca: protocol), wlan (virtual channel sensing using csma/ca protocol), wlan (1-persistent physical carrier sensing protocol), wlan technologies and infrastructure, ad hoc wlan, wlan topological tree, wireless lan (wimax– 802.16: standards, protocol architecture, frame format, services), wan (definition and components, switched data network standards, frame relay, atm).

MODULE XII: INTERNETWORKING

Internetworking (Protocol, Packet Switching, logical and dynamic addressing, Internet Protocol, Ip Address Assignment, Ipv4 And Ipv6 Address Systems, User Datagram Protocol-Udp), Internetworking Ips (Ipv4 Ipv6 Datagram Formats, Transmission Control Protocol-Tcp, Internet Control Message Protocol-Icmp, User Datagram Protocol-Udp)

LEARNING OUTCOMES

Upon successful completion of the course, students should:

1. Know the different types data media, modes of transmission (flow), and communication codes.
2. Know the different categories of data networks as well as support standards and reference models.
3. Understand digital-to-digital conversion, switching (circuit, message, and packet), and routing (unicast, broadcast, multicast, and anycast) of data packets, as well as support algorithms.
4. Understand the functions of Modems and DSL.

5. Understand the different multiplexing techniques (FDM, TDM, WDM, CDM)
6. Know the different types of data networks (PAN, LAN, MAN, WAN, INTERNET) and internetworking.
7. Know the different fundamentals architectures of data networks, their associated problems, and their applications.

GRADING

Method	**Weight**
Report/Presentation	20%
Written CA Test	20%
Written Exams	60%
Total	**100%**

CMEN 832: OPTICAL COMMUNICATIONS (3 CU)

COURSE OBJECTIVES

1. To understand fiber optic concept for information transmission
2. To identify the elements of a fiber optics transmission link.
3. To understand optical fiber structure and wave guiding
4. To understand the structure, the performance and the signal analysis of optical sources.
5. To understand the structure, the performance and signal analysis of optical detectors.
6. To solve problems dealing with light wave propagation in optical fiber, calculate attenuation and dispersion and determine link power budget.

MODULE I: INTRODUCTION TO OPTICAL COMMUNICATIONS

Ray Optics - Basic laws of ray theory/geometric optics, Refraction of light, Refractive Index, Snell's law, Critical angle, Numerical Aperture, Total internal reflection

MODULE II: OPTICAL FIBER CHARACTERISTICS

Type of Fibers, Transmission window, Overview of fiber optics modes and Configurations - Linearly polarized modes; Single mode fibers; Graded index fiber.

MODULE III: SIGNAL DEGRADATION IN FIBER OPTICAL CABLES

Absorption losses, scattering losses; Bending Losses, Core and Cladding losses; Signal Distortion in Optical Wave guides; information capacity determination; Group Delay; Material Dispersion; waveguide Dispersion; Signal distortion in SM fibers – Polarization, Mode dispersion, Intermodal dispersion, Pulse Broadening in fiber optics; Mode Coupling

MODULE IV: OPTICAL SOURCES

Direct and indirect band gap materials; LED structures, Light source materials, quantum efficiency and LED power; Modulation of a LED; Laser diodes: Modes and threshold condition, rate equations, external quantum efficiency, resonant frequencies, Laser diodes structures and radiation patterns; Single mode lasers, temperature effects.

MODULE V: OPTICAL MODULATION AND MULTIPLEXING

Operational principals of WDM, FDM, TDM, PAM, PCM, advanced modulating techniques

MODULE VI: FIBER OPTICAL RECEIVERS

PIN and APD diodes; Photo detector noise, SNR, Detector response time; Avalanche multiplication noise, comparison of photo detectors, fundamental receiver operation – pre-amplifiers; Error sources: receiver configuration, probability of error, the quantum limit.

MODULE VII: OPTICAL COMMUNICATION SYSTEM DESIGN

Evolution of fiber Optic system; Element of an Optical Fiber Transmission link; Point-to-Point links: system considerations, link power budget, risetime budget, noise effects on system performance.

LEARNING OUTCOMES

Upon successful completion of this course, students should be able to:

1. Describe the propagation of light in an optical fibre
2. Explain the generation and detection of light.
3. Carryout performance analyse of practical optical fibre communication links
4. Carryout design of optical communication system

GRADING SYSTEM

Method	**Weight**
Report/Presentation	20%
Written CA Test	20%
Written Exams	60%
Total	**100%**

CMEN 833: DIGITAL COMMUNICATIONS (3 CREDIT UNITS)

OBJECTIVES:

1. To understand the basic structures and fundamental principles of modern digital Communications.

2. To learn the commonly used techniques of modulation, source coding, and channel coding as well as their areas of application

3. To understand the concepts of information, entropy and channel capacity as well as use them to study communications and coding.

4. To understand different types of channel models and how to evaluate their capacities.

5. To understand and analyse the effect of noise on digital signal in terms of probability of error and eye diagram

6. To understand the concept of intersymbol interference and its mitigation through signal shaping and equalization.

COURSE OUTLINE

MODULE I: INTRODUCTION

Generic block diagram of a digital communications system. Digital communications equipment: CODECS, multiplexers, MODEMS, radio transmitter and receivers. Advantages and disadvantages of digital communications.

MODULE II: INFORMATION THEORY

Uncertainty and information, Information and entropy. Entropy of a binary source. Conditional and joint entropies. Redundancy. Mutual information. Information rate. Information loss due to noise. Source coding techniques: Huffman coding, Shannon-Fano coding.

MODULE III: TYPES OF CHANNEL MODELS AND CAPACITY

Types of channel models: discrete memoryless channel, lossless channel, noiseless channel, binary symmetric channel, binary erasure channel. Channel capacity. Capacity of an additive white Gaussian noise (AWGN) channel. The Shannon-Hartley capacity theorem and its practical implications.

MODULE IV: DIGITAL MODULATION TECHNIQUES

Basic binary digital modulation techniques and their bandwidth characteristics: ASK, FSK, PSK. Limitations and applications of these basic techniques. M-ary digital modulation techniques: Need for these techniques; types - quadrature phase shift keying (QPSK), signal space representation of QPSK signal, spectrum of QPSK, error probability of QPSK system. Power spectral density and bandwidth of M-ary PSK. M-ary QAM, M-ary FSK – their spectra and geometric representations. Applications of M-ary PSK, M-ary FSK, M-ary QAM

MODULE V: SAMPLING, MULTIPLEXING AND PCM

Pulse modulation. Sampling: baseband sampling and Nyquist's criterion. Aliasing, practical sampling, reconstruction, signal-to-distortion ratio. Quantised PAM. Signal – to-quantisation noise ratio. Pulse code Modulation (PCM): signal to quantisation noise ratio for linear PCM, companded PCM, PCM multiplexing. Bandwidth reduction techniques: Differential PCM (DPCM), Adaptive DPCM.

MODULE VI: OPTIMUM FILTERING FOR TRANSMISSION AND RECEPTION

Pulse shaping for optimum transmission. Intersymbol interference (ISI). ISI-free signals. Raised cosine filtering. Nyquist filtering for rectangular pulses. Pulse filtering for optimum reception: matched filtering, correlation detection, decision instant SNR. Differences between matched filtering and correlation. Equalisation.

MODULE VII: ERROR CONTROL CODING

Introduction: a taxonomy of error control codes. Error rate control concepts. Threshold phenomenon. Hamming distance and codeword weight. (n, k) block codes: single parity check codes. Probability of error in n-digit codes. Linear group codes: members of the group code family, performance prediction, error detection and correction probabilty. Nearest neighbor decoding of block codes: Hamming bound. Syndrome decoding: the generator matrix, syndrome table for error correction, cyclic codes; polynomial codeword generation. Encoding of convolutional codes. Viterbi decoding and convolutional codes.

MODULE VIII: EQUALISATION

Channel characterization. Eye pattern. Equaliser filter types: transversal equaliser, zero-forcing equaliser, decision feedback equaliser, present and adaptive equalisation. Applications of equalisation

Learning Outcomes

By the end of this course, students should have understood:

1. The principles of digital communications.
2. The different types of digital modulations schemes, their analyses, limitations and areas of applications.
3. The principles and analyses of different types of channel coding techniques and their applications to error control.
4. The need for, and types of source coding techniques for minimizing redundancies.
5. The concept and measure of information.
6. Different types of channel models, determination of their capacities.
7. The Shannon-Hartley capacity theorem and their application in designing digital communication systems.

Grading

1. Continuous assessment: Reports/Presentation, Written test (40%)

2. Semester Examination (60%)

CMEN 835: WIRELESS AND MOBILE COMMUNICATIONS (3 CREDIT UNITS)

OBJECTIVES:

1. To understand the key technical challenges for wireless communications
2. To understand the cellular concept and how it is implemented as well as its limitations
3. To understand the limiting effects of interference on cellular system capacity and other metrics
4. To understand the propagation mechanisms in the mobile environment
5. To understand the basic structure of cellular network and functions of the main building blocks.
6. To understand the concept and limitations of OFDM and MIMO in achieving spectral efficiency in cellular mobile systems
7. To understand the difference between GSM and CDMA cellular mobile technologies and their limitations
8. To design and engineer cellular mobile networks for acceptable quality of service and spectral efficiency in terrestrial and satellite land mobile communications

COURSE OUTLINE

MODULE I: CELLULAR Concept

Define the cellular concept. Cellular spectrum Describe the key building blocks of the cellular concept; mobility, handover/handoff, frequency re-use. Cell shapes. Cellular Deployment concept; cell cluster, frequency reuse distance, system capacity,co-channel interference(CCI), adjacent channel interference (ACI); analysis of the effects CCI and ACI on system capacity. Traffic flow methods; frequency division duplex (FDD), time division duplex (TDD). Hierarchy of cells by sizes

MODULE II: MOBILITY AND LOCATION MANAGEMENT

Radio Mobility: Handover requirements, Handover types; soft handover, hard handover, mobile assisted handover (MAHO), Mobile controlled handover (MCHO), Network Assisted handover (NAHO), network-controlled handover. Determination of handover threshold handover problems and solutions. Network mobility: mobile location management requirements. Mobility models: fluid model, Markovian model, gravity model. Description and analyses of these models

MODULE II: CAPACITY ENHANCEMENT TECHNIQUES

Trunking: concept, Erlang B formula, Erlang C formula. Application to the design of cellular mobile networks. Capacity enhancement techniques; cell splitting, sectoring, microcell zone concept. Quantitative and qualitative descriptions of these techniques.

MODULE IV: MULTIPLE ACCESS TECHNIQUES

Need for multiple access techniques. Types: non-contention based; FDMA, TDMA, CDMA. Principles, limitations and applications of these techniques. Spread spectrum techniques. The

CDMA near-far problem and its mitigation techniques. Orthogonal frequency division multiplexing (OFDM); principles, applications. OFDM limitations and mitigation techniques

MODULE V: MIMO AND DIGITAL BEAMFORMING

Concept, analysis. Drivation of MIMO capacity. Massive MIMO (M-MIMO); concept, applications, technical challenges and proposed solutions. Digital beamforming; concept, analyses and applications

MODULE VI: PROPAGATION IN THE MOBILE ENVIRONMENT

Mobile channel modeling; statistical models: Rayleigh, Rician, Nakagami-m, lognormal. Limitations of statistical models. Empirical models: Okumura model, Hata-Okumura model, COST 231 model, Nakagami model, ITU model. Limitations of empirical models. Analytical models: two-ray model, knife-edge diffraction model, free space path loss model. Propagation mechanisms: reflection, diffraction, scattering. Major types of propagation impairments: path loss, shadowing, multipath fading.

MODULE VII: MULTIPATH FADING AND EQUALISATION

Description of the following types of fading: slow, fast, narrow band, broadband. Description of equalization techniques to mitigate broadband fading

MODULE VIII: CELLULAR MOBILE TECHNOLOGIES

Distinguish between GSM and CDMA cellular technologies. Describe the functions of the key building blocks of GSM and CDMA networks. Evolution of cellular mobile communications: 1G TO 5G: characteristics, limitations, and applications.

MODULE IX: SATELLITE LAND MOBILE COMMUNICATIONS

Concept. Formation of cells. Propagation impairments. Analysis. Advantages and

Disadvantages

Learning Outcomes

By the end of this course, students should have understood:

1. The main types of wireless networks, standards governing them, applications and limitations.
2. The cellular concept and the limitations imposed by interference on system capacity and quality of service.
3. The key propagation impairments
4. How handover is affected when a mobile cross the cell boundary
5. Different techniques for increasing cell capacity
6. How to design and engineer a cellular mobile network to ensure acceptable quality of service

Grading

1. Continuous assessment: Reports/Presentation, Written test (40%)
2. Semester Examination (60%)

CMEN 836: NETWORK MANAGEMENT AND ANALYSIS (3 CREDIT UNITS)

OBJECTIVES:

1. To understand the meaning and needs for network management.
2. To understand the main functions of network management; FCAPS
3. To understand key network management standards
4. To understand the principles and characteristics of the following network management protocols: SNMP, TMN
5. To learn various network management models
6. To understand key techniques and tools for network monitoring
7. To understand the main techniques for fault and performance management
8. To employ the queueing theory in the network analysis of delay, throughput, reliability, etc
9. To. understand the concept of network congestion and the techniques for preventing its occurrence

COURSE OUTLINE

MODULE I: GENERAL OVERVIEW

Fundamental definitions: management, network, network management. Hardware and software resources to be managed. Protocols that support network management. Key areas of network management. Network management system: definition, generic block diagram. Open system interconnection (OSI) and TCP/IP models as related to network management layers.

MODULE II: NETWORK MANAGEMENT FUNCTIONS

Fundamental concepts. Requirements for network management. Advantages of network management. Functions of network management. Network management architecture; generic block diagram, management station, management agent, management information base (MIB), network management protocol. Network management models: organizational model, information model, communication model, functional. model

MODULE III: NETWORK MANAGEMENT MODELS

Open System Interconnection (OSI) network model: organizational model, information model, communication model, functional model. FCAPS model: Fault management, Configuration

management, Accounting management, Performance management, Security management. Interaction of management sub-systems

MODULE IV: NETWORK MANAGEMENT PROTOCOLS

Protocol standards: defacto standard, industry standard. Standard bodies: ITU, AISI, IETE, IEEE. ASN.1: encoding rules; BER, DER, CER,PER, XER, EXER. Need for ASN.1. Simple Network Management Protocol (SNMP): basics, architecture, elements of SNMP, commands, benefits. SNMP Standards and Versions; SNMPv1, SNMPv2, SNMPv3. Their syntax, message format, security features.

MODULE V: PERFORMANCE MANAGEMENT

Performance Metrics: macro level; throughput, response time, availability, reliability. Micro level; bandwidth, peak load, average load. Utilization, error rates. Methods: collect and analyse data; number and types of packets, simulations, notification thresholds, capacity planning, building databases. Traffic flow measurements: the IETF(RFC 2063) hierarchy, measurement tools; RMON. Netflow manager;

Performance statistics: traffic statistics, error statistics. Event correlation techniques: rule-based reasoning, model-based reasoning, case-based reasoning, codebook correlation model, state transition graph model, finite state machine model

MODULE VI: FAULT MANAGEMENT

Basic concepts: event, symptoms, error, fault, classification of faults; permanent, intermittent, transient. Fault diagnosis process: detection, localization, testing. Methods for event evaluation: signature-based/rule-based analysis, anomaly detection. Fault localization techniques: model-based reasoning tools, fault propagation models, model-traversing technique, case-based reasoning tools.

MODULE VII: TELECOMMUNICATIONS MANAGEMENT NETWORK (TMN)

Introduction; definition, need for TMN. TMN conceptual model. TMN architecture. Management functions: Fault management, configuration management, accounting management, performance management, security management. Functional management hierarchy: network element layer, network element management layer, network management layer, service management layer, business management layer. Functional architecture. Physical architecture. Standard interfaces. TMN management platform and its features.

MODULE VIII: DATABASE MANAGEMENT SYSTEMS

Concept of database and its management. Characteristics of modern database management system (DBMS): real - world entitity, relation-based tables, isolation of data and application, less

redundancy, consistency, query language, ACID properties, multiuser and concurrent access, multiviews, security. Architecture: 1st Tier, 2nd Tier, 3rd Tier. Entity – relationship model: Attributes, relationship, relationship set. Mapping cardinalities: one-to-one, one-to-many, many-to-one, many-many. Relational database management model. Storage systems: primary storage, secondary storage, tertiary storage. RAID storage systems.

MODULE IX: SERVICE MANAGEMENT

Reasons for the shift to the new paradigm; service management. Requirements for service management platform: consistency, service integration support, interoperability, Service management platform. Requirements for distributed platform: distribution, scalability, heterogeneity, common services. Description of the following types of fading: slow, fast, narrow band, broadband. Description of equalization techniques to mitigate broadband fading

MODULE X: NETWORK MONITORING

Network analyser: reasons for using network analyser, functional block diagram of network analyser. Monitoring techniques: router-based; SNMP, RMON, Netflow. Non-router based; active monitoring, passive monitoring, combination monitoring. Monitoring tools: protocol analyser

MODULE XI: NETWORK ANALYSIS

Introduction. Common measures of network performance. Queueing Theory: introduction, Queueing models: M/M/1 model, M/M/1/k model, M/M/c model, M/G/1 model. Analyses of loss and delay in networks. Network availability. Congestion analysis and control: Basic concepts, congestion collapse, congestion control techniques: open-loop congestion control, closed loop congestion control.

Learning Outcomes

By the end of this course, students should have understood:

1. The need and functions of network management
2. The main building blocks of a modern network management system.
3. Different types of network management models
4. Different types of network management protocols and their characteristics and limitations
5. Causes of network congestion and the techniques for controlling network congestion.
6. How to use network management tools and equipment to measure key network performance metrics
7. How to use advanced probability concepts and queueing theory for the performance analysis of networks

Grading

1. Continuous assessment: Reports/Presentation, Written test (40%)
2. Semester Examination (60%)

CMEN838: SATELLITE COMMUNICATIONS (3 Credit Units)

OBJECTIVES:

1. To know major applications of satellite communications and its associated problems.
2. To know the different types of satellite networks and their respective roles in delivering fixed, broadcast and mobile services.
3. To understand different elements of satellite systems and their functions.
4. To understand orbital mechanics and effects, as well as orbital perturbations and control.
5. To understand how a satellite is launched into space and how its design is computed for efficient transmissions.
6. To learn how to develop satellite link budget.

MODULE I: OVERVIEW OF SATELLITE COMMUNICATIONS

HISTORICAL PERSPECTIVES (Pioneers, Milestones, Definitions, Components, Classifications: active and passive), HOW SATELLITES WORK, SATELLITE COMMUNICATIONS SYSTEM (applications: telecommunications, remote sensing and Earth observation, military, scientific experiments, and meteorological, frequency and transmission bands: uplink and downlink), MAJOR PROBLEMS FOR SATELLITES.

MODULE II: TYPES AND ROLES OF SATELLITE NETWORKS

Broadcast network, shss network, dhss network, mhms network, shms network, satellite services (Fixed, broadcast, and mobile services).

MODULE III: SATELLITE COMMUNICATIONS SYSTEM SEGMENTS

Satellite communications system segments (Earth segment, Space segment, Telemetry, Command, and Control - TT&C Control segment, Ground segment, Communications subsystem, Transponders, Power subsystem)

MODULE IV: SATELLITE ORBITS

Categorization of satellite orbits (Circular, Elliptical, Equatorial, Polar, Inclined, HEO, LEO, MEO, GEO), Van Allen Radiation Belts, Orbit and performance characteristics, Comparison of LEO, MEO, and GEO, satellite communications systems (Irridium, Globalstar, GPS, INMARSAT, Others), Orbital laws (Kepler's orbital laws), Orbital considerations (Look angles, elements of orbital mechanics).

MODULE V: ORBITAL MECHANICS AND EFFECTS

Description of orbit, elements of orbital mechanics, satellite orbits (Models of orbital mechanics and laws, How satellites stay in orbit, Elevation angle, Coverage and slant range Sun transit outage), ORBITAL EFFECTS (Non-ideal Earth, Third-body perturbation, Atmospheric drag, Doppler shift, Solar eclipse, Sun transit outage)

MODULE VI: ORBITAL PERTURBATION AND ORBIT CONTROL

Sources of orbital perturbations, orbit control (Attitude control, Station keeping), spin stabilization an element.

MODULE VII: SATELLITE LAUNCHING

Launching orbits, hohmaan transfer principles, launch phases, missions, vehicles.

MODULE VIII: SATELLITE MULTIPLE ACCESS TECHNIQUES
Overview, multiple access protocols, fdma, fdma systems, tdma, tdma systems, (cdma).

MODULE IX: SATELLITE LINK BUDGET
Introduction, link budget objectives, elements of a satellite link, benefits of link budget analysis, link budget analysis (uplink and downlink), link design model equation, free space losses, sources of signal loss, overall satellite link budget.

Learning Outcomes

Upon successful completion of the course, students should:

1. Know major applications of satellite communications and its associated problems.
2. Know the different types of satellite networks and their respective roles in delivering fixed, broadcast and mobile services.
3. Understand different elements of satellite systems and their functions to maintain good communications.
4. Understand orbital mechanics and effects, as well as orbital perturbations and control.
5. Know how a satellite is launched into space.
6. Know how a satellite link budget is designed.

GRADING

Method	**Weight**
Continuous Assessment	40%
Written Exams	60%
Total	**100%**

CMEN 847: ENGINEERING PRODUCT DESIGN AND INNOVATION

OBJECTIVES

1. To understand the concept of engineering product design and innovation
2. To understand the concept and importance of design
3. To understand the methods, tools and techniques used in product design
4. To understand and be able to apply concept tool selection and prototyping in product design
5. To understand and use the prototyping/model making and evaluation techniques for user-product interaction

COURSE OUTLINE

MODULE I: GENERAL INTRODUCTION

Discuss the need for innovation and design. Introduction to product and Product design. Difference between Product development and product design. Problem Identification. User study by enquiry. Importance of human factors in product design.

MODULE II: UNDERSTANDING THE DESIGN CONCEPT

Discuss nature of design; design activities; design problems; how designers think. Design process; different design models; different design methods

MODULE III: DETAILED DESIGN PROCESS

Generating objectives; establishing design functions; setting basic product requirement and performance; generating design alternatives and evaluating them; improving details of the design; Proof of concept

MODULE IV: TOOLS SELECTION AND PROTOTYPING

Product prototyping model making workflow. Tools and techniques for model making and prototyping; Introduction to prototype driven innovation; Rapid prototyping; Overview of materials and processes; Evaluation tools and techniques for User- Product interaction

MODULE V: MANUFACTURING AND TROUBLESHOOTING

Manufacturing processes. Product assembly and packaging. Product Test and troubleshooting.

LEARNING OUTCOMES:

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

1. Describe an engineering design and development process
2. Demonstrate individual skill using selected manufacturing techniques, including drilling, pressing, tapping, and rapid prototyping
3. Use engineering design principles to execute a design from concept to finished product
4. Fabricate and assembly a product from engineering drawings
5. Work collaboratively on a team to successfully complete a design project

GRADING

Method	**Weight**
Continuous Assessment	40%
Written Exams	60%
Total	**100%**

CMEN 851: ELECTRONIC COMMUNICATIONS SYSTEMS MODELING AND SIMULATION (3 CREDIT UNITS)

OBJECTIVES:

The student should learn and apply:

1. Methodology of problem solving for simulation
2. Basic concepts of modelling
3. Performance Evaluation Techniques
4. Error sources in simulation
5. Simulation environment and software issues

COURSE OUTLINE

MODULE I: ROLE OF SIMULATION

Examples of complexity: analytically tractable system, analytically intractable system, analytically tedious system. Multidisciplinary aspects of simulation. Models. Deterministic and stochastic simulations: Examples of each. Application: link budget and system level specification process. Implementation and testing of key components, completion of the hardware prototype and validation of the simulation model, end – of - life predictions. Software packages for simulation such as MAPLESIM, CST, R Programing,

MODULE II: SIMULATION METHODOLOGY

Aspects of methodology: Mapping a problem into a simulation model, modeling of individual blocks, random process modeling and simulation. Performance estimation.

MODULE III: FILTER PRE-PROCESSING MODELS AND SIMULATION TECHNIQUES

IIR and FIR filters; synthesis and simulation. Implementation of FIR filter simulation models. Computer aided design of IIR and FIR digital filters

MODULE IV: POST-PROCESSING

Basic graphical techniques: a system example; $\pi/4$ DQPSK transmission. Waveforms, eye diagrams, and scatter plots. Estimation: histograms, power spectral density estimation, gai, delay, signal-to-noise ratio. Coding: analytic approach to block coding; analytic approach to convolutional coding.

MODULE V: INTRODUCTION TO MONTE CARLO METHODS

Fundamental concepts: relative frequency, unbiased and consistent estimations, Monte Carlo estimations, the estimation of π. Application to communications system – The AWGN channel (the Binomial distribution, two simple Monte Carlo simulations). Monte Carlo integration: basic concepts, convergence, confidence intervals.

MODULE VI: MONTE CARLO SIMULATION OF COMMUNICATIONS SYSTEMS

Elements of Semi-analytic techniques: basic considerations, equivalent noise sources, semi-analytic BER estimation for PSK,semi-analytic BER estimation for QPSKchoice of data sequence.

MODULE VII: METHODOLOGY FOR SIMULATING A WIRELESS SYSTEM

System-level simplifications and sampling rate considerations. **Overall methodology:** methodology for simulation of the analogue portion of the system, estimation of coded BER, estimation of voice quality metric,

MODULE VIII: MODELING AND SIMULATION OF WAVEFORM CHANNELS

Models of communication channels, simulation of communication channels, discrete channel models, methodology for simulating communication system performance. Wired and guided wave channels. Radio channels; tropospheric channel, rain effects on radio channels. Multi-path fading channels; introduction, example of a multipath fading channel, discrete versus diffused multipath, modeling multipath fading channel. Examples of discrete multi-path fading channels. Simulation of discrete and diffused multi-path fading channels. Models for indoor wireless channels. Models for temporal variations in the channel response (fading).

MODULE IX: DISCRETE CHANNEL MODELS

Discrete memoryless channel models. Markov models for Discrete Channels with Memory: two-state Markov model, N-state Markov model, first-order Markov process, stationarity, simulation of the Markov model. Estimation of Markov model parameters: scaling, convergence and stopping criteria block equivalent Markov models.

MODULE X: SIMULATION OF A CELLULAR RADIO SYSTEM

Cellular radio system: system level description, modeling of a cellular communication system. Simulation Methodology: the simulation, processing the simulation results. Modeling co-channel interference. Modeling adjacent channel interference.

MODULE XI: EFFICIENT SIMULATION TECHNIQUES

Tail extrapolation. PDF estimators. Importance sampling: area of an ellipse, sensitivity to the pdf, the nature of the communication problem, conventional and improved importance sampling.

LEARNING OUTCOMES

On completion of this course, the student should be able to:

1. understand the roles of electronic simulation and its methods
2. understand and apply Monte Carlo simulation technique
3. understand various simulation techniques
4. understand and apply simulation of a cellular radio system
5. understand discrete channel models
6. be familiar with the various performance evaluation method
7. understand the hierarchical modeling approach for communications networks

8. understand the use of conditional experiments for simulations
9. understand the error sources in simulations
10. understand signals and systems in the time and frequency domains

GRADING

Method	**Weight**
Report/Presentation	20%
Written CA Test	20%
Written Exams	60%
TOTAL	**100%**

CMEN 850: ADVANCED ANALYTICAL TECHNIQUES FOR COMMUNICATIONS ENGINEERING (3 CREDIT UNITS)

OBJECTIVES

1. To understand the concept of liners transformation
2. To know how to analyze communication systems
3. To understand the concept of scalars and vectors in communication analysis
4. To learn how to apply binomial series in communication analysis

MODULE I: MATRICES AND LINEAR TRANSFORMATIONS

Matrices - definition; matrix notation; equal matrices; addition and subtraction of matrices; multiplication of matrices- scalar multiplication, multiplication of two matrices; transpose of a matrix; special matrices

MODULE II: DETERMINANT OF A SQUARE MATRIX

Cofactor, adjoint of a square matrix; inverse of a square matrix- product of a square matrix and its inverse; solution of set of linear equation- Gaussian elimination method for solving of linear equations; Eigen values and Eigen vectors.

MODULE III: SCALAR AND VECTORS

Introduction of scalar and vectors quantities; vector representation- two vectors, types of vectors, addition of vectors, sum of number of vectors; components of a given vector- components of vectors in terms of given vectors; vector in space; direction cosines; scalar product of two vectors; vector product of two vectors; angle between two vectors; direction cosines.

- Ordinary Differential Equation (DE): First order DE, second order DE; formation of DEs- direct integration, separating the variables.

- Polynomials: Polynomial equation; Quadratic equation; solution of cubic equations having atleast one linear factor, solution of quartic equations having atleast two linear factors.

MODULE IV: BINOMIAL SERIES

Factors and combinations- factorials, combination, three properties of combinational coefficient; binomial series- Pascal's triangle, binomial expansion, the general term of the binomial expansion; the ∑ (sigma) notation- general terms, the sum of the first *n* natural numbers, rules for manipulating sums the exponential number *e*.

GRADING

Method	**Weight**
Continuous Assessment	40%
Written Exams	60%
Total	**100%**

CMEN 825: WIRELESS MOBILE Ad Hoc AND SENSOR NETWORKS (3 Credit Units) CORE/COMMON/ELECTIVE

LEARNING OBJECTIVES

The purpose of this course is to introduce students to:

1. broad understanding about the network architecture of wireless sensor network;
2. all basic characteristics of wireless sensor networks and sensor nodes;
3. the principles of data transmission, clustering algorithm and routing protocols;
4. the different constraint of wireless sensor network, e.g., coverage, power management, security and data collisions.
5. the **design** and development of new network architecture and MAC protocols.

COURSE OUTLINE

MODULE I: Introduction to Wireless Sensor Networks

Motivations, Applications, Performance metrics, History and

Design factors. Principles of wireless sensor networks. Features, Design challenges, Network architecture, Sensor deployment mechanisms, Topologies and characteristics.

MODULE II: Network and Component Technologies

Sensors, Coverage, Physical layer, Sensor platforms, Reliable data transport, Radio energy consumption model, Power management, Synchronization, Localization. Sensor network architecture. Localization and calibration. Coverage and connectivity. Body sensor network. Multimedia sensor network.

MODULE III: Data Transmission and Routing

Data processing and aggregation, Data storage, Node discovery algorithms, Wireless sensor network routing, Proactive and reactive routing.

MODULE IV: Protocols

Frame structure, Network clustering protocols, Medium access control protocols, Multi-hop communication protocols, Congestion control and rate control protocols, Protocol overheads. Publish/Subscribe mechanisms. Geographic routing. Robustness. Storage and retrieval

MODULE V: Dependability Issues

Collisions, Collision avoidance mechanism, Hidden node and exposed node problems, Data congestions, Throughput, Security challenges.

MODULE VI: Data Gathering

Tree construction algorithms and analysis. Asymptotic capacity. Lifetime optimization formulations

MODULE VII: Intoduction to Mobile Ad Hoc Networks(MANETs)

Fundamentals of wireless networks; Bluetooth, IrDA, WiFi(IEEE 802.11), WiMAX(IEEE 802.16).Hotspots; requirements to use WiFi hotspots, finding WiFi hotspots, connection to WiFi hotspots. Wireless Internet; IP limitations, mobile Internet protocol, isues in mobile IP. Difference between cellular and Ad Hoc wireless networks. Applications of Ad Hoc wireless networks.

MODULE VIII: Issues in Wireless Ad Hoc Networks

Self-configuring, self-organisation, self-healing schemes in mobile ad hoc networks. Security issues and challenges, different security attacks. Unicast and multicast routing. Location-aware routing. Medium access control(MAC). Hidden terminal problem. Cooperation in mobile ad hoc networks. Mobility management in MANETs

MODULE IX: Mobility Models for Multihop Wireless Networks

Mobility models; random walk, random waypoint, random direction, boundless simulation area, Gauss-Markov, City-section mobility model. Mobility models with geographic restrictions. L model and other random modelsimitations of the random waypoint

MODULE X: Cross-Layer Design Issues

Definition of cross-layer design. **Cross-layer design principle**; general motivations for cross-layer design, the von Neumann architecture, source-channel separation and digital system architecture . **Pitfalls of the cross-layer design approach**; cost of development, performance versus longevity, interaction and unintended consequences, stability. **Performance objectives**; maximizing total capacity, max-min fairness, utility fairness. Cross-layer protocols.

MODULE XI: Applications and Recent Developments

Typical applications; PAN, academic environment applications, defense applications, industrial environment applications, healthcare applications, search and rescue applications, vehicular ad hoc networks. **Highlights of most recent developments**; sensors, mobile ad hoc sensor networks.

LEARNING OUTCOMES

At completing this course the student should be able to:

- be Familiar with the principle of sensor nodes, network deployment and architectures.
- know the differences among different networks.
- know the data transmission and routing protocols;
- know the applications of wireless sensor networks;
- apply and analyse the performance of different routing and MAC protocols;
- evaluate the performance of different MAC protocols and clustering algorithm;
- obtain the throughput and channel utilization;
- design the network architecture and MAC protocol.