NATIONAL COUNCIL OF EXAMINERS FOR ENGINEERING AND SURVEYING

Fundamentals of Engineering (FE) Examination

Effective October 2005

- The FE examination is an 8-hour supplied-reference examination: 120 questions in the 4-hour morning session and 60 questions in the 4-hour afternoon session.
- The afternoon session is administered in the following seven modules—Chemical, Civil, Electrical, Environmental, Industrial, Mechanical, and Other/General engineering.
- Examinees work all questions in the morning session and all questions in the afternoon module they have chosen.

MORNING SESSION (120 questions in 12 topic areas)

Topic Area	Approximate Percentage of Test Content
I. Mathematics A. Analytic geometry B. Integral calculus C. Matrix operations D. Roots of equations E. Vector analysis F. Differential equations G. Differential calculus	**15%**
II. Engineering Probability and Statistics A. Measures of central tendencies and dispersions (e.g., mean, mode, standard deviation) B. Probability distributions (e.g., discrete, continuous, normal, binomial) C. Conditional probabilities D. Estimation (e.g., point, confidence intervals) for a single mean E. Regression and curve fitting F. Expected value (weighted average) in decision-making G. Hypothesis testing	**7%**
III. Chemistry A. Nomenclature B. Oxidation and reduction C. Periodic table D. States of matter E. Acids and bases F. Equations (e.g., stoichiometry) G. Equilibrium H. Metals and nonmetals	**9%**
IV. Computers A. Terminology (e.g., memory types, CPU, baud rates, Internet) B. Spreadsheets (e.g., addresses, interpretation, “what if,” copying formulas) C. Structured programming (e.g., assignment statements, loops and branches, function calls)	**7%**
V. Ethics and Business Practices A. Code of ethics (professional and technical societies) B. Agreements and contracts C. Ethical versus legal D. Professional liability E. Public protection issues (e.g., licensing boards)	**7%**

VI. Engineering Economics **8%**

A. Discounted cash flow (e.g., equivalence, PW, equivalent annual FW, rate of return)
B. Cost (e.g., incremental, average, sunk, estimating)
C. Analyses (e.g., breakeven, benefit-cost)
D. Uncertainty (e.g., expected value and risk)

VII. Engineering Mechanics (Statics and Dynamics) **10%**

A. Resultants of force systems
B. Centroid of area
C. Concurrent force systems
D. Equilibrium of rigid bodies
E. Frames and trusses
F. Area moments of inertia
G. Linear motion (e.g., force, mass, acceleration, momentum)
H. Angular motion (e.g., torque, inertia, acceleration, momentum)
I. Friction
J. Mass moments of inertia
K. Impulse and momentum applied to:
    1. particles
    2. rigid bodies
L. Work, energy, and power as applied to:
    1. particles
    2. rigid bodies

VIII. Strength of Materials **7%**

A. Shear and moment diagrams
B. Stress types (e.g., normal, shear, bending, torsion)
C. Stress strain caused by:
    1. axial loads
    2. bending loads
    3. torsion
    4. shear
D. Deformations (e.g., axial, bending, torsion)
E. Combined stresses
F. Columns
G. Indeterminant analysis
H. Plastic versus elastic deformation

IX. Material Properties **7%**

A. Properties
    1. chemical
    2. electrical
    3. mechanical
    4. physical
B. Corrosion mechanisms and control
C. Materials
    1. engineered materials
    2. ferrous metals
    3. nonferrous metals

X. Fluid Mechanics **7%**

A. Flow measurement
B. Fluid properties
C. Fluid statics
D. Energy, impulse, and momentum equations
E. Pipe and other internal flow

XI. Electricity and Magnetism **9%**

A. Charge, energy, current, voltage, power
B. Work done in moving a charge in an electric field (relationship between voltage and work)
C. Force between charges
D. Current and voltage laws (Kirchhoff, Ohm)
E. Equivalent circuits (series, parallel)
F. Capacitance and inductance
G. Reactance and impedance, susceptance and admittance
H. AC circuits
I. Basic complex algebra

XII. Thermodynamics **7%**

A. Thermodynamic laws (e.g., 1st Law, 2nd Law)
B. Energy, heat, and work
C. Availability and reversibility
D. Cycles
E. Ideal gases
F. Mixture of gases
G. Phase changes
H. Heat transfer
I. Properties of:
    1. enthalpy
    2. entropy

AFTERNOON SESSION IN CHEMICAL ENGINEERING (60 questions in 11 topic areas)

Topic Area		Approximate Percentage of Test Content
I.	**Chemistry** A. Inorganic chemistry (e.g., molarity, normality, molality, acids, bases, redox, valence, solubility product, pH, pK, electrochemistry) B. Organic chemistry (e.g., nomenclature, structure, qualitative and quantitative analyses, balanced equations, reactions, synthesis)	**10%**
II.	**Material/Energy Balances** A. Mass balance B. Energy balance C. Control boundary concept (e.g., black box concept) D. Steady-state process E. Unsteady-state process F. Recycle process G. Bypass process H. Combustion	**15%**
III.	**Chemical Engineering Thermodynamics** A. Thermodynamic laws (e.g., 1st Law, 2nd Law) B. Thermodynamic properties (e.g., internal thermal energy, enthalpy, entropy, free energy) C. Thermodynamic processes (e.g., isothermal, adiabatic, isentropic) D. Property and phase diagrams (e.g., T-s, h-P, x-y, T-x-y) E. Equations of state (e.g., van der Waals, Soave-Redlich-Kwong) F. Steam tables G. Phase equilibrium and phase change H. Chemical equilibrium I. Heats of reaction J. Cyclic processes and efficiency (e.g., power, refrigeration, heat pump) K. Heats of mixing	**10%**
IV.	**Fluid Dynamics** A. Bernoulli equation and mechanical energy balance B. Hydrostatic pressure C. Dimensionless numbers (e.g., Reynolds number) D. Laminar and turbulent flow E. Velocity head F. Friction losses (e.g., pipe, valves, fittings) G. Pipe networks H. Compressible and incompressible flow I. Flow measurement (e.g., orifices, Venturi meters) J. Pumps, turbines, and compressors K. Non-Newtonian flow L. Flow through packed beds	**10%**

V. Heat Transfer **10%**

A. Conductive heat transfer
B. Convective heat transfer
C. Radiation heat transfer
D. Heat transfer coefficients
E. Heat exchanger types (e.g., plate and frame, spiral)
F. Flow configuration (e.g., cocurrent/countercurrent)
G. Log mean temperature difference (LMTD) and NTU
H. Fouling
I. Shell-and-tube heat exchanger design (e.g., area, number of passes)

VI. Mass Transfer **10%**

A. Diffusion (e.g., Fick's 1st and 2nd laws)
B. Mass transfer coefficient
C. Equilibrium stage method (efficiency)
D. Graphical methods (e.g., McCabe-Thiele)
E. Differential method (e.g., NTU, HETP, HTU, NTP)
F. Separation systems (e.g., distillation, absorption, extraction, membrane processes)
G. Humidification and drying

VII. Chemical Reaction Engineering **10%**

A. Reaction rates and order
B. Rate constant (e.g., Arrhenius function)
C. Conversion, yield, and selectivity
D. Series and parallel reactions
E. Forward and reverse reactions
F. Energy/material balance around a reactor
G. Reactions with volume change
H. Reactor types (e.g., plug flow, batch, semi-batch, CSTR)
I. Homogeneous and heterogeneous reactions
J. Catalysis

VIII. Process Design and Economic Optimization **10%**

A. Process flow diagrams (PFD)
B. Piping and instrumentation diagrams (P&ID)
C. Scale-up
D. Comparison of economic alternatives (e.g., net present value, discounted cash flow, rate of return)
E. Cost estimation

IX. Computer Usage in Chemical Engineering **5%**

A. Numerical methods and concepts (e.g., convergence, tolerance)
B. Spreadsheets for chemical engineering calculations
C. Statistical data analysis

X. Process Control **5%**

A. Sensors and control valves (e.g., temperature, pressure)
B. Dynamics (e.g., time constants, 2nd order, underdamped)
C. Feedback and feedforward control
D. Proportional, integral, and derivative (PID) controller concepts
E. Cascade control
F. Control loop design (e.g., matching measured and manipulated variables)
G. Tuning PID controllers and stability (e.g., Method of Ziegler-Nichols, Routh Test)
H. Open-loop and closed-loop transfer functions

XI. Safety, Health, and Environmental **5%**

A. Hazardous properties of materials (e.g., corrosive, flammable, toxic), including MSDS
B. Industrial hygiene (e.g., noise, PPE, ergonomics)
C. Process hazard analysis (e.g., using fault-tree analysis or event tree)
D. Overpressure and underpressure protection (e.g., relief, redundant control, intrinsically safe)
E. Storage and handling (e.g., inerting, spill containment)
F. Waste minimization
G. Waste treatment (e.g., air, water, solids)

AFTERNOON SESSION IN CIVIL ENGINEERING (60 questions in 9 topic areas)

Topic Area	Approximate Percentage of Test Content
I. Surveying	**11%**
A. Angles, distances, and trigonometry	
B. Area computations	
C. Closure	
D. Coordinate systems (e.g., GPS, state plane)	
E. Curves (vertical and horizontal)	
F. Earthwork and volume computations	
G. Leveling (e.g., differential, elevations, percent grades)	
II. Hydraulics and Hydrologic Systems	**12%**
A. Basic hydrology (e.g., infiltration, rainfall, runoff, detention, flood flows, watersheds)	
B. Basic hydraulics (e.g., Manning equation, Bernoulli theorem, open-channel flow, pipe flow)	
C. Pumping systems (water and wastewater)	
D. Municipal water distribution systems	
E. Reservoirs (e.g., dams, routing, spillways)	
F. Groundwater (e.g., flow, wells, drawdown)	
G. Sewer collection systems (storm and sanitary)	
III. Soil Mechanics and Foundations	**15%**
A. Index properties and soil classifications	
B. Phase relations (air-water-solid)	
C. Laboratory and field tests	
D. Effective stress (buoyancy)	
E. Retaining walls (e.g., active pressure/passive pressure)	
F. Shear strength	
G. Bearing capacity (cohesive and noncohesive)	
H. Foundation types (e.g., spread footings, piles, wall footings, mats)	
I. Consolidation and differential settlement	
J. Seepage	
K. Slope stability (e.g., fills, embankments, cuts, dams)	
L. Soil stabilization (e.g., chemical additives, geosynthetics)	
IV. Environmental Engineering	**12%**
A. Water quality (ground and surface)	
B. Air quality	
C. Solid/hazardous waste	
D. Sanitary sewer system loads	
E. Basic tests (e.g., water, wastewater, air)	
F. Environmental regulations	
G. Water treatment and wastewater treatment (e.g., primary, secondary, tertiary)	

V. Transportation **12%**

A. Streets and highways
   1. geometric design
   2. pavement design
   3. intersection design

B. Traffic analysis and control
   1. safety
   2. capacity
   3. traffic flow
   4. traffic control devices

VI. Structural Analysis **10%**

A. Force analysis of statically determinant beams, trusses and frames
B. Deflection analysis of statically determinant beams, trusses and frames
C. Stability analysis of beams, trusses and frames
D. Column analysis (e.g., buckling, boundary conditions)
E. Loads and load paths (e.g., dead, live, moving)
F. Elementary statically indeterminate structures

VII. Structural Design **10%**

A. Codes (e.g., AISC, ACI, NDS, AISI)
B. Design procedures for steel components (e.g., beams, columns, beam-columns, tension members, connections)
C. Design procedures for concrete components (e.g., beams, slabs, columns, walls, footings)

VIII. Construction Management **10%**

A. Procurement methods (e.g., design-build, design-bid-build, qualifications based)
B. Allocation of resources (e.g., labor, equipment, materials, money, time)
C. Contracts/contract law
D. Project scheduling (e.g., CPM, PERT)
E. Engineering economics
F. Project management (e.g., owner/contractor/client relations, safety)
G. Construction estimating

IX. Materials **8%**

A. Concrete mix design
B. Asphalt mix design
C. Test methods (e.g., steel, concrete, aggregates, asphalt)
D. Properties of aggregates
E. Engineering properties of metals

AFTERNOON SESSION IN ELECTRICAL ENGINEERING (60 questions in 9 topic areas)

Topic Area		Approximate Percentage of Test Content
I.	**Circuits** A. KCL, KVL B. Series/parallel equivalent circuits C. Node and loop analysis D. Thevenin/Norton theorems E. Impedance F. Transfer functions G. Frequency/transient response H. Resonance I. Laplace transforms J. 2-port theory K. Filters (simple passive)	**16%**
II.	**Power** A. 3-phase B. Transmission lines C. Voltage regulation D. Delta and wye E. Phasors F. Motors G. Power electronics H. Power factor (pf) I. Transformers	**13%**
III.	**Electromagnetics** A. Electrostatics/magnetostatics (e.g., measurement of spatial relationships, vector analysis) B. Wave propagation C. Transmission lines (high frequency)	**7%**
IV.	**Control Systems** A. Block diagrams (feed forward, feedback) B. Bode plots C. Controller performance (gain, PID), steady-state errors D. Root locus E. Stability	**10%**
V.	**Communications** A. Basic modulation/demodulation concepts (e.g., AM, FM, PCM) B. Fourier transforms/Fourier series C. Sampling theorem D. Computer networks, including OSI model E. Multiplexing	**9%**
VI.	**Signal Processing** A. Analog/digital conversion B. Convolution (continuous and discrete) C. Difference equations D. Z-transforms	**8%**

VII. Electronics **15%**

A. Solid-state fundamentals (tunneling, diffusion/drift current, energy bands, doping bands, p-n theory)
B. Bias circuits
C. Differential amplifiers
D. Discrete devices (diodes, transistors, BJT, CMOS) and models and their performance
E. Operational amplifiers
F. Filters (active)
G. Instrumentation (measurements, data acquisition, transducers)

VIII. Digital Systems **12%**

A. Numbering systems
B. Data path/control system design
C. Boolean logic
D. Counters
E. Flip-flops
F. Programmable logic devices and gate arrays
G. Logic gates and circuits
H. Logic minimization (SOP, POS, Karnaugh maps)
I. State tables/diagrams
J. Timing diagrams

IX. Computer Systems **10%**

A. Architecture (e.g., pipelining, cache memory)
B. Interfacing
C. Microprocessors
D. Memory technology and systems
E. Software design methods (structured, top-down bottom-up, object-oriented design)
F. Software implementation (structured programming, algorithms, data structures)

AFTERNOON SESSION IN ENVIRONMENTAL ENGINEERING (60 questions in 5 topic areas)

Topic Area	Approximate Percentage of Test Content
I. Water Resources	**25%**
A. Water distribution and wastewater collection	
B. Water resources planning	
C. Hydrology and watershed processes	
D. Fluid mechanics and hydraulics	
II. Water and Wastewater Engineering	**30%**
A. Water and wastewater	
B. Environmental microbiology/ecology	
C. Environmental chemistry	
III. Air Quality Engineering	**15%**
A. Air quality standards and control technologies	
B. Atmospheric sciences	
IV. Solid and Hazardous Waste Engineering	**15%**
A. Solid waste engineering	
B. Hazardous waste engineering	
C. Site remediation	
D. Geohydrology	
E. Geotechnology	
V. Environmental Science and Management	**15%**
A. Industrial and occupational health and safety	
B. Radiological health and safety	
C. Radioactive waste management	
D. Environmental monitoring and sampling	
E. Pollutant fate and transport (air/water/soil)	
F. Pollution prevention and waste minimization	
G. Environmental management systems	

AFTERNOON SESSION IN INDUSTRIAL ENGINEERING (60 questions in 8 topic areas)

Topic Area		Approximate Percentage of Test Content
I.	**Engineering Economics** A. Discounted cash flows (equivalence, PW, EAC, FW, IRR, loan amortization) B. Types and breakdown of costs (e.g., fixed, variable, direct and indirect labor, material, capitalized) C. Analyses (e.g., benefit-cost, breakeven, minimum cost, overhead, risk, incremental, life cycle) D. Accounting (financial statements and overhead cost allocation) E. Cost estimating F. Depreciation and taxes G. Capital budgeting	**15%**
II.	**Probability and Statistics** A. Combinatorics (e.g., combinations, permutations) B. Probability distributions (e.g., normal, binomial, empirical) C. Conditional probabilities D. Sampling distributions, sample sizes, and statistics (e.g., central tendency, dispersion) E. Estimation (point estimates, confidence intervals) F. Hypothesis testing G. Regression (linear, multiple) H. System reliability (single components, parallel and series systems) I. Design of experiments (e.g., ANOVA, factorial designs)	**15%**
III.	**Modeling and Computation** A. Algorithm and logic development (e.g., flow charts, pseudo-code) B. Spreadsheets C. Databases (e.g., types, information content, relational) D. Decision theory (e.g., uncertainty, risk, utility, decision trees) E. Optimization modeling (decision variables, objective functions, and constraints) F. Linear programming (e.g., formulation, primal, dual, graphical solution) G. Math programming (network, integer, dynamic, transportation, assignment) H. Stochastic models (e.g., queuing, Markov, reliability) I. Simulation (e.g., event, process, Monte Carlo sampling, random number generation, steady-state vs. transient)	**12%**
IV.	**Industrial Management** A. Principles (e.g., planning, organizing) and tools of management (e.g., MBO, re-engineering) B. Organizational structure (e.g., functional, matrix, line/staff) C. Motivation theories (e.g., Maslow, Theory X, Theory Y) D. Job evaluation and compensation E. Project management (scheduling, PERT, CPM)	**10%**

V. Manufacturing and Production Systems **13%**

A. Manufacturing systems (e.g., cellular, group technology, flexible, lean)
B. Process design (e.g., number of machines/people, equipment selection, and line balancing)
C. Inventory analysis (e.g., EOQ, safety stock)
D. Forecasting
E. Scheduling (e.g., sequencing, cycle time, material control)
F. Aggregate planning (e.g., JIT, MRP, MRPII, ERP)
G. Concurrent engineering and design for manufacturing
H. Automation concepts (e.g., robotics, CIM)
I. Economics (e.g., profits and costs under various demand rates, machine selection)

VI. Facilities and Logistics **12%**

A. Flow measurements and analysis (e.g., from/to charts, flow planning)
B. Layouts (e.g., types, distance metrics, planning, evaluation)
C. Location analysis (e.g., single facility location, multiple facility location, storage location within a facility)
D. Process capacity analysis (e.g., number of machines/people, trade-offs)
E. Material handling capacity analysis (storage & transport)
F. Supply chain design (e.g., warehousing, transportation, inventories)

VII. Human Factors, Productivity, Ergonomics, and Work Design **12%**

A. Methods analysis (e.g., improvement, charting) and task analysis (e.g., MTM, MOST)
B. Time study (e.g., time standards, allowances)
C. Workstation design
D. Work sampling
E. Learning curves
F. Productivity measures
G. Risk factor identification, safety, toxicology, material safety data sheets (MSDS)
H. Environmental stress assessment (e.g., noise, vibrations, heat, computer-related)
I. Design of tasks, tools, displays, controls, user interfaces, etc.
J. Anthropometry, biomechanics, and lifting

VIII. Quality **11%**

A. Total quality management theory (e.g., Deming, Juran) and application
B. Management and planning tools (e.g., fishbone, Pareto, quality function deployment, scatter diagrams)
C. Control charts
D. Process capability and specifications
E. Sampling plans
F. Design of experiments for quality improvement
G. Auditing, ISO certification, and the Baldridge award

AFTERNOON SESSION IN MECHANICAL ENGINEERING (60 questions in 8 topic areas)

Topic Area		Approximate Percentage of Test Content
I.	**Mechanical Design and Analysis** A. Stress analysis (e.g., combined stresses, torsion, normal, shear) B. Failure theories (e.g., static, dynamic, buckling) C. Failure analysis (e.g., creep, fatigue, fracture, buckling) D. Deformation and stiffness E. Components (e.g., springs, pressure vessels, beams, piping, bearings, columns, power screws) F. Power transmission (e.g., belts, chains, clutches, gears, shafts, brakes, axles) G. Joining (e.g., threaded fasteners, rivets, welds, adhesives) H. Manufacturability (e.g., fits, tolerances, process capability) I. Quality and reliability J. Mechanical systems (e.g., hydraulic, pneumatic, electro-hybrid)	**15%**
II.	**Kinematics, Dynamics, and Vibrations** A. Kinematics of mechanisms B. Dynamics of mechanisms C. Rigid body dynamics D. Natural frequency and resonance E. Balancing of rotating and reciprocating equipment F. Forced vibrations (e.g., isolation, force transmission, support motion)	**15%**
III.	**Materials and Processing** A. Mechanical and thermal properties (e.g., stress/strain relationships, ductility, endurance, conductivity, thermal expansion) B. Manufacturing processes (e.g., forming, machining, bending, casting, joining, heat treating) C. Thermal processing (e.g., phase transformations, equilibria) D. Materials selection (e.g., metals, composites, ceramics, plastics, bio-materials) E. Surface conditions (e.g., corrosion, degradation, coatings, finishes) F. Testing (e.g., tensile, compression, hardness)	**10%**
IV.	**Measurements, Instrumentation, and Controls** A. Mathematical fundamentals (e.g., Laplace transforms, differential equations) B. System descriptions (e.g., block diagrams, ladder logic, transfer functions) C. Sensors and signal conditioning (e.g., strain, pressure, flow, force, velocity, displacement, temperature) D. Data collection and processing (e.g., sampling theory, uncertainty, digital/analog, data transmission rates) E. Dynamic responses (e.g., overshoot/time constant, poles and zeros, stability)	**10%**
V.	**Thermodynamics and Energy Conversion Processes** A. Ideal and real gases B. Reversibility/irreversibility C. Thermodynamic equilibrium D. Psychrometrics E. Performance of components F. Cycles and processes (e.g., Otto, Diesel, Brayton, Rankine) G. Combustion and combustion products H. Energy storage I. Cogeneration and regeneration/reheat	**15%**

VI. Fluid Mechanics and Fluid Machinery **15%**

A. Fluid statics
B. Incompressible flow
C. Fluid transport systems (e.g., pipes, ducts, series/parallel operations)
D. Fluid machines: incompressible (e.g., turbines, pumps, hydraulic motors)
E. Compressible flow
F. Fluid machines: compressible (e.g., turbines, compressors, fans)
G. Operating characteristics (e.g., fan laws, performance curves, efficiencies, work/power equations)
H. Lift/drag
I. Impulse/momentum

VII. Heat Transfer **10%**

A. Conduction
B. Convection
C. Radiation
D. Composite walls and insulation
E. Transient and periodic processes
F. Heat exchangers
G. Boiling and condensation heat transfer

VIII. Refrigeration and HVAC **10%**

A. Cycles
B. Heating and cooling loads (e.g., degree day data, sensible heat, latent heat)
C. Psychrometric charts
D. Coefficient of performance
E. Components (e.g., compressors, condensers, evaporators, expansion valve)

AFTERNOON SESSION IN OTHER/GENERAL ENGINEERING (60 questions in 9 topic areas)

Topic Area	Approximate Percentage of Test Content
I. Advanced Engineering Mathematics	**10%**
A. Differential equations	
B. Partial differential calculus	
C. Numerical solutions (e.g., differential equations, algebraic equations)	
D. Linear algebra	
E. Vector analysis	
II. Engineering Probability and Statistics	**9%**
A. Sample distributions and sizes	
B. Design of experiments	
C. Hypothesis testing	
D. Goodness of fit (coefficient of correlation, chi square)	
E. Estimation (e.g., point, confidence intervals) for two means	
III. Biology	**5%**
A. Cellular biology (e.g., structure, growth, cell organization)	
B. Toxicology (e.g., human, environmental)	
C. Industrial hygiene [e.g., personnel protection equipment (PPE), carcinogens]	
D. Bioprocessing (e.g., fermentation, waste treatment, digestion)	
IV. Engineering Economics	**10%**
A. Cost estimating	
B. Project selection	
C. Lease/buy/make	
D. Replacement analysis (e.g., optimal economic life)	
V. Application of Engineering Mechanics	**13%**
A. Stability analysis of beams, trusses, and frames	
B. Deflection analysis	
C. Failure theory (e.g., static and dynamic)	
D. Failure analysis (e.g., creep, fatigue, fracture, buckling)	
VI. Engineering of Materials	**11%**
A. Material properties of:	
1. metals	
2. plastics	
3. composites	
4. concrete	
VII. Fluids	**15%**
A. Basic hydraulics (e.g., Manning equation, Bernoulli theorem, open-channel flow, pipe flow)	
B. Laminar and turbulent flow	
C. Friction losses (e.g., pipes, valves, fittings)	
D. Flow measurement	
E. Dimensionless numbers (e.g., Reynolds number)	
F. Fluid transport systems (e.g., pipes, ducts, series/parallel operations)	
G. Pumps, turbines, and compressors	
H. Lift/drag	

VIII. Electricity and Magnetism **12%**

A. Equivalent circuits (Norton, Thevenin)
B. AC circuits (frequency domain)
C. Network analysis (Kirchhoff laws)
D. RLC circuits
E. Sensors and instrumentation
F. Electrical machines

IX. Thermodynamics and Heat Transfer **15%**

A. Thermodynamic properties (e.g., entropy, enthalpy, heat capacity)
B. Thermodynamic processes (e.g., isothermal, adiabatic, reversible, irreversible)
C. Equations of state (ideal and real gases)
D. Conduction, convection, and radiation heat transfer
E. Mass and energy balances
F. Property and phase diagrams (e.g., T-s, h-P)
G. Tables of thermodynamic properties
H. Cyclic processes and efficiency (e.g., refrigeration, power)
I. Phase equilibrium and phase change
J. Thermodynamic equilibrium
K. Combustion and combustion products (e.g., CO, CO_2, NOX, ash, particulates)
L. Psychrometrics (e.g., humidity)