

PAKISTAN ENGINEERING COUNCIL

Syllabus for Engineering Practice Examination (EPE)

Mechanical Engineering & Allied disciplines (Mechanical/ Industrial/ Automotive Engineering)

Total Marks: 60

PART-II

This is an open book breadth and depth examination, comprising 60 Multiple Choice Questions (MCQs) of one mark each (total 60 marks) with a duration of three hours. There shall be two sections of Part-II for each major discipline of EPE. Qualifying Marks for this part shall be *sixty per cent*.

SECTION-A / BREADTH

This section will generally confirm to latest (updated) B.E./equivalent qualification of Mechanical Engineering and allied disciplines. The examination of this section shall comprise 25 MCQs (total 25 marks).

1. MATHEMATICS, PROBABILITY & STATISTICS 7%

- i. Calculus and Analytical Geometry
- ii. Linear Algebra
- iii. Differential Equations
- iv. Complex Variables and Transforms
- v. Probability and Statistics
- vi. Numerical Methods

Suggested Books:

- Erwin Kreyszig, "Advanced Engineering Mathematics," 9th Ed., 2005, International Edition, John Wiley & Sons.
- Stephen Goode, "Differential Equations and Linear Algebra," 2nd Ed., 2000, Prentice Hall.
- Susan Milton and Jesse C Arnold, "Introduction to Probability and Statistics: Principles and Applications for Engineering and the Computing Sciences," 4th Ed., 2003, McGraw-Hill.

2. MEASUREMENT AND INSTRUMENTATION 3%

- i. Basic principles for measurement of temperature, pressure, mass flow rate, volume flow rate, length and motion
- ii. Instruments and gauges

iii. Calibration, accuracy, repeatability and error analysis

Suggested Books:

- E. Doebelin Measurement Systems, “Applications and Design”, 3rd Ed., McGraw Hill.
- Jack Holman “Experimental Methods for Engineers” 4th Ed., McGraw-Hill.
- R. Figliola, And D. Beasley, “Theory and Design for Mechanical Measurements”, John Wiley, 1991.
- J. G. Webster “The Measurement, Instrumentation and Sensors Handbook”, CRC Press, Taylor and Francis Group, 1998, ISBN 10: 0849383471.
- B. G. Liptak, “Instrument Engineers Handbook’ 4th Ed., CRC Press, Taylor and Francis Group.

3. DESIGN

30%

i. Engineering Drawing & Graphics (6%)

- Fundamentals: types of lines, lettering, dimensioning, use of pencil and drawing instruments, planning of drawing sheet
- Projections: types of projections, orthographic projections, plane of projections, four quadrants, projection of points, projection of straight lines, examples with different quadrants, traces of a line, true length of a line, inclination to both the planes, projection of oblique and auxiliary planes
- Loci of Points and Generated Curves: loci of points and straight lines, cycloid, epicycloids, involutes, arch median spiral
- Development of Solids: types of solids, polyhedral, solids of revolution, prism, pyramid, cylinder, cone, sphere
- Intersection of Surfaces: intersection of cylinder and cylinder, cone and cylinder, cone and cone, cone and prism
- Projection of Solids: projection of various solids in simple position and inclined positions
- Section of Solids: true shape of section on auxiliary plane of various solids
- Computer Aided Drawing (CAD)
- Symbols: machining, welding, tolerances and fits
- Extrusions, sweeps, blends, patterns.

Suggested Books:

- Bertoline Wiebe, Miller. “Technical Graphics Communication” 4th Ed. Mohler, Irwin McGraw-Hill, 1997.
- Abbot, “Practical Geometry & Engineering Graphics” .
- Craft, Meyers & Boyer, “Engineering Graphics”
- Gary R. Bertoline and Eric N. Wiebe “Technical Graphics Communication”, 3rd P Ed., McGraw-Hill

ii. Engineering Statics & Dynamics (6%)

a. Statics:

- Force System: force, rectangular components, moment, couples, resultant of forces, moments and couples (two and three dimensional systems)
- Equilibrium: mechanical systems, isolation and equilibrium equations for two and three dimensional systems. Free body diagram, two force and three force members
- Structures: plane trusses, method of joints, method of sections, frames and machine analysis. Forces in beams and cables
- Friction: types and applications of friction.

Suggested Books:

- R.C. Hibbler, "Engineering Mechanics" (Vol. 1) 8th Ed. Prentice Hall
- By J. L. Meriam & L.G.Kraige, "Engineering Mechanics", Vol. 1, Statics, 6th Ed., John Wiley & Sons
- Ferdinand P. Beer & E. Russel Johnston Jr. "Vector Mechanics for Engineers" (Statics) 4th Edition, McGraw-Hill Science
- A. Bedford and W. Fowler, "Engineering Mechanics-Statics", 4th Ed. Addison Wesley, McGraw-Hill Science.

b. Dynamics:

- Kinematics of Particles: rectilinear motion, plane curvilinear motion, rectangular coordinates, normal and tangential coordinates polar coordinates
- Kinetics of Particles: force, mass, and acceleration, Newton's second law of motion, equations of motion, kinetic diagrams, rectilinear motion, curvilinear motion, work and energy, potential energy. Impulse and momentum, conservation of momentum
- Plane Kinematics of Rigid Bodies: angular motion relation, absolute motion, relative velocity, instantaneous centre of zero velocity, relative acceleration
- Plane Kinetics of Rigid Bodies: force, mass, and acceleration, equation of motion, translation, fixed axis rotation, general plane motion, work and energy relationship, impulse and momentum equation.

Suggested Books:

- R.C. Hibbler, "Engineering Mechanics" (Vol. 2) 8th Ed., Prentice Hall
- J. L. Meriam & L.G.Kraige "Engineering Mechanics", Vol. 2, Dynamics, 6th Ed., John Wiley & Sons
- Ferdinand P. Beer & E. Russel Johnston Jr. "Vector Mechanics for Engineers (Dynamics)" 4th Ed., McGraw-Hill Science
- A. Bedford and W. Fowler, "Engineering Mechanics, Dynamics", 4th Ed., Addison Wesley McGraw-Hill Science

iii. Mechanics of Materials (6%)

- Mechanical properties of materials
- Stress & Strain: Hooke's law, stress strain relationship, thermal stresses, plane stress and strain, principal stresses and strains, Mohr's circle for stress and strain, stress concentration
- Bending: shearing force and bending moment diagrams, bending and shear stresses in beams, deflection of beams
- Torsion: hollow and compound shafts
- Strain energy
- Theory of columns
- Pressure Vessels: deflection and stresses, thin and thick walled cylinders.

Suggested Books:

- Ferdinand P. Beer & Russel Johnston Jr., "Mechanics of Materials", 4th Ed., McGraw-Hill
- P.P. Benham & R.J. Crawford Longman Sc & Tech "Mechanics of Engineering Materials"
- Crandall, Dahl, and Lardner "An Introduction to the Mechanics of Solids: 2nd Ed., McGraw Hill
- F.V. Warnock, Pitman, "Mechanics of Solids & Strength of Materials" (1970)

iv. Machine Design (6%)

- Basic criteria of design of machine parts
- Determination of permissible and actual stresses
- Design of simple machine elements
- Failure theories
- Design for fatigue resulting from variable loading

Suggested Books:

- J.E. Shigley, "Mechanical Engineering Design", 8th Ed., McGraw Hill
- R L Norton "Machine Design, An Integrated Approach", 3rd Ed., McGraw Hill, 1986.
- M.F. Spotts, "Design of Machine Elements", 7th Ed., Prentice Hall
- J. E. Shigley, C. Mischke and T. H. Brown, "Standard Handbook of Machine Design", 3rd Ed., McGraw Hill
- H. A. Rothbart, "Mechanical Design Handbook" 2nd Ed., McGraw Hill
- Enk Oberg and F.D. Jones, "Machinery Handbook", 28th Ed., Industrial Press Inc., USA

v. Mechanics of Machines (6%)

- Linkages and Mechanisms: position, velocity and acceleration analysis
- Friction between un-lubricated surfaces, screw threads and efficiency, friction of pivot, collar and conical bearings, cone, plate and centrifugal clutches
- Belts, ropes, chains and sprockets

- Brakes
- Turning moment diagrams and fly wheel
- Governors: effort and power, sensitivity, controlling force and stability
- Cams and followers.

Suggested Books:

- Erdman and Sanders, "Mechanism Design" Vol. 1, 7th Ed., McGraw-Hill 1992.
- J.E. Shigley and J. Uicker Junior, "Theory of Machines and Mechanisms", 3rd Ed., McGraw-Hill
- Martin, "Kinematics and Dynamics of Machines", 2nd Ed., McGraw-Hill
- R. L. Norton, "Design of Machinery" 2nd Ed., McGraw-Hill
- Enk Oberg and F.D. Jones, "Machinery Handbook", 28th Ed., Industrial Press Inc., USA

4. MANUFACTURING ENGINEERING

30%

i. Engineering Materials (10%)

a. Metals:

- Structure of metals
- Metals and Alloys: production and classification of iron and steel, phase diagram, alloying elements and their effects, refining of copper, aluminum and zinc alloys
- Material Forms and Designation: Heat treatment, critical temperature, transformation on heating/cooling, annealing, normalizing, tempering, quenching, hardening. Rolling processes and production of various steel sections
- Corrosion of metals, anti-corrosive coatings and paints.

b. Non Metals:

- Composition, properties and uses of plastics, rubber, ceramics, fiberglass, composite materials and polymers.
- Polymers: molecular structure, bonding & classification of polymer compounding, forming operations etc, plastics.
- Ceramics and Refractories: ceramic bonding, properties, ceramics material, crystalline and amorphous, silica, glass, refractory materials and their types, introduction to composite materials and material failure analysis.

c. International Codes and Standards

Suggested Books:

- E.P Degarmo, J.T. Black and R.A. Kohser, "Materials and Processes in Manufacturing", 10th Ed., Wiley, 2007.

- R.A Lindberg, “Process and Materials of Manufacturing”, 4th Ed., Prentice Hall, 1998.
 - HT William F.SmithTH, “Introduction to Engineering Materials”, 2ndP Ed., McGraw-Hill Science
- ii. Manufacturing Processes (10%)
- Forming & Shaping Processes and Equipment: rolling, flat rolling, rolling mills, shapes rolling, production of seam less tubing and piping, extrusion and drawing, hot and cold extrusion, extrusion and drawing equipment, hydrostatic extrusion
 - Sheet Metal Forming: sheet metal characteristics, formability of sheet metals, bending sheet and plate, tube bending & forming, deep drawing, supper plastic forming, explosive forming, equipment for sheet metal forming
 - Forming & Shaping Plastics & Composite Materials: extrusion, injection molding, blow molding, thermo-forming, processing elastomers, processing reinforced plastics, manufacturing honeycomb material, processing metal matrix and ceramic matrix composites
 - Joining Process & Equipment: fusion welding process, oxy-fuel gas welding, arc welding, electrodes, thermo welding, electron beam welding, solid state welding process, cold welding, ultrasonic welding, friction welding, resistance welding, weld design and process selection, brazing, soldering, adhesive bonding, joining plastics
 - Metal Casting Process & Equipment: molding and molding sands, classification of foundry process, casting and its types, pattern and pattern making, core and core making, furnaces, crucibles, molding tools and foundry equipment
 - Powder Metallurgy: production of metal powders, compaction, sintering, design considerations
 - Surface Treatment, Coating and Cleaning: mechanical surface treatment and coating, painting and its testing, thermal spraying, vapor deposition, electroplating and electro forming, anodizing, hot dipping, surface texturing and cleaning
 - Metrology: specification and standardization, limit and fits tolerances and allowances
 - Precision measurements: standards, sources of errors, angular measurement, measuring microscope, optical projection straightness and flatness testing, surface finish measurement.

Suggested Books:

- E.P Degarmo, J.T. Black and R.A. Kohser, “Materials and Processes in Manufacturing”, 10th Ed., Wiley, 2007.
- R.A Lindberg, “Process and Materials of Manufacturing”, 4th Ed., Prentice Hall, 1998.
- Mikell P. Groover, “Fundamentals of Modern Manufacturing: Materials, Processes, and Systems”, 4th Ed., Wiley 2010.

iii. Workshop Practices (10%)

- Fitting Shop: assembly/disassembly of basic mechanical components
- Carpentry Shop: timber, its defects and preservation methods, different

types of wood joints, making a small wooden model

- Electric Shop: types and uses of cables. Study of household electrical appliances
- Forging & Foundry Shop: brief introduction, tools and accessories, furnace types, casting and forging presses
- Machine Shop: introduction to machine tools, basic operations of lathe, shaping, milling, grinding, drilling and gear hobbling
- Welding Shop: introduction to welding, soldering and brazing; brief details of gas, electric arc welding and gas/plasma cutting.

Suggested Books:

- W. Chapman, "Workshop Technology", 4th Ed., Part. 1, 2 & 3, Butterworth-Heinemann Title 1972.
- H.P. Richter and W.Creighton Schwan, "Practical Electrical Wiring: Residential, Farm and Industrial", 15th Ed., McGraw-Hill 1990.

5. THERMO-FLUIDS

30%

i. Thermodynamics (12%)

- Basic concepts
- Thermodynamic properties
- Thermodynamic cycles
- Laws of thermodynamics
- Heat and mass balance principles
- Combustion
- Introduction to psychometric properties
- Refrigeration cycles

Suggested Books:

- Yunus A. Cengel, Michael A. Boles, "Thermodynamics, An Engineering Approach", 6th P Ed., McGraw-Hill
- M.J. Moran and H.O. Shapiro, "Fundamentals of Engineering Thermodynamics", 5th P Ed., HT John Wiley & Sons
- Sonntag, Borgnakke, Van Wylen HT, "Fundamentals of Thermodynamics", 6th Ed., John Wiley & Sons
- Rayner and Joel, "Basic Engineering Thermodynamic", 5th P Ed., Prentice Hall

ii. Heat Transfer (8%)

- Thermal conduction

- Forced and free convection
- Heat exchangers
- Radiation

Suggested Books:

- Myer Kutz, “Mechanical Engineer’s Handbook”, 3rd Ed., 2005, John Wiley and Sons, Inc.
- “Marks’ Standard Handbook for Mechanical Engineers”, McGraw Hill
- “The CRC Handbook of Mechanical Engineering”, 2nd Ed., CRC Press LLC.
- Incropera, dewitt, “Fundamentals of Heat and Mass Transfer”, 6th Ed.,
- Frank Kreith, and Mark S. Bohn, “Principles of Heat Transfer” , 6th Ed. ISBN: 0534375960

iii. Fluids Mechanics (10%)

- Fundamental principles
- Liquid forces on submerged surfaces
- Governing equations of fluids
- Dimensionless numbers
- Type of flows
- Boundary layers
- Flow of fluids in open and closed channels
- Flow measurements
- Impact of jets, turbines and pumps

Suggested Books:

- Myer Kutz, “Mechanical Engineer’s Handbook”, 3rd Ed., 2005, John Wiley and Sons, Inc
- “Marks’ Standard Handbook for Mechanical Engineers”, McGraw Hill
- “The CRC Handbook of Mechanical Engineering”, 2nd Ed., CRC Press LLC.
- F White, “Fluid Mechanics”, 4th Ed.

PART-II

SECTION-B / DEPTH

This section shall be based on practical concepts framed to judge the practical experience and field based knowledge of Registered Engineers (REs). The examination of this section shall comprise 35 MCQs. Each candidate may attempt the only opted area of practice, among the followings.

1. THERMO-FLUIDS ENGINEERING

i. Thermodynamics

- Non-reacting gas mixtures: Dalton's law and the Gibb's Dalton law, volumetric analysis of gas mixtures, gas mixture constants and specific heats, adiabatic mixture of perfect gases
- Mixture with chemical reaction: simple reaction equation, stoichiometric chemical reaction, rich and lean air-fuel ratio mixture, enthalpy of formation and reaction, adiabatic flame temperature
- Compressors: classification and working principles, single stage and multistage compressors, inter-cooling, efficiencies and P-V diagrams of reciprocating compressors, performance characteristics and working regimes
- Boilers: generation of steam through boilers; classification and configurations of boilers and their applications, boiler efficiency and heat balance
- Nozzles: flow through nozzles, their efficiencies, types and working principles.

Suggested Books:

- Yunus A. Cengel, Michael A. Boles, "Thermodynamics, An Engineering Approach", 6th P Ed., McGraw-Hill
- M.J. Moran and H.O. Shapiro, "Fundamentals of Engineering Thermodynamics", 5th P Ed., HT John Wiley & Sons
- Sonntag, Borgnakke, Van Wylen HT, "Fundamentals of Thermodynamics", 6th Ed., John Wiley & Sons
- Rayner and Joel, "Basic Engineering Thermodynamic", 5th P Ed., Prentice Hall

ii. HVAC/ Refrigeration

- Psychometrics (heating / cooling cycles, humidification / dehumidification, heating / cooling loads)
- Cooling towers (types, configurations, flow rates, conditions)
- Condensers (configurations, conditions, flow rates)
- Refrigerants (types, properties)
- Evaporators / Chillers (configurations, conditions, flow rates)
- Refrigeration components (expansion valves, accumulators)
- Fluid distribution (system types and design)

Suggested Books:

- "ASHRAE Handbooks", 2009

- Shan K. Wang, “Handbook of Air Conditioning and Refrigeration”, 2nd Ed., McGraw-Hill

iii. IC Engines and Power Plants

- Thermodynamic cycles
- Gas turbine power plants (efficiencies and heat balance)
- Steam turbine power plants (efficiencies and heat balance)
- Heat recovery steam generators (types, efficiencies, design)
- IC Engines
- Energy balance sheets

Suggested Books:

- Cohen, Roger & Saravanamutto Longman, “Gas Turbine Theory”, 4th Ed.
- M. M. al-Wakil. “Power Plant Technology”, McGraw Hill
- Myer Kutz, “Mechanical Engineer’s Handbook”, 3rd Ed., 2005, John Wiley and Sons, Inc
- “Marks’ Standard Handbook for Mechanical Engineers”, McGraw Hill
- “Turbine Handbook, : Principles and Practice”, 4th Ed., 2009, Tony Giampaolo

iv. Energy Resources and Utilization (Conventional and non-conventional)

- Solar energy
- Wind energy
- Hydel energy
- Coal gasification
- Bio-fuel gasification
- Biomass gasification
- Fuel cells
- Ocean energy
- Hybrid-systems
- Geo-thermal
- Energy conservation and auditing

Suggested Books:

- Mukund R. Patel, “Wind and Solar Power Systems” , CRC Press LLC
- “Fuel Cell Technology Handbook”, 2002, CRC Press LLC, ISBN: 9780849308772
- Dr Nasim A. Khan, “Energy Recourses and their Utilization” 2010

2. MANUFACTURING ENGINEERING

i. CAD-CAM and Automation

- CAD: fundamentals of CAD, hardware in CAD, computer graphics software and data base, mathematical elements of CAD, finite element analysis
- CAM: Conventional Numerical Control (CNC), NC part programming, computer controls in NC
- Automation: basic concepts, automation strategies, economics of automations, partial automations, line balancing techniques, group technology and flexible manufacturing
- Robotics: basic concepts, classification and structure of robotic system, coordinate transformation, applications of robots
- Programmable Logic Controller (PLC): basic components and terminologies, ladder diagram elements, relay sequencing, processor input and output modules, programming unit and programming procedures with machines or assembly language
- Process Planning: approaches to process planning, operation sheet, manual approach, variant approach, generative approach, introduction to various process planning systems.

Suggested Books:

- “Automation, Production Systems and Computer Integrated Manufacturing”, 3rd Edition by Mikell P. Groover; Prentice Hall 2007.
- “CAD/CAM: Computer-Aided Design and Manufacturing”, by Mikell P. Groover; Prentice Hall 1986.
- “Robotics for Engineers”, by Yorem Korem; 1985.
- “Introduction to Robotics: Mechanics & Control”, 3rd Edition by John Craig; Prentice Hall.

ii. Production Management

- Operations Planning and Scheduling: Project scheduling and control techniques (CPM/PERT), project risk analysis, time compression and resource leveling, computerized project management, special software packages such as MS Project and Primavera
- Motion & time study
- Maintenance management
- Materials Management: inventory control, types of inventory, inventory costs, independent versus dependent demand, EOQ/EPQ models, types of control systems, selective inventory control, inventory system development, Just In Time (JIT) technique, MRP, MRP inputs & outputs, product structures and types of MRP. Transportation and handling of Raw Material to finished product & importance of various material handling equipments.

Suggested Books:

- J. Heizer and B. Render, “Principles of Operations Management”, 6th Ed., Pearson Prentice Hall 2006.
- James B. Dilworth, “Operations Management”, 2nd Ed., McGraw-Hill

1996.

- Richard J. Tersine, "Production/Operations Management: Concepts, Structure and Analysis", 2nd Ed., Appleton & Lange 1985.

iii. Quality and Safety Management

- Quality Management: fundamental principles, standards, techniques for quality analysis and improvements, statistical methods and SPC, control charts and acceptance sampling, QFD, value engineering, cross-functional management and benchmarking, ISO-9000 application, clauses, and implementation issues, techniques of quality control, management of quality control, total quality control, process capability & variability analysis, reliability & maintainability
- Safety Management: introduction of health & safety, industrial safety, introduction objectives of safety, importance of safety in an industry, industrial accidents, effects of accidents, types of accidents, fire prevention & control and ISO standard for safety, health & environment
- Cost Management: direct, indirect, overheads, fixed, variable, opportunity, sunk, cash flow diagrams, time value of money, discounted cash flows, present worth, annual equivalent costs, internal rate of return, payback period, project feasibility analysis, depreciation accounting, straight line, declining balance and sum of year digits, plant replacement analysis, types of taxes, after tax economic analysis, cost estimating methods, project cost control, financial management and accounting methods.

Suggested Books:

- Amitava Mitra, "Principles of Operations Management", 2nd Ed., Prentice Hall 1998.
- Douglas C. Montgomery, "Introduction to Statistical Quality Control", 5th Ed., John Wiley & Sons 2004.
- John Ridley, "Safety at Works", 6th Ed., Butterworth-Heinemann, 2003.
- L. Blank and A. Tarquin, "Engineering Economy", 5th Ed., McGraw Hill 2002.

iv. Machine Tools and Machining

- Material Removal: mechanics of chips formation, types of chips produced, forces and pressures involved, surface finishing and integrity, machinability, calculation of material removal rate
- Cutting Tools: single point tool geometry, mill cutters, factors which affect tool life, tool life relationships, tool materials, types and properties of cutting fluids
- Machine Processes for Producing Various Shapes: milling operation, milling machines, planning and shaping, broaching and broaching machines, gear manufacturing by machining
- Abrasive Machining & Finishing Operations: abrasive, bonded abrasives (grinding wheels), grinding process, grinding fluids, design considerations for grinding, ultrasonic machining
- Non Conventional Machining Process: electrochemical machining, Electrical Discharge Machining (EDM), wire EDM
- Dies, Jigs and Fixtures: general design principle, elements of jig, locating devices and clamping devices.

Suggested Books:

- S. Kalpakjian & S. Schmid, "Manufacturing Engineering and Technology", 6th Ed., Prentice Hall.
- E.P DeGarmo, J.T. Black, R.A. Kohser; "Materials and Processes in Manufacturing", 10th Ed., Prentice Hall 2008.

3. DESIGN ENGINEERING

i. Mechanics of Materials

- Analysis of stress and strain in two and three dimensions
- Equilibrium, compatibility and strain relations
- Analysis of torsion
- Thin and thick walled cylinders
- Rotating disks and flat plates
- Symmetrical and asymmetrical loading
- Secondary stresses
- Statically indeterminate problems
- Photo-elasticity
- Strain gauges
- Castigliano's theorem
- Introduction to fracture mechanics
- Critical stress intensity factor
- Impact and shock loads.

Suggested Books:

- Ferdinand P. Beer & Russel Johnston Jr., "Mechanics of Materials", 4th Ed., McGraw-Hill.
- P.P. Benham & R.J. Crawford Longman, "Mechanics of Engineering Materials", 7th Ed. 2007, ISBN: 0132209918.
- Crandall, Dahl, and Lardner, "An Introduction to the Mechanics of Solids", 2nd Ed., McGraw Hill.

ii. Mechanics of Machines

- Geometry of gears
- Types of gear trains
- Torque on gear trains
- Valve diagrams and valve gears
- Steering gears
- Static and dynamic balancing
- Gyroscope

Suggested Books:

- Erdman and Sanders, "Mechanism Design", Vol. 1, 7th Ed., McGraw-Hill 1992.

- J.E. Shigley and J. Uicker Junior, "Theory of Machines and Mechanisms", 3rd Ed., McGraw-Hill
- Martin, "Kinematics and Dynamics of Machines", 2nd Ed., McGraw-Hill
- R. L. Norton, "Design of Machinery", 2nd Ed., R. L. Norton McGraw-Hill
- J. Hannah, R. Stephens, "Mechanics of Machines", 4th Ed.

iii. Machine Design

- Design of welded, riveted and bolted joints
- Design of translation screws
- Standards of fits & tolerances
- Design of spur, helical, bevel & worm gears
- Design and selection of bearings
- Design of mechanical springs
- Design of shafts
- Design of flexible mechanical components
- Design for manufacture and assembly
- Design codes and standards (DIN, ASTM, ASME, BS, and JIS).

Suggested Books:

- J.E. Shigley "Mechanical Engineering Design", 8th Ed., McGraw Hill
- R L Norton, "Machine Design, An Integrated Approach", 3rd Ed., McGraw Hill, 1986.
- M.F. Spotts, "Design of Machine Elements", 7th Ed., Prentice Hall
- J. E. Shigley, C. Mischke and T. H. Brown, "Standard Handbook of Machine Design", 3rd Ed., McGraw Hill
- H. A. Rothbart, "Mechanical Design Handbook", 2nd Ed., McGraw Hill
- R.E. Green, "Machinery Handbook", 28th Ed., Industrial Press Inc - USA

4. CONTROL ENGINEERING

i. Control Systems

- Basic Concepts: system, control system, input, output, open-loop and closed loop control systems, elements of a general control system, examples of control systems
- Mathematical Modeling of Physical Systems: operational notation, grounded chair representation, series and parallel laws, equations of motion for spring mass damper systems, levered systems, rotational systems, geared systems, electrical components and R.L.C. circuits, electrical analogies for mechanical systems, scale factors, thermal systems and fluid system
- Transfer Functions and Systems Response: review of laplace transformation, impulse, step and ramp functions, concept of transfer functions of common components, block diagram algebra, signal flow graphs, impulse, step, and ramp response of first and second order systems, characterization of system response, relation of system response to location of system poles and zeros
- Stability of Control Systems: concept of stability, Routh Hurwitz criterion, Root locus Methods and its use in control system design, frequency response and bode diagram

- Introduction to digital control.

Suggested Books:

- B. C. Kuo, F. Golnaraghi, "Automatic Control Systems", 8th Ed., John Wiley & Sons, Inc.
- Richard C. Dorf, "Modern Control System", 10th Ed., Prentice Hall
- J.J Distefano, "Automatic Control", 1981.
- Francis H. Raven, "Automatic Control", 2001, McGraw Hill, ISBN: 0130432458
- L.C. Westphal, "Handbook of Control Systems Engineering" 2nd Ed', Springer Publishing Company
- Norman S. Nise, "Feedback Control System" 5th Ed., 2010.

ii. Mechanical Vibrations

- Oscillatory Motion: elements of vibrating systems, harmonic motion, periodic motion, vibration terminology
- Single Degree of Freedom Systems: equation of motion, Newton's method, energy method, undamped free vibration, viscously damped free vibration, logarithmic decrement, harmonically excited vibration, vibration isolation
- Two Degrees of Freedom Systems: normal modes of vibration, coordinate coupling, forced harmonic vibration, vibration absorber, vibration damper, orthogonality conditions
- Vibration of Elastic Bodies: free and forced vibration of uniform bars and simply supported beams, torsional vibration of shafts loaded with single and multiple rotors, determination of critical speeds
- Vibration measurement and control.

Suggested Books:

- W. T. Thompson, "Mechanical Vibrations: Theory and Applications" 5th Ed., Prentice Hall Publishing Company
- S. S. Rao, "Mechanical Vibrations", 4th Ed., McGraw Hill
- L. Meirovitch, "Elements of Vibration Analysis", McGraw Hill
- B. Balachandran and E. B. Magrab, "Vibrations", 2008, Thomson Publishing Company

iii. . Instrumentation

- Significance of measurement
- General measurement system
- Calibration, accuracy, repeatability and error analysis
- Static and dynamic measurement range
- Sensors and transducers
- Instruments for measurement of length, force, torque, frequency, pressure, flow and temperature
- Introduction to data acquisition systems.

Suggested Books:

- E. Doebelin, "Measurement Systems: Applications and Design" 3rd Ed., McGraw Hill
- Holman, "Experimental Methods for Engineers", 4th Ed., McGraw-Hill

- R. Figliola, And D. Beasley, “Theory and Design for Mechanical Measurements”, John Wiley, 1991
- J. G. Webster, “The Measurement, Instrumentation and Sensors Handbook”, CRC Press, Taylor and Francis Group
- B. G. Liptak, “Instrument Engineers Handbook”, 4th Ed., CRC Press, Taylor and Francis Group

5. AERONAUTICAL ENGINEERING (AEROSPACE ONLY)

i. Aerospace Structures :

- Matrix method of structural analysis
- Basic structural elements, Line forming and surface forming element, Axial member, Shear panel, Bending Member, Torsion Member, Basic elements of aircraft structure and their functions, Construction of parts of an aircraft including wing and fuselage construction, Spars, Stringers, Ribs, Webs, Shear panels and frames etc.
- Buckling of bars, plates, circular cylindrical shells.
- Energy methods and Castigliano’s theorem for deflection and force estimation
- Airworthiness and aircraft loads, aircraft inertia loads, Symmetric maneuver loads, Gust loads and gust envelope, Fatigue and its damages
- Bending, Shear and Torsion of open and closed thin walled beams, Direct stress distribution due to bending, Shear force and bending moment relation, Approximation of thin-walled section, Analysis of wing and fuselage, composite material for aircraft structures.

Suggested Books:

- Aircraft Structures for Engineering Students by THG Megson, Elsevier Butter Worth Heinemann
- Mechanics of Aircraft Structures by C. T. Sun
- Aircraft Structures by D. Perry & J. J. Azar

ii. Structural Dynamics and Vibrations:

- Single Degree of Freedom Systems - Free Vibratory Systems
- Single Degree of Freedom Systems – Forced Vibratory Systems
- Transient Vibration
- Systems with Two Degrees of Freedom
- Multi Degree of Freedom Systems
- Vibration control

Suggested Books:

- Theory of Vibration with Applications by W. T. Thomson and Marie Dillon Dahleh
- Mechanical Vibrations by S. S. Rao
- Engineering Vibration by Daniel J. Inman
- Mechanical Vibration by William W. Seto

- iii. Controls and Instrumentation:
 - a. Control Systems:
 - Introduction to Control Systems
 - Laplace Transform
 - Mathematical Modeling
 - Transient & Steady-State Response Analysis
 - Root-Locus Analysis
 - Frequency-Response Analysis
 - Control System Design by Frequency-Response

Suggested Books:

- Modern Control Engineering, 4th edition by K.Ogata.
- A guide to MATLAB by B.R. Hunt, R.L. Lipsman and J.M. Rosenberg
- Basic MATLAB, Simulink and Stateflow by Richard Colgren
- Modern Control Engineering, 8th edition by R.C. Dorf and R.H. Bishop
- Design of Feedback Control Systems by R.T. Stefani, B. Shahian, C.J. Savant and G. Hostetter
- Multivariable Control Systems by P. Albertos and A. Sala

b. Flight Control System

- Control of Aircraft and rocket systems
- Derivation of transfer functions for longitudinal and lateral equation of motion and different modes of longitudinal and lateral dynamics
- Transient response of the aircraft
- Displacement autopilot
- Pitch orientation control system
- Acceleration Control system
- Glide path slope coupler and automatic flare control
- Flight path stabilization
- Transient response of the aircraft
- Lateral Autopilot
- Coordination's methods
- Yaw orientation control system
- Rocket control systems
- Roll stabilization
- Control of aerodynamic rocket
- Guidance Systems
- Proportional Navigation Guidance
- Command guidance

Suggested Books:

- Automatic Control of Aircraft and Missiles, 2nd edition, John H. Blakelock
- Flight Stability and Automatic control, 2nd Edition, by Robert C Nelson

c. Aerospace Instrumentation:

- Measurement Principles

- Data and Data Analysis
- Standards and Calibration of Instruments
- Operational Amplifiers
- Digital Circuits
- Meters, Bridges and Oscilloscope
- Noise and Noise Reduction Techniques
- Transducers
- Data Acquisition, Recording and Control

Suggested Books:

- Applied Electronics Instrumentation & Measurements, by Buchla & Mclachlan
- Industrial instrumentation, by Donald P. Eckman
- Electronic Measurement Systems, by Anton F. P. Van
- Industrial Control Electronics (2nd Ed.) by John Webb & Kevin Greshok
- Industrial Electronics (4th Ed.) by James T. Humphries & Leslie P. Sheets.

d. Aero Vehicle Performance:

- The evolution of the airplane and its performance
- Aerodynamics of the airplane: the drag polar
- Propulsion characteristics
- Airplane performance
- Airplane performance: steady flight
- Airplane performance: Accelerated Flight.

Suggested Books:

- Aircraft Performance and Design by John D Anderson
- Introduction to Aircraft Flight Mechanics by Thomas R. Yechout
- Performance, Stability, Dynamics, and Control of Airplanes, 2nd Edition, by Bandu N. Pamadi.

e. Flight Dynamics and Stability:

- Flight Mechanics
- Static Stability and Control
- Aircraft Equations of Motion
- Longitudinal Motion
- Lateral Motion.

Suggested Books:

- Intro to A/c Flight Mechanics by T.C.Yechout
- Flight Dynamics Principles by M. V. Cook
- Mechanics of Flight By A. C. Kermode.

iv. Propulsion

a. Propulsion and Power Systems:

- Introduction
- Shaft Power Cycles
- Gas Turbine cycles for Aircraft Propulsion
- Centrifugal Compressors
- Axial Flow Compressors
- Combustion Chambers
- Turbine, Exhaust Nozzles and Future Aspects.

Suggested Books:

- Mechanics & Thermodynamics of Propulsion Systems by Hill and Petersons
- Elements of Gas Turbine Propulsion by Mattingly C. Gordon
- Gas Turbine theory by HIH Saravanamuttoo, H COHEN, GFC Rogers

b. Space Propulsion:

- Fundamentals of space propulsion
- Nozzle Theory and Thermodynamic Relations
- Chemical Rocket Propellant Performance Analysis
- Solid Propellant Rocket Fundamentals
- Solid Propellants

Suggested Books:

- Elements of Rocket Propulsion; George P. Sutton, 7th Edition
- Solid Rocket Propulsion Technology, Alain Davenas
- Space Propulsion Analysis and Design; Humble, Henry and Larson
- Rocket Propulsion, M. Barrere.

v. Aerodynamics:

a. Compressible Aerodynamics:

- Compressible Flow: Some Preliminary Aspects
- Normal Shocks and Related Topic
- Oblique Shocks and Expansion Waves
- Compressible Flow through Nozzle, Diffuser and Wind Tunnels
- Subsonic Compressible Flow Over Airfoils : Linear Theory
- Linearized Supersonic Flow
- Elements of Hypersonic Flow

Suggested Books:

- Fundamentals of Aerodynamics, 3rd Ed. by John D Anderson Jr.
- Gas Dynamics by Robert D Zucker and Oscar Biblarz
- Gas Dynamics by James E. A. John

b. Incompressible Aerodynamics:

- Lift, Drag, pitching moment
- Flow over airfoil
- Finite Wing Theory
- Thin aerofoil theory
- Lift Distribution

Suggested Books:

- Fundamentals of Aerodynamics 3rd Edition, by John D. Anderson Jr.
- Introduction to Flight 5th Edition by John D. Anderson Jr.

6. HVAC & REFRIGERATION

i. HVAC & Refrigeration Systems

- Basic concepts and classification of HVAC and refrigeration systems
- Components of HVAC and refrigeration systems: compressors, condensers, evaporators, expansion devices, chillers, boilers, cooling towers, air-handling units (AHUs), ducting, piping, fans, pumps, and valves
- Principles of operation of air-conditioning systems: comfort and industrial air conditioning
- Refrigeration systems: vapor compression and vapor absorption systems
- Heating systems: hot water, steam, and electric heating systems
- Air distribution and ventilation systems
- Energy efficiency and performance of HVAC and refrigeration systems
- Filtration standards and air quality: ISO, Eurovent, and AHRI
- Introduction to HVAC standards, codes, and safety practices

Suggested Books:

- W.F. Stoecker and J.W. Jones, *Refrigeration and Air Conditioning*, 2nd Ed., McGraw-Hill
- Roy J. Dossat and Thomas J. Horan, *Principles of Refrigeration*, Pearson Education
- McQuiston, Parker, and Spitler, *Heating, Ventilating, and Air Conditioning: Analysis and Design*, 7th Ed., Wiley
- SMACNA, *HVAC Duct Construction Standards – Metal and Flexible*, 4th Ed., 2020
- ASHRAE Handbook – *Fundamentals*, 2022 Edition
- K.G. Dales, *Cleanroom Design: ISO 14644 Standards, Eurovent and AHRI Applications*, Elsevier, 2019

ii. Mechanical Aspects of HVAC & Refrigeration

- Mechanical behaviour of HVAC and refrigeration equipment
- Compressors, fans, blowers, pumps, and motors used in HVAC&R
- Mechanical vibrations and noise in HVAC and refrigeration systems
- Mounting, alignment, and balancing of rotating equipment
- Ductwork and piping design considerations
- Thermal expansion, stresses, and support systems
- Operation, maintenance, and reliability of HVAC&R equipment

Suggested Books:

- S. S. Rao, *Mechanical Vibrations*, McGraw-Hill
- Marks' Standard Handbook for Mechanical Engineers, McGraw-Hill
- Myer Kutz, *Mechanical Engineer's Handbook*
- SMACNA, *HVAC Duct Construction Standards – Metal and Flexible*, 4th Ed., 2020
- ASHRAE Handbook – HVAC Systems and Equipment

iii. Design of HVAC Systems and Load Calculations

- Principles and methodology of HVAC system design
- Design criteria for comfort air-conditioning and industrial HVAC applications
- Heating and cooling load estimation techniques
- Sensible and latent heat load calculations
- Heat gain and heat loss through the building envelope
- Selection and sizing of HVAC equipment: chillers, boilers, air-handling units (AHUs), fan coil units (FCUs), VRF/VRV systems, cooling towers, pumps, and fans
- Duct design principles and air distribution system layout
- Piping design for chilled water, hot water, condenser water, and refrigerant systems
- Principles of energy-efficient and sustainable HVAC system design
- Indoor air quality (IAQ) requirements and ventilation rate calculations
- Clean room HVAC design concepts, ISO cleanliness classification, and Eurovent/AHRI referenced calculation methods

Suggested Books:

- W.F. Stoecker and J.W. Jones, *Refrigeration and Air Conditioning*, 2nd Ed., McGraw-Hill
- McQuiston, Parker, and Spitler, *Heating, Ventilating, and Air Conditioning: Analysis and Design*, 7th Ed., Wiley
- Carrier Air Conditioning Company, *Handbook of Air Conditioning*

System Design, 9th Ed.

- ASHRAE Handbook – Fundamentals, 2022 Edition, ASHRAE, Atlanta
- ASHRAE Handbook – HVAC Systems and Equipment, 2022 Edition, ASHRAE, Atlanta
- Roy J. Dossat and Thomas J. Horan, *Principles of Refrigeration*, Pearson Education
- K.G. Dales, *Cleanroom Design: ISO 14644 Standards*, Eurovent and AHRI Applications, Elsevier, 2019

iv. Instrumentation & Measurement in HVAC & Refrigeration

- Importance of measurement in HVAC and refrigeration applications
- Measurement of temperature, pressure, flow, humidity, and velocity
- Sensors and instruments used in HVAC&R systems
- Calibration, accuracy, and error analysis
- Monitoring of system performance and energy consumption
- Data logging and basic monitoring systems in HVAC installations

Suggested Books:

- E. O. Doebelin, *Measurement Systems: Application and Design*, McGraw-Hill
- J. P. Holman, *Experimental Methods for Engineers*, McGraw-Hill
- R. S. Figliola and D. E. Beasley, *Theory and Design for Mechanical Measurements*, John Wiley
- ASHRAE Handbook – Fundamentals

7. Automotive Engineering

i. Vehicle Dynamics and Chassis Engineering

- Vehicle structure types (Ladder frame, Monocoque, Space frame) and components (Chassis frame, cross members, pillars, panels)
- Load analysis on structures (Static and dynamic loads, impact loads, fatigue)
- Suspension systems (Solid axle, independent, MacPherson strut) and components (Leaf springs, coil springs, torsion bars, dampers)
- Braking systems (Mechanical, Hydraulic, Pneumatic) and components (Lever, Disc, Drum, Pads, Brake fluids)
- Steering systems (Worm & wheel, rack & pinion, power steering) and components (Steering wheel, column, gears, linkages)
- Vehicle Ride and handling dynamics (Longitudinal, lateral, and vertical dynamics)
- Tire types, construction, specifications and road interaction (forces, wear and rolling resistance)
- Wheel balancing and alignment angles (Camber, Caster, steering axis angle, Toe-in and out)

- Single and multi-degree of freedom vibration systems, Damping and vibration control, NVH
- Vehicle handling, stability, and control systems (ABS, TCS, ESP)

Suggested Books:

- G. Genta, The Automotive Chassis Volume 1: Components Design, Springer, 2009
- G. Genta, The Automotive Chassis Volume 2: System Design, Springer, 2018
- Thomas D. Gillespie, Fundamentals of Vehicle Dynamics, SAE
- Reza N. Jazar, Vehicle Dynamics: Theory and Applications, Springer
- James Halderman, Automotive Technology: Principles, Diagnosis and Service, 2011
- Rao, "Mechanical Vibrations", Pearson, 2016.
- Julian Happian-Smith, "Modern Vehicle Dynamics", Butterworth Heinemann, 2002.

ii. Automotive Powertrain and Propulsion

- Combustion processes in Spark Ignition (SI) and Compression Ignition (CI) engines, combustion chamber design (including Stratified Charge and Lean Burns), and the phenomenon of knocking and auto-ignition
- Combustion characteristics (Air fuel ratio, Auto-ignition, Knocking)
- Fuel Injection in SI & CI engines (Octane and Cetane numbers)
- Engine performance and testing: Performance and Emissions: Volumetric efficiency, pumping losses, scavenging, and engine valve timing diagrams;
- Pollution and Emission Control: Emission control and pollution definitions.
- Driveline (FF, FR, MR, 4WD, AWD) and components (gears, differentials, drive shafts, Universal joints)
- Manual and Automatic transaxle and transmissions (Clutch, gear box, CVT, DCT)
- Introduction to Fuel Cells (types and applications), Stirling engines, hybrid power plants, downsizing, hybridization, and EV propulsion.

Suggested Books:

- John B. Heywood, Internal Combustion Engine Fundamentals, McGraw-Hill
- R.K. Rajput, Internal Combustion Engines, Laxmi Publications
- James Larminie, "Electric Vehicle Technology Explained", John Wiley & Sons, 2012
- Mehrdad Ehsani, "Modern Electric, Hybrid Electric and Fuel Cell Vehicles
- J.D. Halderman, "Automotive Technology", Prentice Hall, 2005

iii. Automotive Thermal and Fluid Systems

- Engine cooling and lubrication systems: components of cooling and lubrication systems, cooling circuits, use of thermostat, Coolant properties, Lubrication systems, Lubricant properties.
- HVAC and refrigeration systems: Vapor Compression Refrigeration systems, psychrometric analysis, cabin heating/cooling load calculations, engine cooling systems, waste heat recovery systems, and battery thermal

management for hybrid/electric vehicles (using air, liquid, refrigeration, phase change materials).

- Aerodynamics and fluid flow analysis: External fluid flow, Impact of aerodynamics on vehicle shape, aerodynamic forces, Lift and Drag force calculations, Interpreting CFD results.

Suggested Books:

- Dincer, H. S. Hamut, N. Javani, "Thermal Management of Electric Vehicle Battery Systems", John Wiley, 2017
- G.D Mathur, "Vehicle thermal Management", SAE, 2004
- C. P Arora, "Refrigeration and Air conditioning", McGraw-Hill, 2000
- Munson, "Fundamentals of Fluid Mechanics", John Wiley, 2014
- J. Katz, "Automotive Aerodynamics", Wiley, 2016
- J.D. Halderman, "Automotive Technology", Prentice Hall, 2005

iv. Automotive Electronics and Instrumentation

- Microcontroller and Programming: Internal architecture, data types, programming instructions, timer operation, interrupts.
- Sensors and actuators: Basic electronic instrumentations, digital multi-meters, analyzers, Transducers (resistive, capacitive, inductive), automotive sensors.
- Engine management and control systems: ECU, EFI, EGR.
- Vehicle communication and diagnostics (OBD): Diagnostic process, fault codes, engine system diagnostics (fuel, ignition, emissions), chassis system diagnostics (brakes, ABS, suspension), and electrical system diagnostics.

Suggested Books:

- William B. Ribbens, "Understanding Automotive Electronics-Engineering Perspective", Elsevier, 2012.
- Tom Denton, "Automobile Electrical and Electronics", Routledge, 2007
- Nicolas Navet, "Automotive Embedded Systems Handbook", CRC Press, 2017.
- J.D. Halderman, "Automotive Technology", Prentice Hall, 2005

v. Automotive Manufacturing, Materials and Quality Control

- Manufacturing processes: Sheet metal forming, sheet metal dies, plastic injection molding technology, molds, jigs and fixtures.
- Automotive materials and body structures: Body types, Body structure, Body materials, Body finishing, Material selection, automotive glasses, automotive seals, Crashworthiness.
- Statistical Process Control (SPC): Control charts, process capability indices, acceptance sampling, introduction to Six-Sigma and DMAIC.
- Japanese Production System: Principles of Takt-time, Quality circle, Kanban, 5S, Poka-yoke, and 3M (Mura, Muri, Muda).
- Total Quality Management (TQM): Tools like Pareto, Cause & Effect Diagram, Failure Mode & Effect Analysis (FMEA), Lean concepts, PDCA Cycle, KAIZEN.

Suggested Books:

- William D. Callister, Jr., Materials Science and Engineering An Introduction, John Wiley & Sons, Inc., HOBOKEN, USA, 2019.
- J. Happian-Smith, "Introduction to Modern Vehicle Design", SAE, 2002
- Dale H Besterfield, "Total Quality Management: International Edition", Pearson, 2015
- Douglas C Montgomery, "Introduction to Statistical Quality Control", Wiley, 2009.
- Amitava Mitra, "Fundamentals of Quality Control and Improvement", Wiley, 2016.
- M. P. Groover, "Fundamental of Modern Manufacturing: Materials, Processes and Systems", John Wiley & Sons, 2020.
- M. A. Omar, "The Automotive Body Manufacturing Systems and Processes", John Wiley & Sons, 2011.