PAKISTAN ENGINEERING COUNCIL

Syllabus for Engineering Practice Examination (EPE)
Aeronautical Engineering
(Aerospace and Avionics only)

Total Marks: 60

SECTION-A / BREADTH

This section will generally conform to latest (updated) B.E./equivalent qualification of Aeronautical Engineering. The examination of this section shall comprise 25 MCQs (total 25 marks).

1. MATHEMATICS, PROBABILITY & STATISTICS 30%

(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:

- Thomas' Calculus by George B. Thomas, Jr., Maurice D. Weir, Joel R. Hass, Pearson, USA, 2014/ Latest Edition.
- Introductory Linear Algebra: By Bernard Kolman and David R. Hill, Latest Edition.
- Kreyszig, Erwin. Advanced Engineering Mathematics. Wiley, 2011/Latest Edition.
- Probability and Statistics for Engineers and Scientists, by Antony Hayter.
- Numerical methods for scientists and engineers by R.W. Hamming, Latest Edition.

2. INTRODUCTION TO AEROSPACE ENGINEERING 40%

(i) Fundamental elements of aerodynamics
(ii) Basics of airfoils and wings
(iii) Concept of performance, stability, and control of airplane
(iv) Various aircraft propulsion systems
(v) Aircraft structures
(vi) Avionics

Suggested Books:

- John D. Anderson, 'Introduction to Flight', 8th Edition, McGraw-Hill Education, 2016 / Latest Edition.
- John D. Anderson, 'Fundamentals of Aerodynamics', 6th Edition, McGrawHill Education, 2016 / Latest Edition.
- Dave Newman, 'Interactive Aerospace Engineering and Design', McGrawHill Education, 2002

3. ENGINEERING MECHANICS - STATICS 10%

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

Suggested Books:

- Engineering Mechanics: Statics by J L Meriam & L.G. Kraige, John Wiley & Sons, Latest Edition
- Engineering Mechanics: Statics by Russell C. Hibbeler, Pearson, Latest Edition
- Engineering Mechanics by Irving H Shames, Latest edition.

4. ENGINEERING MECHANICS - DYNAMICS 10%

(i) Introduction to dynamics
(ii) Kinematics of Particles: rectilinear motion, plane curvilinear motion, rectangular coordinates, normal and tangential coordinates polar coordinates
(iii) 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
(iv) Plane Kinematics of Rigid Bodies: angular motion relation, absolute motion, relative velocity, instantaneous centre of zero velocity, relative acceleration
(v) 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:

- Engineering Mechanics (Dynamics) by J L Meriam & L G Kraige, Wiley, Latest Edition.
- Engineering Mechanics (Dynamics) by R C Hibbeler, John Wiley, 2016/ Latest Edition.
- Engineering Mechanics by Higdon and Stiles, Latest Edition

5. ELECTRIC CIRCUITS AND MACHINES 10%

(i) Basics of electrical parameters and their units
(ii) Impedance, admittance and transient
(iii) Phasor notation in the solution of AC circuits
(iv) Circuit laws, network theorems
(v) Resonance
(vi) Power and energy
(vii) DC machines (DC generator and DC motor), alternator, transformer etc.

Suggested Books:

- Charles K. Alexander, Matthew Sadiku, Fundamentals of Electric Circuit, McGraw-Hill, Latest Edition
- Stephen J. Chapman, Electric Machinery Fundamentals, McGraw-Hill, Latest Edition
- William H. Hayt, Jack Kammerly, Jamie Phillips, Steven M. Durbin Engineering Circuit Analysis, McGraw-Hill, Latest Edition
- Rosenblatt and Friedman, Direct & Alternating Current Machinery (2ndEdition), 1990.

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. AEROSPACE ENGINEERING

1. 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

2. 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

3. 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.

4. 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 Matingly 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, 7^{th} Edition

- Solid Rocket Propulsion Technology, Alain Davenas
- Space Propulsion Analysis and Design; Humble, Hennry and Larson
- Rocket Propulsion, M. Barrere.

5. 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.

2. AVIONICS ENGINEERING

i. Navigation, Guidance and Control

- Navigation basics
- Navigation technology used by moving platforms
- Automatic direction finder (ADF)
- VHF omni-directional range (VOR)
- Distance measuring equipment (DME)
- Tactical air navigation (TACAN)
- Long range navigation systems (LORAN), Area Navigation
- Global positioning system (GPS)
- Inertial navigation system (INS)
- Flight-deck audio systems
- Air traffic control (ATC) systems
- Traffic alert and collision avoidance systems (TACAS)
- Guidance basics
- Types of guidance sensors
- Missile guidance and homing radar

ii. Radar Systems Engineering

- Radar basics, Radar equation, radar cross-section and radar frequencies
- Pulse repetition frequency, staggered PRFs and radar blind speeds
- Radar range resolution and tracking in range
- Delay line cancellers**,** T/R switch, duplexer and diplexer
- Effects of noise, weather, sea and land backscatter on radar performance
- Radar antennas: parameters, parabolic reflector, scanning feed, Radomes
- Moving Target Indicator (MTI), Pulse Doppler, CW and FM radar
- Synthetic aperture and over-the-horizon (OTH) radar
- Air surveillance radars and weather radar
- Tracking radars: mono-pulse, sequential lobing, conical scan radars
- Track-while-scan (TWS) radar
- Airborne and multimode radars

iii. Aerodynamics and Aerospace Propulsion

- Basic aerodynamics: Lift, drag and thrust, load factor
- Airfoils, wings, and other aerodynamic shapes
- Special lift and drag control surfaces
- Elements of airplane performance
- Elements of aircraft structure
- Principles of stability and control
- Principles of helicopter flight
- Supersonic flight
- Propulsion: propeller
- Jet propulsion – The thrust equation
- Turbo jet engine, Turbo-fan engine, Ram jet engine, rocket engine
- Turbo-engine components: compressor, turbine and exhaust nozzle
- Rocket propulsion and propellants

- Nozzle design and rocket performance

iv. Flight Control Systems

- Conventional flight control systems
- Servomechanisms and automatic control fundamentals
- Sensing of attitude changes
- Synchros and instrumentation
- Conventional and radar altimeters, gyroscopes, electronic compass, accelerometer
- Command signal detection and processing
- Outer loop control
- Autopilot and flight director system
- Fly-by-wire (FBW) control systems
- Instrumental landing system (ILS), Microwave landing system (MLS)
- Ground controlled approach (GCA) radar

v. Avionics System Design

- Importance and role of avionics
- Avionics architecture
- Displays and man-machine interaction
- Air data and Air data systems
- Flight management systems (FMS)
- Multi-sensor fusion: inertial, GPS, doppler, stellar and barometer inputs
- Avionics interfaces: data buses, crew displays, power, maintenance, physical interfaces
- Avionics systems integration: data bus systems, integrated modular avionics
- Commercial off-the-shelf (COTS) avionics
- Unmanned air vehicle (UAV) avionics

Suggested Books:

- Cary R. Spitzer, "*The Avionics Handbook*", December 2000, CRC Press, ISBN: 0-8493-8348-X.
- Mike Tooley and David Wyatt, "*Aircraft Communication & Navigation Systems*", First Edition, 2007, Elsevier, ISBN: 978-0-750681377.
- R. P. G. Collinson, "*Introduction to Avionics Systems*", Second Edition, 2003, Kluwer Academic Publishers, ISBN: 1-4020-7278-3.
- Ian Moir & Allan Seabridge, "*Military Avionics Systems*", First Edition, 2006, John Wiley & Sons, Inc., ISBN: 0-470-01632-9.
- Merrill I. Skolnik, "*Introduction to Radar Systems*", Third Edition, 2001, Tata McGraw-Hill, ISBN: 0-07-044533-8.
- John D. Anderson Jr., "*Introduction to Flight*", Fifth Edition, 2005, McGraw-Hill Higher Education, ISBN: 0-07-383569-3.
- E. H. J. Pallet and S. Coyle, "*Automatic Flight Control*", Fourth Edition, 2006, Blackwell Publishing, ISBN: 0-632-03495-5.
- P. D. Hill and C. R. Peterson, "*Mechanics & Thermodynamics of Propulsion*", Second Edition, 1991, Prentice Hall, ISBN: 978- 0201028386.