PAKISTAN ENGINEERING COUNCIL

Syllabus for Engineering Practice Examination (EPE)

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

1. Mathematics 10%

a. Calculus and Analytical Geometry

i. Functions Limit and Continuity
ii. Differentiation
iii. Applications of Derivatives
iv. Applications of Integration
v. Infinite Sequence and Series

Suggested Books:

i. George B. Thomas, Jr., Maurice D. Weir, Joel R. Hass, Thomas' Calculus, Pearson, USA.
ii. Earl W. Swokowski, Michael Olinick, Dennis Pence, Calculus

b. Multivariate Calculus and Transform

i. Geometry of Space
ii. Vector-Valued Functions and Motion in Space:
iii. Partial Differentiation
iv. Applications of Partial Derivatives:
v. Vectors in 3-D Space

Suggested Books:

i. Erwin Kreyszig, Advanced Engineering Mathematics, Latest Edition
ii. George B. Thomas, Jr., Maurice D. Weir, Joel R. Hass, Thomas' Calculus, Pearson, USA.
iii. Earl W. Swokowski, Michael Olinick, Dennis Pence, Calculus
iv. George B. Thomas, Jr., Ross L. Finney, Calculus and Analytic Geometry.

c. Linear Algebra

i. Matrices
ii. System of Linear Equations and Applications
iii. Vector Spaces and Transformations
iv. Eigenvalues and Eigen Vectors

Suggested Books:

i. Bernard Kolman, David R. Hill, Introductory Linear Algebra, Latest Edition.
ii. Howard Anton, Chris Rorres, Elementary Linear Algebra, Latest Edition.

d. Differential Equations

i. Basic Concepts and Modelling
ii. Analytical Methods of Solution for First-order ODEs
iii. Mathematical Models Based on Second-order ODEs
iv. Analytical Methods of Solution for Second-order ODE

Suggested Books:

i. Erwin Kreyszig, Advanced Engineering Mathematics, Latest Edition
ii. D. G. Zill, M. R. Cullen, Differential Equation with Boundary Value Problems, Brooks/Cole Publishers, Latest Edition.
iii. D. G. Zill, A First Course on Differential Equations with Modelling Applications, Brooks/Cole Publishers, Latest Edition.

2. Electrical/Electronics and Instrumentation 30%

a. Electric Circuit Analysis

i. Basic Circuit Elements
ii. Ohm's law
iii. KCL and KVL
iv. Series and Parallel Circuits
v. Node and Mesh Analysis
vi. Inductive and Capacitive circuits, concepts of circuit reactance and impedance

Suggested Books:

i. Sergio Franco, Fundamentals of Electric Circuits, Oxford English Press,Latest Edition.

b. Electronic Circuits Design

i. Circuit modelling in s-domain, pole and zeros
ii. BJTs and MOSFETs
iii. Differential and Multistage Amplifiers
iv. Active Filters

v. Ideal linear op-amp circuits
vi. inverting amplifier, non-inverting amplifier, summing amplifier, instrumentation amplifier

Suggested Books:

i. A. S. Sedra, K. C. Smith, Microelectronics Circuits, Oxford University Press, Latest Edition.
ii. Millman, Grabel, Microelectronics, McGraw Hill, Latest Edition.

c. Instrumentation and Measurements

i. Measurements terminologies including resolution, sensitivity, accuracy, and uncertainty, engineering units and standards.
ii. Principles of different measurement techniques
iii. Sensors for measurement of temperature; Thermocouples, RTDs, Thermistors
iv. Sensors for displacement and position; digital encoders, shaft encoders, absolute and relative encoders, linear encoders
v. Sensors for force, pressure, strain, vibration, velocity, flow rates etc.
vi. Signal conditioning and filter design
vii. Types of bridge circuits for measurement of resistance, inductance, and capacitance
viii. Analog to digital conversion
ix. Systems for signal processing and signal transmission
x. Data recording and data acquisition systems
xi. Techniques to select different sensors, sensor calibration

Suggested Books:

i. Klaas B. Klaassen and Steve Gee “Electronic Measurement and Instrumentation”, Cambridge University Press, ISBN: 0521477298.
ii. William C. Dunn,Fundamentals of Industrial Instrumentation and Process Control, McGraw Hill, ISBN: 0071457356 / 9780071457354
iii. Kevin James, Newness “PC Interfacing and Data Acquisition Techniques for Measurements, Instrumentation and Control”, Newness, ISBN: 0750646241.

3. Computing and Embedded Systems 30%

a. Digital Logic Design

i. Numbering systems, conversions, and logic gates
ii. Combinational Logic Circuits and Devices
iii. Sequential Logic Circuits and Devices

Suggested Books:

i. M. Morris Mano, ***Digital Logic and Computer Design*** , Prentice Hall, Latest Edition

b. Computer Programming

i. Data, Data types, Data representation, Identifiers, Reserved words, Variables and constants
ii. Arithmetic and logical Operators
iii. If and If/else statements and conditional expressions

iv. Switch statements
v. Loops
vi. Arrays
vii. Pointers

Suggested Books:

i. Deitel and Deitel, C++ How to program , Prentice hall, Latest Edition, ISBN: 0-13-185757-6.

c. Data Structures and Object Oriented Programming

i. Introduction to Data Structures and Object Oriented Programming
ii. Recursion
iii. Trees
iv. Sorting and Searching
v. Classes
vi. Objects
vii. Data Types
viii. Access Specifiers
ix. Data Members
x. Member functions
xi. Constructors and Destructors

Suggested Books:

i. Mark Allen Weiss, “Data Structures and Problem Solving Using C++”, Addison Wesley, Latest Edition.
ii. Dietel and Deitel, “C++ How to Program”, Latest Edition. (10th Edition)

d. Microcontroller and Embedded Systems

i. Introduction to Microprocessors and Microcontrollers
ii. Architecture of a modern microcontroller
iii. Programming languages; Assembly and C
iv. Concepts of timers, interrupts, RS-232, I2C, SPI etc

Suggested Books:

i. Muhammad Ali Mazidi, 8051 Microcontroller and Embedded Systems, Prentice Hall, Latest edition
ii. Dr. David A. Patterson and Dr. Paul Hennessey, Computer Architecture, A Quantitative approach , Latest edition
iii. Muhammad Ali Mazidi, AVR Microcontroller and Embedded Systems using Assembly and C, Prentice Hall, Latest edition.

4. Mechanics and Design 30%

a. Engineering Statics

i. Force System
ii. Equilibrium
iii. Structures
iv. Friction

Suggested Books:

i. R.C. Hibbler, Engineering Mechanics (Vol. 1) , Latest Edition.

b. Engineering Dynamics

i. Kinematics of Particles
ii. Kinetics of Particles

Plane Kinematics and Kinetics of Rigid Bodies **Suggested Books:**

i. R. C. Hibbeler, Engineering Mechanics Dynamics, Pearson, Latest Edition.

c. Mechanics of Material

i. Concepts of stress and strain
ii. Axial loading
iii. Torsion
iv. Pure bending
v. Shear Force and Bending Moment Diagrams
vi. Beams under transverse loading
vii. Transformation of stress and strain, biaxial stress
viii. Mohr's Circle

Suggested Books:

i. E. P. Popov, Mechanics of Materials, Prentice Hall Inc., Latest Edition
ii. F. P. Beer, E. R. Johnson, Mechanics of Materials, Latest Edition.
iii. J. Alexander, Strength of Materials, Latest Edition.
iv. Strength of Materials by James by M. Gere and Barry Goodno, Latest Edition.

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.

1. MECHATRONICS ENGINEERING

i. Power Electronics and Devices

- Devices Used in Power Electronics: power diode, power BJT, power MOSFET, SCR, GTO, IGBT, TRIAC, DIAC, Op-Amps, and voltage regulators
- Rectifiers and Thyristors: half-wave, full-wave, and bridge rectifiers with RL load, performance parameters of rectifiers, model of thyrist,r; turn-on and turn-off techniques
- DC-to-DC Converters: step-down operation with RL load, step-up converter with RL load, converter classifications
- PWM Inverters: principle of operation, performance parameters, single-phase bridge inverter, three-phase inverter, voltage control of three-phase inverter, advanced modulation techniques
- Static Switches: single-phase and three-phase AC switches, DC switches, solid-state relays.

Suggested Books:

- Muhammad H. Rashid, “Power Electronics”, Latest Ed.
- Floyd, “Electronic Devices”, Latest Ed.
- Robert Boylestad, “Electronic Devices and Circuit theory”, Latest Ed.

ii. Control Systems

- Dynamic Models: Transfer functions of electrical, mechanical, and electromechanical systems, heat and fluid flow models, basic properties of feedback control systems
- Feedback Control System Characteristics: open-loop and closed- loop systems, sensitivity to parameter variation, control of transient response, disturbance signals, steady-state errors, cost of feedback
- Performance Of Feedback Control Systems: test signals, performance of second order systems, damping ratio estimation, s- plane, steady-state errors, linear system simplification, routh-hurwitz stability criterion, stability of state variable systems, root locus method, parameter design by root locus method, PID controllers
- Frequency-Response Methods: bode plots, performance specifications, log magnitude and phase diagrams
- Stability in Frequency Domain: nyquist criterion, system bandwidth, stability of control systems with time delays, PID controllers in frequency domain

- Design of Feedback Control Systems: approaches, cascade compensation networks, phase lead design, phase lag design, system design using analytical and computer methods.

Suggested Books:

- R. T. Stefani, C. J. Savant, B. Shahian, G. H. Hostetter, Design of Feedback Control Systems, OUP, USA, Latest Edition
- Richard C.Dorf and Robert H. Bishop, **"**Modern Control System", Latest Ed.
- F. Golnaraghi, Benjamin C. Kuo, Automatic Control Systems, John Wiley & Sons, Latest Edition

iii. Robotics

- Overview of Robots: robot types, configurations, industrial applications of robots
- Robot Kinematics and Dynamics: transformations, forward and reverse kinematics, robot dynamics, trajectory generation
- Robot Control and Sensing System: robot vision, robot programming and interfacing, gripper design and applications, mechanism design, robot configurations
- Trends in Robotics: rehabilitation robotics, behavior-based robotics, bio-mimetic design of robots
- Robot Programming Languages and Systems: three levels of robot programming, requirements of robot programming language.

Suggested Books:

- Philip McKerrow, "Introduction to Robotics", 1st Ed. Addison-Wesley Longman Publishing Co., Inc. Boston, USA ©1991, ISBN:0201182408
- O. Khatib, K. Kolarov, Introduction to Robotics, Latest edition
- John J. Craig, "Introduction to Robotics", Latest Ed., Adept Technology, Inc. ISBN: 0201543613

iv. Machine Vision

- Cameras: CCD sensors, CMOS sensors, color cameras, sensor sizes, camera performance
- Camera-Computer Interface: Analog Video Signal, Digital Video Signal, Camera Link, IEEE 1394, USB2.0
- Image and Image Geometry: sampling and quantization, perspective projection, coordinate systems
- Image Filtering: linear filters, median filter, gaussian filters, discrete gaussian filter
- Edge Detection: gradient, first derivative based edge detection operators
- Image Segmentation: segmentation by thresholding
- Feature Extraction: gray value features
- Object Measurement: size measurement, shape analysis, texture analysis
- Camera Calibration: coordinate systems, rigid body transformation, intrinsic

and extrinsic parameters, simple method for camera calibration
- Object Recognition: system components, complexity of object recognition, feature detection, classification, matching.

Suggested Books:

- Bruce G. Bachelor and Paul F. Whelan, "Intelligent Vision Systems for Industry" Latest Edition.
- Gonzalez, Woods and Eddins, "Digital Image Processing using Matlab" Pearson Ed, Latest Edition.
- Ramesh jain,Rangachar Kasturi and Brain G. Schunck, "Machine Vision" McGraw-Hill Companies,Inc., Latest Edition.

v. Actuating Systems

- Electrical Actuation Systems: electrical systems, mechanical switches, solid-state switches, solenoids, DC motors, AC motors, stepper motors
- Mechanical Actuation Systems: mechanical systems, types of motion, kinematics chains, cams, geartrains, ratchet and pawl, belt and chain drives, bearings, mechanical aspects of motor selection
- Pneumatic and Hydraulic Actuation Systems: pneumatic and hydraulic systems, directional control valves, pressure control valves, cylinders, process control valves, rotary actuators.

Suggested Books:

- Stephen J. Chapman, Electric Machinery Fundamentals, Latest Edition.
- Fritzgerald, Charles Kingsley, Umans, Electric Machinery, Latest Edition.
- W. Bolton, Pneumatics and Hydraulic Systems, Butterworth Heinemann Ltd., Latest Edition.
- G. Prede D. Scholz, "Electro-pneumatics: Basic Level", 2010.
- Robert H. Bishop, "Mechatronics Hand Book", 2nd Ed.

vi. Modeling and Simulation

- Modeling of Mechanical Systems: springs, dampers, mass, rotational and translational systems, geared systems, levered systems
- Modeling of Electrical Systems: capacitor, inductor, resistor, analog electronic devices, operational amplifiers, summers, comparators, integrators and analog computing
- Modeling of Hydraulic and Pneumatic Systems: hydraulic inertance, capacitance, introduction to discrete event systems, difference equations, z transform and sampling, introduction to s-plane and z- plane, transfer function, characteristic equation, poles, zeros, stable and unstable regions in s and z planes, modeling of event operated systems, state equation describing relation between multi input and output in digital systems
- Simulation of Modeled System: impulse, step, ramp and periodic inputs and disturbance signal in s and z planes.

Suggested Books:

- Robert L. Woods and Kent L. Lawrence, Modelling and Simulation of Dynamics Systems, Prentice-Hall, Latest Ed.

- 2. Charles M. Close, Dean K. Frederick, Jonathan C. Newell, Modelling and Analysis of Dynamic Systems, Latest Edition.
- 4. Devendra K. Chaturvedi, Modelling and Simulation of Systems Using MATLAB and Simulink, Latest Edition
- W. Bolton, "Pneumatic and Hydraulic Systems", 2nd Ed.

vii. Mechatronics and System Design

- Introduction: mechatronics and its components, fields covered by mechatronics, applications of mechatronics, mechatronics system design approach
- Sensors: sensor criteria, sensor performance parameters, types of sensors (for example, displacement, proximity, pressure, light, force)
- Signal Conditioning: necessary condition to implement, various types of signal conditioning (for example, filters, amplifiers, ADC, DAC, noise removal)
- Actuators: pneumatic actuators, hydraulic actuators, electromechanical actuators, types of electric motors (DC, stepper, and servos)
- Motion Control: effect of vibration on a system, data acquisition and control system
- Communication: communication (LPT), serial communication (RS232, RS422)

Suggested Books:

- David Alciatore, Introduction to Mechatronics and Measurement Systems, Latest edition.
- Devdas Shetty, Richard Kolk, Mechatronics System Design, Brooks/ Cole CENGAGE Learning, Latest edition.
- R. K. Rajput, A Textbook of Mechatronics, S. Chand & Company Ltd., Latest edition.
- Robert H. Bishop, "Mechatronics Hand Book", 2nd Ed.

viii. Design of Machines

- Machine design concepts: Introduction to Static loading, Factors of safety, Stress concentration factor
- Failure Theories, Failure of Ductile/Brittle Materials
- Introduction to fatigue loading, S-N Diagram and loading, Stress concentration effect on fatigue failure
- Fluctuating loading, Combined loading
- Machine parts loading and design considerations

Suggested Books:

Joseph Edward Shigley, Mechanical Engineering Design, McGraw Hill, Latest Edition.