

PAKISTAN ENGINEERING COUNCIL
Syllabus for Engineering Practice Examination (EPE)
Electrical Engineering and Allied Disciplines
(Biomedical 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 Biomedical Engineering. The examination of this section shall comprise **25 MCQs** (total 25 marks). This main focus of the breadth area is knowledge-based skills from engineering foundation, breadth courses and their applications and general understanding and practices of Biomedical Engineering.

1. Mathematics **20%**

- i. Calculus and Analytical Geometry
- ii. Linear Algebra & Differential Equations
- iii. Numerical Methods in BME
- iv. Probability & Statistics

Suggested Books

- i. Advanced Engineering Mathematics, 10th Edition, Erwin Kreyszig, ISBN: 978-1-119-57109-4 July 2019
- ii. Mathematical Methods, S. M. Yusuf, Abdul Majeed, Muhammad Amin, Ilmi Kitab Khana, 2000.

2. Engineering Foundation **40%**

- i. Basic Electrical Engineering
- ii. Physiology-I & II
- iii. Biophysics
- iv. Human Anatomy
- v. Digital Logic Design
- vi. Circuit Analysis

Suggested Books

- i. Basic Engineering Circuit Analysis, 12th Edition, J. David Irwin, R. Mark Nelms, ISBN: 978-1-119-50201-2 August 2020.
- ii. Circuit Analysis, ISBN10: 1264149913 | ISBN13: 9781264149919 by William Hayt, Jack Kemmerly, Jamie Phillips and Steven Durbin.

- iii. Guyton and Hall Textbook of Medical Physiology (Guyton Physiology) 14th Edition by John E. Hall PhD (Author), Michael E. Hall MD MSc. (Author).
- iv. Sybesma, Christiaan, Biophysics : An Introduction, Published by Springer Netherlands, December 2012, ISBN 978-9-40-092239-6
- v. Clinical Anatomy By Regions., by Richard S. Snell, ISBN: 978-8189836962, Lippincott; 8th edition

3. Biomedical Instrumentation & Electronics 40%

- i. Biomedical Instrumentation
- ii. Signals & Systems
- iii. Digital Image Processing
- iv. Medical Imaging
- v. General Engineering Practices & Knowledge of Field

Suggested Books

- i. Electronic Principles 8th Edition, by Albert Malvino (Author), ISBN 978-0073373881, McGraw Hill, 2015
- ii. David Bates (Author) Susan J. Hall, Basic Bio-Mechanics, 5th Ed, 2007.
- iii. Signals and Systems 2nd Edition by Alan Oppenheim, Alan Willsky, S. Nawab 978-0138147570, Pearson, 1996
- iv. Digital Image Processing, Rafael Gonzalez, Richard Woods, 4th Edition, 2017 ISBN: 978-0133356724, Pearson
- v. Fundamentals of Medical Imaging 3rd Edition by Paul Suetens (Author) by Paul Suetens (Author), ISBN 978-1107159785, Cambridge University Press

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. BIO-INSTRUMENTATION (I &II)

1. Instrumentation Fundamentals e.g. Precision, Resolution etc.
2. Physiological Parameters
3. Cardiovascular Measurements
4. Biomedical Sensors & Transducers
5. Patient Monitoring and Therapeutic Equipment
6. X-ray imaging, Ultrasound, CT Scan, MRI, PET imaging
7. Safety in Medical Equipment
8. Clinical Biochemistry Instrumentation (analytical, diagnostic, and biochemical instruments used in medical labs)
9. Quality Assurance and Quality Control

Recommended Books:

- i. John G. Webster, Medical Instrumentation: Application and Design, 4th Ed, 2009.
- ii. Bengt Nolting, Methods in Modern Physics
- iii. I.D. Campbell & Ragmod A. Dwel, Biological Spectroscopy. The Benjamin Publications.
- iv. Ramrit Sood, Medical Laboratory Technology: Methods and Interpretations, 2003, Jaypee Brothers, New Delhi.
- v. Leslie Cromwell, Fred J. Weiball and Erich, A. Pleiffer, Biomedical Instrumentation and Measurements, Prentice Hall , India
- vi. Joseph, J. Carr, John, M. Brown, Introduction to Biomedical Equipment Technology, Prentice Hall Career & Technology.
- vii. Mary C. Haven (Editor), et al, Laboratory Instrumentation
- viii. James W. Dally, William, Instrumentation For Engineering Measurements-2nd Ed
- ix. Cromwell, Bio-Medical Instrumentation & Measures 2nd ed.
- x. Walter Welhowitz, Sid Deutsch and Metin Alsey, Biomedical Instruments: Theory & Design, Academic Press, Inc.
- xi. R.S. Khandpur, Handbook of Biomedical Instrumentation, Tata McGraw Hill Publishing Co.
- xii. Hauptmarn, P., Sensors Principles and Applications Prentice Hall.
- xiii. Donald L. Wise, Bioinstrumentation and Biosensors
- xiv. Richard Normann, Principles of Bioinstrumentation

2. BIOMECHANICS

1. Biomechanics Fundamentals
2. Biomechanical Dynamics (motion analysis, vibration/SHM, degrees of freedom, and their applications in the human body and biomedical machines)
3. Biofluid Mechanics (fluid mechanics concepts and their application to synovial joint lubrication and biological systems)
4. Musculoskeletal Biomechanic (Cardiac Mechanics and Modeling, Muscle Mechanics, Gait Kinetics)
5. Human Motion Analysis (dynamometry, joint angles, range of motion, and volumetric measurements of body segments)
6. Human Motion Mechanics (stress analysis, center of gravity, and motion analysis in human movement)
7. Study of myoelectric activity using Electromyograph
8. 3D Motion Analysis (human modeling, joint articulation, and gait/stance analysis using Visual 3D)
9. Study of blood flow using blood vessel models

Recommended Books:

- i. Susan J. Hall, Basic Bio-Mechanics, 5th Ed, 2007.
- ii. Schnech Bronzino, Bio-Mechanics Principles and Application, 2008
- iii. J.L. Meriam & L.G. Kraige, Engineering Mechanics, 6th ed, 2006.
- iv. Pal, Subrata, Text book of Biomechanics, 2009
- v. Peterson, Donald.R, Biomechanics principles & applications, 2008
- vi. Asif Mahmood Mughal, Analytical Biomechanics – Modeling & Optimal Control, 2009
- vii. Margareta Nordin, Victor H Frankel, Basic Biomechanics of the Musculoskeletal System
- viii. Peter M. McGinnis, Biomechanics of Sport and Exercise; Hardcover
- ix. Nihat Özkaya, et al, Fundamentals of Biomechanics: Equilibrium, Motion, and Deformation
- x. David A. Winter, Biomechanics and Motor Control of Human Movement
- xi. Frans Bosch, Ronald Klomp, Running: Biomechanics and Exercise Physiology in Practice
- xii. Y.C. Fung, Biomechanics: Motion, Flow, Stress, and Growth
- xiii. Edward C. Benzel, Biomechanics of Spine Stabilization (Book with CD-ROM).
- xiv. Graham E. Caldwell, et al, Research Methods in Biomechanics

3. BIOMEDICAL MODELING & SIMULATION

1. Concept of modeling in Biomedical Engineering and realization of models in simulation systems
2. Queuing theory (examples, why queues form and waiting lines)
3. Digital simulation and mathematical modeling
4. Time-oriented and event-driven processes
5. Physiological System Modeling (modeling of cardiorespiratory, circulatory, respiratory systems, and physiological control systems)
6. Applications of Modeling in Liver, Heart, and Lungs
7. Simulation of first and higher order models
8. Motion: Electrical analogy of steady Flow, Newton law of viscosity, Laminar flow and Viscosity of Blood, general form of equation of motion
9. Human Modeling: Techniques for Physiological system, Autoregressive modeling, EMG and Its spectral analysis and mean power frequency

Recommended Books

- i. Asif Mahmood Mughal, "Real Time Modeling, Simulation and Control of Dynamical Systems", ISBN 978-3-319-33905-4, Springer International Publishing Switzerland, 2016.
- ii. Willem van Meurs, Modeling and Simulation in Biomedical Engineering, 2011
- iii. Moon, Todd K., Mathematical Methods & Algorithms Signal Processing (With Cd)
- iv. Frank C. Hoppensteadt, Charles S. Peskin, Modeling and Simulation in Medicine and the Life Sciences
Hartmut Bossel, Modeling and Simulation
- v. Bernard P. Zeigler, et al, Theory of Modeling and Simulation
- vi. Stanislaw Raczynski, Modeling and Simulation: The Computer Science of Illusion (RSP Bird)
- vii. D. C. Karnopp, R. Rosenberg & Margolis, Systems Dynamics-Introduction to Mechatronics Systems, 2006.

4. BIOMEDICAL CONTROL SYSTEMS

1. Modeling of Human Systems: Formation of differential equations of electrical, mechanical, electromechanical and other systems.
2. Transient Response Analysis: Poles and zeros of a transfer function, stability, standardized inputs, steady state and transient response of first order, second order and higher order systems.
3. Modeling and analysis of systems using state and output equations, solutions, eigenvalues, and state-transition matrices

4. Steady State Response: Types and analysis of feedback control systems based on steady state error coefficients, sensitivity function
5. Time Domain Analysis: Root locus diagrams, Analysis and Design of Control Systems Based on Root locus technique
6. Frequency Domain Analysis: Routh Herwitz Stability criterion, Bode plots, Polar plots, Nyquist stability criterion, Gain and phase margins, Nichol's chart
7. Application of principles of control theory, analysis of biological system development and computer simulation techniques to study dynamic response of physiological system.
8. Use of Sensors/Transducers
 - Position and Speed Control of DC Motors
 - Temperature Control
 - Time Domain and Frequency Domain Response using MATLAB

Recommended Books:

- i. Asif Mahmood Mughal, "Real Time Modeling, Simulation and Control of Dynamical Systems", ISBN 978-3-319-33905-4, Springer International Publishing Switzerland, 2016.
- ii. Charles S. Lessard, Basic feedback control in biomedicine, 2009
- iii. K. Ogatta, Modern Control Engineering, Prentice Hall.
- iv. Stefni, Savant Shahan and Hosteller, Design of Feedback Control System, Oxford University Press.
- v. Richard C. Dorf, Modern Control System
- vi. Zhou, Essentials of Robust Control- 1st –Ed
- vii. W.E. Snyder, Industrial Robots-Computer interface and Control, Prentice-Hall.
- viii. Malcolm, Robotics- an Introduction, Breton publishers.
- ix. Design of Feedback Control System, Stefni, Savant Shahan and Hosteller, Oxford University Press.
- x. Asif Mahmood Mughal, Analytical Biomechanics – Modeling & Optimal Control, 2009