## Ph.D. Entrance Test Syllabus for Ph.D. in Engineering and Technology

The PET (Ph.D. Entrance Test) for Ph.D. in Engineering and Technology consists of two parts:

- Part I: Research Methodology (50 marks) and
- Part II: Subject Specific (Related to the branch for 50 marks)

**Total Marks for Ph.D. Entrance Test is 100 Marks**

***The Syllabus for Research Methodology is common to all branches of Engineering and Technology***

### SYLLABUS

### PartI: Research Methodology (50 Marks)

1. **Introduction to Research and Research Problem**
   Meaning of Research, Types of Research, Objectives of Research, Research and Scientific Method, Sources of Research Problem, Criteria/ Characteristics of a Good Research Problem, Errors in Selecting a Research Problem, Scope, and Objectives of Research Problem, Defining a Research Problem (Real Life Example or Case Study), Formulation of Research Hypotheses, Qualities of a Good Hypothesis.

2. **Research Design and Literature Review: Research Design**
   Concept and Importance in Research, Features of A Good Research Design, Research Designs - Experimental & Analytical Research Designs (Informal and Formal), Literature Survey- Definition of Literature and Survey, Need of Literature Survey, Objectives of Literature Survey, Sources of Literature Review. Critical Literature Review–Identifying Gap Areas from Literature Review and Strategies of Literature Survey, Errors in Research.

3. **Data Collection, Measuring, Sampling And Scaling:**
   Classification of Data, Benefits and Drawbacks of Data, Evaluation of Data, Qualitative Methods of Data Collection, Types Of Data Analysis, Sampling, Sample Size, Sample Design- Concept of Probability Sampling and Non- Probability Sampling, Attitude, Measurement and Scaling, Types of Measurements, Criteria of Good Measurements, Classification of Scales.

4. **Data Analysis**
   Testing of Hypothesis and Goodness of Fit: Definition of Null and Alternative Hypothesis, Students 'T' Distribution, Chi-Square Distribution, F-Test, Analysis of Variance Techniques, Introduction to Non-Parametric Tests. Regression Analysis – Simple Linear Regression, Multiple Linear Regression, Correlation and Regression Analysis. Introduction to Factor Analysis, Discriminant Analysis, Cluster Analysis, Multidimensional Scaling, Multidimensional Measurement and Factor Analysis.

5. **Report, Research Proposal and Funding Agency:**
   Need of Effective Documentation, Types of Reports and Their Format. Essentials of a Research Proposal. Different Funding Agencies for Research. Research Briefing, Presentation Styles, Elements of Effective Presentation, Writing of Research Paper, Presenting and Publishing Paper, Patent Procedure, Ethical Issues.

**Reference Books:**


- Dr. C. R. Kothari, Research Methodology: Methods and Trends, New Age International Publishers, 3rd Edition, 2014.
- Ranjit Kumar, Research Methodology: A Step by Step Guide for Beginners, SAGE Publications Ltd., 2014.
- Wayne Goddard and Stuart Melvill, Research Methodology: An Introduction, Juta and Company Ltd. 2004.


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The syllabus for each of Branch (Subject Specific) is given below:

- Ph.D. in Civil Engineering
- Ph.D. in Computer Engineering and Technology
- Ph.D. in Electronics and Communication Engineering
- Ph.D. in Mechanical Engineering
- Ph.D. in Petroleum Engineering
- Ph.D. in Polymer Engineering
- Ph.D. in Chemical Engineering
- Ph.D. in Bioengineering

# Ph.D. in Bioengineering

### Part II: Subject Specific Syllabus (50 Marks)

The subject specific Ph.D. entrance examination of Ph.D. in Bioengineering will be based on fundamental concepts and applications in the following major areas:

1. **Engineering Mathematics`**
    - Linear Algebra: matrices, determinants, linear equations, Eigen values and eigenvectors.
    - Calculus: single variable, limits, continuity and differentiability, partial derivatives, total derivative, maxima and minima, gradient.
    - Differential Equations: first order equations (linear and nonlinear), higher order linear differential equations with constant coefficients, Laplace transforms
    - Numerical methods: numerical solutions of linear and non-linear algebraic equations. Integration by trapezoidal and Simpson's rule.
    - Probability and statistics: Random variables. Probability distributions: Normal, Exponential, Poisson and Binomial distributions. Mean, median, mode and standard deviation. Conditional probability and Bayes theorem, regression and correlation analysis, t-test, ANOVA.

2. **Biochemistry**
    - Biomolecules: structure, function and regulation of proteins, nucleic acids, carbohydrates and lipids.
    - Biological membranes: structure, membrane channels and pumps, molecular motors, action potential and transport processes, Photosynthesis, respiration and electron transport chain.
    - Enzymes: classification, catalytic and regulatory enzyme; enzyme kinetics and enzyme inhibition; Buffers and pH, Biothermodynamics

3. **Cell and Molecular Biology**
    - Prokaryotic and eukaryotic cells; Cell cycle and cell growth; cellular communication; cell signalling and signal transduction; Regulation of gene expression; Replication, transcription, post-transcriptional changes, splicing, translation, Post-translational modifications
    - Non-coding and micro RNA; RNA interference; DNA damage and repair; Protein trafficking; Cell death and autophagy; Biofilms and extra-cellular matrix.
    - Genes and chromosomes; Mendelian inheritance; Gene interaction; Complementation; Linkage, recombination and chromosome mapping; Chromosomal variation; Genetic disorders; Population genetics; Selection and inheritance; Genetic drift; speciation, mutations.

4. **Genetic Engineering**
    - Enzymes and vectors in genetic engineering, cloning, cDNA and genomic libraries, screening and detection methods for clones. Recombinant DNA technology, Restriction and modification enzymes; Vectors - plasmids, cosmids, bacteriophage and other viral vectors, Expression vectors; Gene isolation and cloning, strategies for production of recombinant proteins.
    - Immune System: Innate and acquired immunity; polyclonal, monoclonal antibodies and immunological techniques; Antibody structure and function; T cell and B cell development; Autoimmunity; basics of Immunization and vaccines.
    - Technologies: DNA fingerprinting; Gene transfer technologies; CART-cells, CRISPR/CAS, artificial cells and applications, Gene therapy and regulatory aspects.

5. **Animal and Microbial Biotechnology**
    - Mammalian Cell Culture: techniques, application, maintenance; cell separation, media composition and growth conditions; animal cell and tissue preservation; Kinetics of cell growth; Stem cell technology; cloning. Current trends in tissue culture and applications in pharmaceutical and allied fields.
    - Microbes: Bacterial classification, microbial ecology, microbial growth, kinetics and nutrition; Nitrogen fixation, Microbial diseases and antimicrobial resistance, Basic microbiology techniques; Screening strategies for new microbes and products.
    - Production of biomass and primary/secondary metabolites - Biofuels, industrial enzymes, Large-scale production and purification of recombinant proteins and metabolites; Bio-pesticides and Bio-fertilizers; Clinical-, food- and industrial- microbiology; Viruses - structure and classification and viral vaccines.

6. **Bioprocess Engineering**
   - Bioreaction engineering: Ideal reactors - batch, mixed flow and plug flow; Enzyme and cell immobilization, Kinetics of cell growth, substrate utilization and product formation; Structured and unstructured models; Batch, fed-batch and continuous processes; Microbial and enzyme reactors; Optimization and scale up.
   - Upstream and Downstream Processing: Media formulation, pre-treatment and optimization; Sterilization of air and media; Filtration - membrane filtration, ultra-filtration; Centrifugation - high speed and ultra; Cell disruption, hydrophobic interaction, adsorption and drying.

7. **Bioanalytical and biomolecular techniques**
   - Spectroscopic techniques: principles, instrumentation and applications of UV-Visible Spectroscopy, FTIR Spectroscopy, NMR Spectroscopy: Mass Spectroscopy
   - Chromatographic techniques: principles, instrumentation and applications of GC, HPLC, Ion-Exchange Chromatography, Gel Filtration and affinity chromatography
   - Electrophoresis; Micro-arrays; Enzyme assays; ELISA; immunoblotting; Flow cytometry.
   - Molecular tools**:** PCR; DNA/RNA sequencing; SDS-PAGE, Southern, northern and western blotting

8. **Computational Biology**
   - Bioinformatics overview and applications.
   - Biological databases and tools
   - Sequence analysis - sequence file formats, alignment, phylogeny;
   - Structural analysis – PDB, Protein folding and visualizations tools
   - Computational genomics and proteomics: Gene prediction; Functional annotation; Structureprediction.

9. **Biomedical Engineering**
   - Basics of Electrical Circuits: V-I characteristics, Kirchoff's laws, Thevenin, Norton, maximum power transfer theorem.
   - Analog and Digital Electronics: Characteristics and applications of semiconductor devices and operational amplifiers, Number systems, Boolean algebra; combinational logic circuits: arithmetic circuits; Microprocessor and Microcontrollers: Architecture, interfacing memory, input-output devices.
   - Human Anatomy and Physiology- types of tissues and organ systems; Homeostasis; Body fluids, Basics of organ systems: cardiovascular, nervous, respiratory, urinary, endocrine, digestive, reproductive and lymphatic. Applications in biomechanics, biomaterials, nanotechnology, biomedical devices and drug-discovery.
   - Bioinstrumentation: Biosensors, Origin of bio potentials and their measurement, imaging devices: X-Ray, Computed Tomography, Magnetic Resonance Imaging, and Ultrasound. Measurements and Control Systems: SI units, systematic and random errors in measurement, accuracy and precision index.

**Reference Books:**


- D.C. Montgomery and G.C. Runger. Applied Statistics and Probability for Engineers, 5$^{th}$ edition, John Wiley and sons, New York.
- D. C. Lay. Linear Algebra and its Applications (3$^{rd}$ edition), Pearson, 2006.
- Biochemistry, D. Voet, J. Voet, Willey, 4$^{th}$ edition, 2010.
- Nelson and Cox (2017). Lehninger Principles of Biochemistry, 7$^{th}$ edition, W.H. Freeman and Company.
- Wilson K. and Walker. J. (2018). Principles and Techniques of Biochemistry and Molecular Biology, 8$^{th}$ edition, Publisher: Cambridge University Press.
- Cooper, G.M. (2000). The Cell: A Molecular Approach (2$^{nd}$ edition), Sunderland (MA): ASM Press.
- Brown TA. (2023) Genomes 5. CEC Press.
- Michael L.Shuler, Fikret Kargi, Bioprocess Engineering- Basic concepts 2$^{nd}$ ed., PHI Learning Pvt. Ltd.
- Gregory N. Stephanopoulos, Aristos A. Aristidou, Jens Nielsen, "Metabolic Engineering: Principles and Methodologies", Academic Press 1998.
- Mustafa Ozilgen, Esra Sorguven, Biothermodynamics principles and applications, CRC Press, 2017.
- Bioreactor Design and Product Yield- Biotol Series
- Casida Jr, L. E., "Industrial Microbiology", Wiley, 1968.

- Stanbury, P.F., A. Whitaker and S.J. Hall "Principles of Fermentation Technology", 2nd Edition, Butterworth – Heinemann (an imprint of Elsevier), 1995.
- Genes XI, 11th edition (2012), Benjamin Lewin, Publisher - Jones and Barlett Inc. USA
- From Genes to Genomes, 2nd edition, (2008), J. Dale and M. Schantz, John Wiley & Son Ltd. USA.
- Friedman T. 1999. The Development of Human Gene Therapy. Cold Spring Harbor,NY: Cold Spring Harbor Lab.Press.
- Bioinformatics - sequence and genome analysis (2$^{nd}$ ed.) by David W. Mount, CSHL Press 2004.
- Arthur M. Lesk, Introduction to Bioinformatics by Oxford University Press, 2008
- Khandpur R.S, Handbook of Biomedical Instrumentation, Tata McGraw-Hill, 2003.
- Guyton and Hall, Medical Physiology
- Michael M Domach, Introduction to Biomedical Engineering
- JB Gupta, Electronic Devices and Circuits