Guidelines for PhD Entrance Examination 2018

1. Entrance exam will be divided into two parts : Part I and Part II.

2. Part-I is intended to test the basic mathematics knowledge of students and will be used for screening purpose. Part-I will consist of objective (multiple choice) type mathematics questions and the list of topics are given in the **syllabus** below.

3.Part-I will be compulsory for all candidates except the candidates appearing for Arts, Humanities, and Social Sciences.

4.Time duration to answer part I is 1 hour.

5. Part-II will comprise of questions from any one of the five sections viz. A. Mathematics, B. Physics C. Computer Science and Information Technology, D. Electronics, E. Communication and Signal Processing. List of topics and suggested readings for each section are provided in the **syllabus**.

6. Students are required to answer questions from **only one** (out of five) section of her/his choice. Part-II is intended to test the fundamental knowledge, analytical skills and problem solving abilities of the student in that particular section/ subject-area of choice.

7. Time duration to answer part II is 2 hours.

Syllabus

Part-I: Compulsory Mathematics Section

Basics of the following topics:

- Sets, Relations and Functions
- Complex Numbers
- Permutations, Combinations and Binomial Theorem
- Statistics and Probability
- Matrices and Determinants
- Vectors
- Sequence and Series
- Limits, Derivatives and integrals
- Mathematical Reasoning

Reference material:
http://ncert.nic.in/textbook/textbook.htm (Select class XI, XII and Select subject Mathematics)
http://ncert.nic.in/textbook/textbook.htm?kemh1=0-16
http://ncert.nic.in/textbook/textbook.htm?lemh1=0-6
http://ncert.nic.in/textbook/textbook.htm?lemh2=0-6

Part-II: Electronics

Basic Electronics:
Time and frequency domain analysis of simple RLC circuits; Thevenin's and Norton's theorems; Maximum Power Transfer; Simple Diode Circuits, Clipping, Clamping, Rectifiers.

Basic Transistor Circuits:
Amplifiers: Single-and Multi-stage, Differential and Operational; Amplifier Building Blocks; Frequency response of amplifiers.

Field Effect Transistors:
JFET and MOSFET Characteristics; Biasing and Bias Stability of Transistor and FET amplifiers.

Feedback and Operational Amplifiers:
Simple Op-amp circuits; Simple filters and Active Filters; Sinusoidal oscillators and Criterion for Oscillation; Single-transistor Op-amp configurations.

Digital Electronics:
Basic Logic Concepts; TTL and CMOS; Combinational Logic; Sequential Logic and Finite State Machine Design; Monostable Multivibrators.

Recommended books :

1. Engineering Circuit Analysis by Hayt, Kemmerly &Durbin
2. Basic Electrical and Electronics Engineering by M.S. Sukhija, T.K. Nagsarkar OxfordPress
3. Microelectronic Circuits by Adel S. Sedra and Kenneth C. Smith, Oxford University Press
4. Digital design by M. Morris Mano and Michael Ciletti
5. Low Power Design Essentials Jan Rabaey, Springer

Part-II: Communication Systems

Analog Modulation and Digital Communication
AM, FM and PM, Sampling, quantization, PCM, companding and delta modulation, Basics of Digital Modulation Schemes like ASK, FSK, PSK, QAM.

Signals and Systems
Introduction of signals and systems (ranging from their types, properties and different examples). Linear time-invariant (LTI) systems and their representation with the help of convolution sum or integral (which can be used to model many real physical systems). Fourier analysis ranging from Fourier series, Fourier transform, time and frequency characterization of signals and systems (e.g. Fourier transform phase and concept of group delay), Shannon's sampling theory, Laplace and Z-transform, basics of linear algebra (linear independence of vectors, Eigen value decomposition, overdetermined and undetermined nature of linear system of equations).

Digital Signal Processing
Discrete-time LTI systems, convolution sum, Discrete-Time Fourier Transform (DTFT) and its properties, Discrete Fourier Transform (DFT), Fast Fourier Transform (FFT), Z-transform, Sampling and Quantization, Design of FIR filters (concept of linear phase, zero locations of FIR filters, etc) and design of IIR Filters (impulse invariant vs.bilinear transformation, Butterworth and Chebyshev filters), Digital Filter Structures.

Electromagnetic Theory
Electrostatic Fields, Electric Fields in Material Space, Electrostatic Boundary Value Problems, Magnetostatic Fields, Magnetic Forces, Time Varying Field &Maxwell's Equations, Propagation of EM Waves, Plane Waves, Wave Impedance, EM Wave Equation, EM Energy and Power Flow, Poynting Theorem, Waveguides, Coaxial cable, Antennas and Radiating Systems. Single and Multi-port Networks, S-Parameters and Scattering Matrix, Transmission Line, Reflection coefficient, Standing Wave Ratio, Impedance matching.

Statistics
Probability space, basics of random variables, characterization of random variables like PDF, CDF, moments and characteristic functions.

Suggested Books:

1. An Introduction to signals and noise in electrical communication by A. Bruce Carlson and Paul B Crilly, Fifthedition, McGraw Hill
2. Modern Analog and Digital Communication Systems by B. P. Lathi and Zhi Ding, Fourthedition, Oxford UniversityPress.
3. Alan V. Oppenheim and R. W. Schafer, Discrete-time Signal Processing. Third Edition. Prentice Hall, 2009.
4. Jordan, Edward C. & Balmain, Keith G., "ElectromagneticWaves and RadiatingSystems", Prentice Hall of India, New Delhi, 2003.
5. Hayt, William H. & Buck, John A., "Engineering Electromagnetics", Sixth Edition, TataMcGraw-Hill, New Delhi, 2001.
6. Alan V. Oppenheim, Alan S. Wilsky, and D. Hamid, Signals and Systems. Second Edition, Prentice Hall, 1996.
7. Introduction to LinearAlgebra by Gilbert Strang, Fourthedition, Wellesley-Cambridge Press.
8. Probability, Random Variables and StochasticProcesses by A. Papoulis and U. Pillai, McGraw Hill. (lecture slides are availableat www.mhhe.com/papoulis).

Part-II: Computer Science and IT

Algorithms
Basic Data Structures such as Stacks, Queues, Priority Queues, Heaps, Trees, Hash Tables, and Dictionaries; sorting and searching; data structures for graphs; shortest path algorithms; basic algorithm
Design paradigms such as Greedy, Divide and Conquer Method.

Theory of Computation
Regular languages, finite state automaton, regular expressions, pumping lemma, and properties of Regular languages; context free languages, pushdown automaton, pumping lemma, and properties of context free languages.

Database Management System
Basic Concepts of Database and DBMS, Data Abstraction, Data Independence, Database Modeling, E-R Model, Relational Model, Integrity Constraints, relational algebra, SQL Queries, Database Design, Functional Dependencies and Normalization, Data Storage and Indexing

Computer Networks
ISO/OSI protocol stack. LAN technologies, Basic concepts of hubs, switches, gateways, and routers. Flow and error control techniques. MAC protocols. Routing algorithms. Congestion control. IP, TCP/UDP and ICMP protocols. Application layer protocols (dns, smtp, pop, ftp, http).

Operating systems
Process concept and management, scheduling, process synchronization, concurrency control, critical section problems, deadlocks, memory management, file systems.

Suggested Books:

1. Introduction to Algorithms by Cormen, Leiserson, Rivest
2. Introduction to Theory of Computation by Michael Sipser
3. Silberschatz, Korth&Sudarshan, “Database System Concepts,” McGraw-Hill
4. Kurose and Ross, Computer Networking, A Top Down Approach, Pearson

A. Silberschatz, P. B. Galvin, G. Gagne, Operating System Concepts John Wiley& Sons, Inc.

Part-II: Mathematics

Calculus--Functions of single and two variables: limit, continuity, differentiability, mean value theorems, Theorems of integral calculus, improper integrals, partial derivatives, total derivatives, maxima and minima, double and triple integrals. Sequences and series of real numbers: tests for convergence, power series, Linear and non-linear 1storderordinarydifferentialequation, higher order linear differential equation with constant coefficients, system of linear differential equations, initial and boundary value problems.

Complex Variables—Analytic functions, Cauchy-Riemann equations, line integral, Cauchy's integral theorem and integral formula, Taylor's and Laurent's series, residue theorem and its applications.

Discrete Mathematics—Propositional logic, first order logic, relations, permutations, combinations, pigeonhole principle, principle of inclusion-exclusion, generating functions, graph isomorphism, spanning trees, graph connectivity, graph colouring.

Abstract Algebra and Linear Algebra--Groups: basic definitions and rules, subgroups, cyclic groups, Lagrange's theorem and its applications. System of linear equations, Determinants, inverse, rank, Eigenvalues and eigenvectors, diagonalisation of matrices, Cayley-Hamilton theorem.

Probability and Statistics—Probability space, conditional probability, random variables, binomial, Poisson, geometric, uniform, exponential and normal probability distributions, estimation, correlation and linear regression.

Suggested Books:

1. G. Strang, Linear Algebra and its Applications, Cengage.
2. J.B. Conway, Functions of One Complex Variable I & II, Graduate Texts in Mathematics, Springer.
3. J.B. Fraleigh, A First Course in Abstract Algebra, Pearson.
4. K.H. Rosen, DiscreteMathematics and its Applications withCombinatorics and Graph Theory, Edition, Tata Mcgraw Hill Education, 2011.
5. M.D. Weir, J. Hass, and F.R. Giordano: G.B. Thomas' Calculus, 11th Edition, Pearson, 2011.
6. R. Kreyszig: Advanced Engineering Mathematics, 8th Edition, John Wiley, 1999.
7. S. Ross: A First Course in Probability, 8th Edition, Pearson, 2010.

Part-II: Physics

Classical Mechanics:
Newton's laws of motion and applications, Simple Harmonic Oscillator, Kepler's laws, Gravitational Law and field, Conservative and non-conservative forces. System of particles, Centre of mass, equation of motion of the CM, conservation of linear and angular momentum, conservation of energy. Elastic and inelastic collisions. Rigid body motion, fixed axis rotations, moments of Inertia. Lagrange's and Hamilton's formalisms.

Electromagnetic Theory:
Coulomb's law, Gauss's law, Field and Boundary Conditions, Laplace equation, Conductors, capacitors, dielectrics, dielectric polarization, volume and surface charges, electrostatic energy. Biot-Savart law, Ampere's law, Lenz's law, Faraday's law of electromagnetic induction, Displacement current, Maxwell's equations and plane electromagnetic waves.Lorentz Force and motion of charged particles in electric and magnetic fields.

Thermodynamics and Statistical Physics
Laws of thermodynamics; Thermodynamic potentials, Maxwell relations; Chemical potential, phase equilibria; macrostates and microstates; Microcanonical Canonical and grand Canonical ensembles; phase space; probability ensembles; partition function, free energy, calculation of thermodynamic quantities; classical and quantum statistics; degenerate Fermi gas; black body radiation and Planck's distribution law.

Quantum Mechanics:
Mass energy equivalence, Blackbody radiation, photoelectric effect, Compton effect, Bohr's atomic model, X-rays. Wave-particle duality, Uncertainty principle, Schrodinger equation and application to simple examples like particle in a box, potential barrier, square potential, harmonic oscillator, hydrogen atom.

Nuclear Physics
Structure of atomic nucleus, mass and binding energy. Radioactivity and its applications. Laws of radioactive decay. Nuclear fission, Nuclear Fusion, Nuclear Fusion in stars.

Mathematical Physics:
Cartesian system of base vectors: orthogonal basis, position vector. Vector differentiation: derivative of a vector, del operator, Gradient and its concept, Divergence, Curl.
Integration of Vectors: line integral, conservative forces, Gauss' divergence theorem, Expression in plane polar coordinate, cylindrical coordinates, spherical polar coordinates.

Suggested reading:

1. An Introduction to Mechanics by Daniel Kleppner, Robert Kolenkow.
2. Introduction to Electrodynamics by D. J. Griffiths.
3. Concepts of Modern Physics by Arthur Beiser.
4. Schaum's Outlines.
5. Daniel Schroeder, An Introduction to Thermal Physics
6. Classical Dynamics, Thornton and Marion

Other than books recommended above, candidates can refer to their own study materials to prepare for the entrance exam.