

Ph.D Preliminary Qualifying Examination
Syllabus - Paper I : Research Methodology in Physics
(w.e.f. 2011 Admission)

1. Research Methodology of Science: Areas of Science, Philosophy of science, Characteristics of Research, Types of research, Research process; Methodology: Topic selection, Hypothesis, Designing experiment, Analysis, Results, Models; Critical thinking and Science: Strategies and common fallacies. (12 hours)
Text Book: The Scientific Endeavor -Methodology and Perspectives of Sciences- Jeffrey A.Lee, Pearson India (2010)
2. Numerical differentiation and integration: Numerical differentiation, General numerical formula for integration (SB), Trapezoidal formula, Simpsons rules, Gauss quadrature formula (SB), Monte Carlo method of integration, Example: finding the value of π (SS, SB & NR), Numerical method for evaluation of indefinite integrals, Eigen value problems. (12 hours)
Text Books: i) Introductory Methods of Numerical Analysis- S.S. Sastry (SS), PHI
ii) Numerical Mathematical Analysis- J.B.Scarborough (SB), Oxford & IBH
3. Numerical solution of differential equations: Ordinary Differential Equations: Eulers formula and its modification, Runge-Kutta methods, Predictor-Corrector methods, boundary value problems. Solving higher order ODEs by splitting into first order coupled and non-coupled ODEs. (12 hours)
Text Books: i) Introductory Methods of Numerical Analysis- S.S. Sastry (SS), PHI ii) Numerical Mathematical Analysis- J.B.Scarborough (SB), Oxford & IBH
4. Data reduction and error analysis: The presentation of physical quantities with their inaccuracies, significant figures, Errors: classification and propagation, Probability distributions, Processing of experimental data, Graphical handling of data with errors, Fitting functions to data. (12 hours)
Text Books: i) A Students Guide to Data and Error Analysis, Hernan J C Berendsen, (Cambridge).
ii) An Intrdoduction to Error Analysis, J R Taylor, (University Science Books).
iii) Data reduction and error analysis for the physical sciences, P Bevington, (McGraw-Hill Science).
5. Manuscript writing and Document Preparation: Scientific writing: Structure and components of research paper, types of reports, research papers, thesis, research project reports, citations, impact factor, Latex, TeX, different styles for science journals, Plotting programs, gnuplot. (12 hours)

Text Books : i) *How to write and Publish: Robert A Day and Barbara Gastel (Cambridge 2006)*
ii) *The Craft of Scientific Writing: Michael Alley (Springer 1996).*
iii) *LaTeX A Document Preparation System 2e, Lamport, (AW,1994)*
iv) <http://www.gnuplot.org>

(Model Question Paper)

Reg. No.:.....

Name :.....

Ph.D COURSE WORK EXAMINATION
Physics
PAPER I - RESEARCH METHODOLOGY IN PHYSICS

Time: Three Hours

Maximum 70 Marks.

Section A

Answer all questions.

(Each question carries 3 Marks).

1. Distinguish between basic and applied research.
2. Write a short note on Trapezoidal rule.
3. Write a short note on different methods for solving ordinary differential equations.
4. Distinguish between accuracy and precision.
5. What are dependent variables and independent variables in an experiment.
6. Write the following equation using latex.

$$E = \frac{2GM}{a^2} \frac{1}{r^2} - \frac{1}{\sqrt{r^2 + a^2}}$$

(6 × 3 = 18 marks)

Section B

Answer any two questions.

(Each question carries 14 Marks.)

7. Explain scientific methodology of research by elaborating on hypothesis, design of experiment and analysis of results.
8. Write down the Normal distribution, and obtain expression for mean and standard deviation. What is the significance of 3σ ?
9. Write briefly on the various methods of research in science.
10. Write an essay on Gauss quadrature formula for numerical integration
(2 × 14 = 28 marks)

Section C

Answer any three questions.

(Each question carries 8 marks)

11. Compute the value of π from the numerical integration with minimum intervals using Simpsons 1/3 and 3/8 rules and find the percentage error in each case.

$$\int_0^1 \frac{1}{1+x^2} dx = \frac{\pi}{4}$$

12. Check whether the following hypothesis are valid or invalid. Give your reasons. (a) Paracetamol tablets cures head aches faster than externally applied balms. (b) Force of attraction between two opposite charges is proportional to the product of their charges and decreases exponentially with distance. (c) If the gravitational force of attraction is varied by cube of the distance between the masses, earth around sun would be in a different orbit.
13. Solve the differential equation $\frac{dy}{dx} = -y$ with condition $y(0) = 1$, for $y(0.02)$ with $h = 0.01$ using Euler's and modified Euler's methods and find the error in each case. The exact solution is $y = e^{-x}$.
14. To find the velocity of a cart on a horizontal air track, a student measures the distance d it travels and the time taken t as $d = 5.10 \pm 0.01m$ and $t = 6.02 \pm 0.02s$. (a) What is his result for $v = d/t$, with its uncertainty? (b) If he measures the cart's mass as $m = 0.711 \pm 0.002kg$, what would be his answer for the momentum $p = mv = mdv/dt$? (Assume all errors are random and independent).
15. Use the method of least squares to find the line $y = A + Bx$ that best fits the four points $(-3, 3), (-1, 4), (1, 8)$ and $(3, 9)$. ($3 \times 8 = 24$ marks)