INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI

Department of Physics

Course Structure and Syllabus of Ph.D Programme

(Effective from July 2009)

Semester I (July-November)

Code	Name	L	T	P	C
PH701	Classical Mechanics	2	2	0	8
PH703	Quantum Mechanics	2	2	0	8
PH705	Computer Programming and Numerical Method	2	1	2	8

Semester II (Jan-April)

Code	Name	L	T	P	C
PH702	Electrodynamics	2	2	0	8
PH704	Statistical Mechanics	2	2	0	8
PHXXX	Elective*				

* from the list of Available elective courses for MSc/ BTech (final semester)/ open elective.

PH 701 Classical Mechanics (2-2-0-8)

Review of point-particle mechanics, lagrangian mechanics of point particles and rigid bodies, Legendre transformations, Hamiltonian description, conservation laws, Poisson brackets, perturbation theory in classical mechanics. Classical theory of real and complex scalar fields. Noether's theorem. Symmetries and conserved currents. Lagrangian description of classical fluids. Navier Stokes Equation. Energy momentum tensor. Hamiltonian and Lagrangian description of the electromagnetic field. Gauge invariance. Lagrangian description of general relativity.

Texts/References

1. Classical Mechanics (3rd Edition) by Herbert Goldstein, Charles P. Poole, and John L. Safko, Addison Wesley Longman (2001)
2. Course of Theoretical Physics : Mechanics(Paperback) by L. D. Landau, Butterworth-Heinemann (2003)
3. Course of Theoretical Physics : The Classical Theory of Fields(Paperback), Vol.2, 4th Edn. by L. D. Landau and E.M. Lifshitz, Butterworth-Heinemann (2000)
4. Course of Theoretical Physics : Fluid Mechanics(Paperback), vol.6, 2nd Edn. by L. D. Landau and E.M. Lifshitz, Butterworth-Heinemann (2000)

PH 703 Quantum Mechanics: (2-2-0-8)

Basic Postulates and Mathematical Tools. particles in different one dimensional potential, Harmonic Oscillator, spin and orbital angular momentum, Commutation Relations, Hydrogen Atom, time independent and time dependent perturbation theory, Interaction of Atoms with Electromagnetic Radiation, L-S Coupling, J-J Coupling, line width and transition probability, fine and hyperfine structure, Zeeman's and stark effect, Clebsch-Gordon Coefficients, Pauli Matrices, Scattering Theory, The Quantum Theory of Radiation. Relativistic Quantum Mechanics of Spin ½ particles.

Texts/References:

1. R. Shankar, Principles of Quantum Mechanics, Springer; 2nd edition (September 1, 1994)
2. J. J. Sakurai, Quantum Mechanics, Pearson Education (2002).
3. J.J. Sakurai, Advanced Quantum Mechanics, Pearson Education (2002).
4. Claude Cohen-Tannoudji, Bernard Diu and Frank Laloe, Quantum Mechanics, Wiley-Interscience (October 6, 2006)

PH705 Computer Programming and Numerical Method: (2-1-2-8)

Errors and Uncertainties in Computations: Types of Errors, Errors in Algorithms. Approximation of a function: Theory of Curve Fitting, Cubic Spline Method, Fitting of

Exponential Decay, Probability Theory, Linear and Nonlinear Least Squares Fitting, Goodness of Fit. Numerical methods for matrices: Jacobi Transformation of a Symmetric Matrix, The Power Method, The QR Method and Matrix computing with usage of Standard Scientific Libraries. Numerical calculus: Romberg Integration, Gaussian Quadratures and Orthogonal Polynomials, Central Difference Differentiation, Extrapolated Difference Differentiation. Ordinary differential equations: Runge-Kutta Method, Adaptive Stepsize Control for Runge-Kutta Method, Richardson Extrapolation and the Bulirsch-Stoer Method. Partial differential equations: Finite Difference method, Polynomial Expansions Method, Split Step Exponential Methods. Monte Carlo simulations: Sampling and integration, The Metropolis Algorithm, Applications in Statistical Physics, Variational Quantum Monte Carlo Simulations. Introduction to Parallel programming: Overview, Architecture Taxonomy, Memory Architecture, Parallel Programming Paradigms, Steps for creating a parallel programme, Parallel examples,

Texts/References:

1. R. H. Landau, M. J. Paez and C. C. Bordeianu, *Computational Physics: Problem Solving with Computer*, Wiley Vch Verlag Gmbh & Co. KGaA (2007).
2. W. H. Press, S. A. Teukolsky, W. T. Verlling and B. P. Flannery, *Numerical Recipes in C,* Cambridge (1998).
3. Tao Pang, An Introduction to Computational Physics, Cambridge University Press (2006).
4. Peter Pacheco, *Parallel Programming with MPI,* Morgan Kaufmann; 1st edition (October 15, 1996)

PH 702 Electrodynamics (2 2 0 8)

Review of electrostatics: Differential form of Gauss's law, continuous charge distributions, scalar potential.
Review of magnetostatics: Biot-Savert's Law, Ampere's law, vector potential, magnetic field, moments, force, torque and energy of localized current distributions.
Boundary value problems: Solution of Laplace's and Poisson's equations, multipole expansion and Green's function approach.
Maxwell's equations and electromagnetic waves: Vector and scalar potentials, gauge transformations, Poynting's theorem. Wave propagation in dielectric and conducting media, wave guide
Radiation: Lienard-Wiechert potential, accelerated charges, radiation from an oscillating electric dipole fields and Bremsstrahlung, radiation.
Scattering and diffraction: Scattering at long wavelengths, perturbation theory, Rayleigh scattering, scalar diffraction theory, Kirchhoff's integral and applications.

Special theory of relativity: Lorentz Transformations and it's consequences, conservation laws, mass energy relation, relativistic momentum and energy, relativistic force.

Relativistic electrodynamics: Covariant formalism of Maxwell’s equations, transformation laws.

Texts/References:

1. J. D. Jackson,Classical Electrodynamics, John Wiley (1999).
2. L. D. Landau and E. M. Lifshitz, Electrodynamics of Continuous Media, Butterworth (1995).
3. G. S. Smith, Classical Electromagnetic Radiation, Cambridge (1997).
4. D. J. Griffiths, Introduction to Electrodynamics, Prentice-Hall (1999).
5. J. R. Reitz and F. J. Millford, Foundation of Electromagnetic Theory, Narosa (1986).

PH 704 Statistical Mechanics: (2-2-0-8)

Microstates and Macrostates, Ensemble theory, Ergodic hypothesis, Liouville's theorem, Microcanonical, Canonical and Grand Canonical ensembles, Partition function and its applications, Equipartition and Virial theorems, Quantum Statistics, Density matrix and its applications, ideal quantum gas, MB, FD and BE statistics, BE condensation, cold atoms, Fermi gas in metals, white dwarf stars, superconductivity, Transport phenomena, Diffusion, Boltzmann transport equation, interacting systems, Ising model, Ginzburg-Landau equations.

Texts/References

1. R.K. Pathria, Statistical Mechanics, Butterworth-Heinemann, 2nd Ed. (1996)
2. S.R.A. Salinas, Introduction to Statistical Physics, Springer New York(2001)
3. K. Huang, Statistical Mechanics, John Wiley Asia (2000)
4. M. Plishke and B. Bergersen, Equilibrium Statistical Mechanics,World Scientific, 2nd Ed. (1994)
5. D. Chandler, Introduction to Modern Statistical Mechanics, Oxford University Press (1987)