School of Pure & Applied Physics

M Phil Syllabus

Theoretical Methods in Physics

Unit I. Introduction to Quantum field theory (18 hrs)

Classical Lagrangian Dynamics; Lagrangian Field Theory; Global and Local Symmetries; Noether's Theorem; Canonical Quantization: From Classical to Quantum Mechanics; Quantum Fields and Causality; Canonical Quantization of Scalar Field Theory; Complex Fields and Anti-Particles. The S-Matrix in Quantum Field Theory: Time Evolution of Quantum States and the S-Matrix; Feynman Propagator and Wick's Theorem; Transition Amplitudes and Feynman Rules; Particle Decays and Cross Sections; Unitarity and the Optical Theorem.

Unit II. Quantum Electrodynamics (18 hrs)

Weyl and Dirac Spinors; Quantization of the Fermion Field; Gauge Symmetry; Quantization of the Electromagnetic Field; the Photon Propagator and Gauge Fixing; Becchi--Rouet--Stora Transformations, Feynman Rules for Quantum Electrodynamics. Renormalization: Dimensional Regularization, Renormalization of a Scalar Theory; Displacement Operator Formalism of Renormalization to All Orders; Renormalization Group Equation; Anomalous magnetic moment and the Lamb shift

Unit III. Quantum Optics (18 hrs)

Representation of EMF. Photon statistics, photon number representation. Coherent light: Poissonian photon statistics, Classification of light by photon statistics, super-poissonian light , Thermal light, Chaotic light, sub-poissonian light. Theory of photodetection. Photon antibunching. Quantum state of light, coherent state light, squeezed-state light. Interaction of photon with atoms. Laser cooling and trapping of atoms.

Unit IV. Non Linear Optics (18 hrs)

Theory of linear and nonlinear susceptibilities. Nonlinear electron oscillator model- Nonlinear oscillator equation- polarization and wave equation-Second Harmonic generation and phase matching-multiphoton absorption and emission-phase conjugation by nonlinear processes.

References:

1. F. Mandl and G. Shaw, Quantum Field Theory, Wiley, 1992.
2. M. E. Peskin and D. V. Schroeder, Quantum Field Theory, Perseus Books Group, 1995.
3. T. P. Cheng and L.-F. Li, Gauge Theory of Elementary Particle Physics, Oxford University Press, 1984.
4. S. Pokorski, Gauge Field Theories, Cambridge University Press, 2000, Second Edition.
5. Quantum Optics Mark Fox

6. Quantum Optics M O Scully & M Suhail
7. Fundamentals of Photonics Saleh & Teich
8. Lasers P Miloni & J H Eberly
9. Quantum electronics Amnon. Yariv

Optoelectronics

SECTION 1

Basic Semiconductors, PN junction, carrier recombination and diffusion, injection efficiency, heterojunction, internal quantum efficiency, double hetero junction, fabrication of hetero junction, quantum wells and super lattices. Optoelectronic devices, LED- Power and efficiency, double hetero structure LED, LED structures. LED characteristics, laser modes, strip geometry, gain guided lasers, index guided lasers.

SECTION II

Modulation of light, birefringence , electooptic effect,EO materials, Kerr modulators, scanning and switching, self electro optic devices, MO devices, AO devices, AO modulators.

SECTION 1II

Display devices, Photoluminescence, cathodo luminescence, EL display, LED display, drive circuitary, plasma panel display, liquid crystals, properties, LCD displays, numeric displays.

SECTION 1V

Photo detectors, thermal detectors, photoconductors, photon devices, PMT, photodiodes, phototransistors, PIN diode, APD characteristics, APD Design of detector arrays, CCD, Solar cells.

REFERENCES:-

1. Opto electronics- An introduction- J Wilson and JFB Hawkers. (Prentics- Hall India, 1996)
2. Optical fibre communication- J M Senior (Prentice Hall)
3. Optical fibre communication systems – J Gowar (Prentice Hall 1995)
4. Introduction to optical electronics- J Palais (Prentice Hall 1988)
5. Semiconductor opto electronics- Jasprit Singh (McGraw-Hill, Inc,1995)
6. Semiconductor optoelecttronic devices-P Bhattacharya
(Prentice Hall of India, 1995)

APPLIED PHYSICS

(Quantum Electronics)

Unit I

Laser resonator theory. Quality factor, Spherical resonators and stability condition. Techiniques of Q-Switching and mode locking- Active and passive Techniques. Generation of femto second pulses-Group velocity dispersion- Laser pulse compression- experimental arrangements. **(18 hrs)**

Unit II

Optical parametric amplification and oscillations- Basic equation- Manley-Rowe relations –single and doubly resonant oscillators- Theory of self phase modulation. Frequency chirping and generation of solitons- Non-Linear Shrodinger equation (NLSE). Dispersion and Non-Linearity-Soliton solution to NLSE-Number of modes in an optical fibre. Material dispersion and pulse dispersion. . **(18 hrs)**

(Nano Photonics)

Unit III

Fundamentals of photonics and photonic devices – lasers, LEDs, Optical modulators (acousto-optic and electro-optic), Optical fibers and fiber optic components, Frequency conversion, Propagation and confinement of photons and electrons, tunneling, band gap, Quantum confinement effects, Quantum Dots, Interaction dynamics, Electronic energy transfer and emission. . **(18 hrs)**

Unit IV

Single molecular spectroscopy and Nonlinear Optical Processes,Time-resolved studies, Heterostructures, Features of photonics crystals, Modeling of photonics crystals, Nonlinear photonic crystals, photonic crystal fibers, Applications in communication and sensing. Near-field imaging of biological systems, Nanoparticles for optical diagnosis, Upconverting nanophores for bioimaging. **(18 hrs)**

References:

Principles of Lasers — Orazlo Swelto
Quantum electronics — Amnon. Yariv
Optical Electronics — Ghatak & Tyagaraj
Nanophotonics — Paras N. Prasad
Nanophotonics with Surface Plasmons : Vladimir M.Shalaev ,Stoshi Kawata
Principles of Nanophotonics — Motoichi Ohtsu,Kiyoshi Kobayashi,Makato Naruse
Photonic devices — Jia Ming Liu
Integrated Photonics — Fundamentals: Gines Lifante
Photonic Crystals: Kurt Busch — Stefan.Lolkes

Computational Methods in Physics

Unit 1: Solution of Ordinary Differential equations

Initial value problems – Taylor's series method, Euler's method, Runge-Kutta method, Milne's predictor-corrector method, Adam's predictor-corrector method. Boundary value problems – Finite difference method, Shooting method, Weighted residual method, Cubic spline method.

Unit 2: Solution of Partial Differential equations

Parabolic partial differential equations – finite difference method, Crank Nicolson method, Elliptic partial differential equations - finite difference method, Iterative method, Finite element method, Hyperbolic partial differential equations – Finite difference method.

Unit 3: Approximation methods

Least squares approximation, Chebyshev polynomial approximation, Economized power series, Rational function approximation - Pade approximation, Fourier series approximation, Harmonic analysis, Fast Fourier transform.

Unit 4: MATLAB

MATLAB Environment – Vectors and Matrices, Plotting and Graphics, Solving Algebraic equations and other Symbolic tools, Basic symbolic Calculus and Differential equations, Numerical solutions of ODEs – Integrations, Transforms – Laplace and Fourier, Special functions – Beta, Gamma and Bessel functions.

Reference Books:

Numerical Analysis – R L Burden and J D Faires

Introduction to Methods of Numerical Analysis - S S Sastry

MATLAB Demystified – David McMahon, McGraw Hill

A guide to MATLAB - Hunt B R, Lipsman R L and Rosenberg J M, Cambridge University Press

MATLAB – A practical introduction to Programming and Problem Solving – Attaway – S, Elsevier.