`FOURTH YEAR

Distribution of marks for the session 2013-2014 ; 2014-2015

Course Code	**Course Title**	**Marks**	**Time In hours**	**Credits**
PHYS-401	Relativity (5 Questions)	100	4	4
PHYS-402	Electrodynamics (5 Questions)	100	4	4
PHYS-403	Quantum Mechanics - II (5 Questions)	100	4	4
PHYS-404	Digital Electronics and Communication Systems (5 Questions)	100	4	4
PHYS-405	Solid State Physics - II (5 Questions)	100	4	4
PHYS-406	Nuclear Physics - II (5 Questions)	100	4	4
PHYS-407	Computational Physics (5 Questions)	100	4	4
PHYS-408	Physics Practical - IV	250	24	10
PHYS-409	Sessional	75	-	3
PHYS-410	Viva-Voce	75	-	3
	Total	**=1100**		**44**

SYLLABUS

PHYS-401: RELATIVITY

5 Questions x 20 **100 Marks** **4 hours** **4 Credits**

(Answer at least two questions from each group)

Special Theory of Relativity

1. Inertial and non-inertial frames, Michelson-Morley experiment, Galilean transformation, Lorentz transformation and its consequences.

2. Variation of mass with velocity, mass-energy equivalence, energy momentum relation, transformation of momentum and energy, relativistic Lagrangian and Hamiltonian formulation.
3. Minkowski space, space-like, time-like and singular intervals, space-like vectors,time-like vectors,four vectors, relativistic formulation of the equation of motion and covariant four dimensional formulation of the laws of mechanics.

(**30 Lectures)**

General Theory of Relativity

1. Quotient law, Christoffel's three index symbols, geodesics, covariant differentiation of vectors, tensors and invariant, Ricci's theorem, tensor form of gradient, divergence, Laplacian and curl, geodesic co-ordinstes, Riemann Christoffel tensor, Ricci tensor, Bianchi identities, Einstein tensor, construction of a uniform vector field and necessary and sufficient condition for the flat spacetime.
2. Principle of general covariance, principle of equivalence, inertial and gravitational mass, Newton's equation of motion as an approximation of geodesic equations, deduction and solution of Einstein's field equations, Poisson's equations as an approximation of Einstein' field equations, planetary orbits, three tests of general relativity and time delay of light.

(**30 Lectures)**

REFERENCES

1.	Satya Prakash	Relativistic Mechanics
2.	Bergmann	Special theory of Relativity
3.	A. Einstein	Relativity the special & General theory
4.	J. N. Islam	Introduction to Mathematical Cosmology
5.	Robert Resnick	Special theory of Relativity
6.	James B. Hartle	Gravitation: An introduction to Einstein's General Relativity

PHYS- 402: ELECTRODYNAMICS

5 Questions x 20 **100 Marks** **4 hours** **4 Credits**

1. Maxwell's equations: Introduction; Maxwell's electromagnetic equations and their development; Electromagnetic energy, Poynting's theorem, Wave equations in vacuum, Wave equations in conducting and non-conducting media and their solution, electromagnetic skin depth.
2. Application of Maxwell's equations: Reflection and Refraction's at the boundary of two non-conducting media, Reflection from a conducting plane; total internal reflection. Snell's law, Brewster's law.
3. Wave propagation between parallel conducting plates: Wave guides; Modes of progation of TE, TM and TEM wave in Wave-guides, rectangular wave guide, the coaxial transmission line, cavity resonators, short antenna, Radiations from an oscillating dipole.
4. Potentials and Fields: Scalar and Vector Potentials, Guage transformation, Coulomb gauge, Lorentz gauge, Calculation of field and potentials, Retarded potentials, The Lienard-Wiechert potentials; field due to uniformly moving point charge: Power Radiated by a point charge.
5. Electromagnetic Despersion: Dispersive power of a prism and refractive index, Lorentz's theorem; Dispersion in gases, liquids and solids, Normal and anormalous dispersion; Clausius Mossotti relation.
6. Scattering of electromagnetic radiation: scattering parameters, total scattering cross section, Scattering by a free electron; Thomson scattering, Rayleigh scattering, Resonant scattering, blueness of the sky, ocean and glaciers.

7. <u>Concept of Plasma Physics:</u> Definition, sources of plasma, production of plasma, uses of plasma, ,plasma frequency,Debye screening length, plasma behaviour in electric, magnetic and gravitational fields, Electrical conductivity and mobility; the Langevin equation, pinch effect and its uses. **(60 Lectures)**

REFERENCES

1. Milford & Christy	Foundations of Electromagnetic Theory
2. J.D. Jackson	Classical Electrodynamics
3. David J. Griffiths	Introduction of Electrodynamics (3rd edition)
4. Landau & Lifshitz	Classical Theory of Fields
5. A.M.H. Rashid	Classical Electrodynamics
6. M. Wazed Miah	Fundamentals of Electromagnetism
7. B. S. Tanenbaum	Plasma Physics
8. M. R. Islam	Lecture Notes on Electrodynamics (unpublished)

PHYS-403: QUANTUM MECHANICS-II

5 Questions x 20 — 100 Marks — 4 hours — 4 Credits

1. <u>Operators and Matrices:</u> linear operators, kets and bras, eigenvalues and eigenkets; expansion in eigenkets; completeness and orthogonality of eigenkets; representation of an operator; commuting operators, projection, hermitian and unitary operators; diagonalization of a matrix.

2. <u>Matrix formulation of Quantum Mechanics:</u> State vectors; linear vector spaces; Hilbert space; orthonormal system; matrix representation of state vectors and operators; change of representation; Simple harmonic oscillator.

3. <u>Dynamical behavior of a quantum system:</u> Schrodinger, Heisenberg and Interaction pictures.

4. <u>Angular Momentum:</u> Rotation operator, commutation rules, addition rules for Angular momentum, Orbital angular momentum, Eigenvalues and eigenfunction of L^2, L_z, Spin angular momentum, Matrix representation of the Angular momentum, Spherical Hormonics, Application of Clebsch-Gordan co-efficients.

5. <u>Symmetry in Quantum Mechanics:</u> Space and time displacements; the group concept; rotation, angular momentum and unitary groups; combination of angular momentum states and tensor operators; space inversion and time reversal; dynamical symmetry.

6. <u>Approximation methods:</u> WKB approximation method; time independent and time-dependent perturbations; density of states and transition probability; applications; Zeeman effect and Stark effect.

7. <u>Theory of scattering:</u> Scattering of particles by spherically symmetric potentials, partial waves phase shifts; General Formulation of scattering theory, Born's approximations

8. <u>Identical particles:</u> Symmetric and antisymmetric wave functions; the exclusion principle; spin and statistics; spin matrices.

9. <u>Relativistic Wave Equation:</u> Schrödinger equation, Klein-Gordon equation, Dirac's equation for a Free particle, Dirac Matrices, Covariant form of Dirac equation, Negative Energy Solution, Spin of the Dirac Particle, Magnetic Moment of Electron, Spin Orbit Interaction. **(60 Lectures)**

REFERENCES

1. L.I.Schiff	Quantum Mechanics
2. P.A.M. Dirac	The principle of Quantum Mechanics
3. Landau & Lifshitz	Quantum Mechanics

4. Merzbacher — Quantum Mechanics
5. Powell and Crasemann — Quantum Mechanics
6. R.G.Newton — Scattering Theory of Waves and Particles
7. Walster Glockle — The Quantum Mechanical Few-body Problem
8. A.R.Edmonds — Angular momentum in Quantum Mechanics
9. Morse & Feshbach — Methods of Theoretical Physics(2 Vols)
10. Courant & Hilbert — Methods of Mathematical Physics(2 Vols)

PHYS-404: Digital Electronics and Communication Systems

5 Questions x 20 — 100 Marks — 4 hours — 4 Credits

Digital Electronics

1. Operational amplifiers: Op-amp and its characteristics; 8-lead mini-DIP op-amp; general purpose op-amp and its inputs & output details; negative feedback; closed-loop & open-loop gains; applications in computing circuits: op-amp as inverting and non-inverting amplifiers, adder/averager, subtractor, multiplier/divider, voltage follower/ buffer amplifier, integrator and differentiator/ solver of differential equations.

2. Bi-stable devices and digital designs: Basic idea on storage elements; latches and flip-flops; flip-flops with logic gates: construction and operation; TTL clock: construction and operation; 555 timer : clock wave forms; charging /discharging times and duty cycles; positive and negative-edge-triggering; astable, monostable, and bi-stable multivibrators with 555 timers: construction, operation and wave forms/ timing analyses; digital synchronization; fan-out, power dissipation, noise margin and propagation delay; digital designs for positive and negative narrow pulses.

3. Digital circuit: Counters and registers; ADC & DAC; multiplexer, de-multiplexer, encoder, decoder, digital voltmeter.

4. IC and its fabrication: IC, its characteristics, uses: advantages and disadvantages, basic processes of IC fabrication, diffusion epitaxy, oxidation, photolithography, thin film deposition, monolithic and hybrid IC's, assembly of IC typical circuit packages, monolithic fabrication of IC diode & transistor, reliability, integration process and testing, SSI, MSI, LSI, VLSI(Concept only), basic idea on nanofabrication.

5. Microprocessor: General purpose & special purpose microprocessor, Memory, 80x86 microprocessor, BUS, Pins & signals, Instructions, Addressing Modes, Stack, subroutine, Interrupt & interrupt service routine.

Communication Systems

6. Modulation and detection: Amplitude, frequency and phase modulation, their mathematical expressions, power in AM wave, modulation factor, bandwidth and Detection.

7. Antenna: Poynting vector, antenna action, characteristics, short electric doublet, radiation resistance and power radiated by short doublet, field pattern, distribution of radiated energy in vertical plane.

8. Micro-wave and satellite communications: Wave guide, cavity resonator, Klystron tubes, reflex klystron tube, klystron as oscillators & amplifiers; magnetron, multi-cavity magnetron, cut-off magnetic field, visibility zone, channels, servo-control systems.

9. Radar: Radar system, Radar range equation and detection of distant objects.

10. Radio and Television: Radio receiver and transmitting systems, Black & white and coloured television, scanning, transmission and receiving system of television.

(60 Lectures)

REFERENCES

1. Millman & Halkias — Integrated Electronics

2. Reinties and Coate — Principle of Radar
3. Ryder — Engineering Electronics
4. Millman & Taub — Pulse, Digital and Switching Waveforms
5. Terman — Electronics and Radio Engineering
6. S.B.Seely — Electronic circuits
7. Keith Henny — Radio Engineering Hand Book
8. Guy & Others — Fundamental of Radio Electronics
9. Skelink — Introduction to Radar System
10. Rapheel — Pulse Electronics
11. Diefender — Digital Electronics Instrumentation

PHYS-405: SOLID STATE PHYSICS-II

5 Questions x 20 — 100 Marks — 4 hours — 4 Credits

1. Band Theory of Solids: Nearly free electron model; origin of energy gap; The Bloch theorem, The Kronig-Penney model, the motion of electrons in one and three dimensions and their consequences.

2. The conductivity of Metals: Some features of electric conductivity of metals; A simple model leaeding to a steady state; drift velocity and relaxation time; Boltzmann transport equation; Sommerfeld theory of electrical conductivity; mean free path in metals, quantitative discussions of the features of resistivity; thermal scattering as electron-phonon collision, electrical conductivity at low temperature; thermal conductivity of insulators, metals

3. Dielectric and Optical Properties of Solids: Macroscopic electric field; local field at an atom; the dielectric constant and polarizability; dipolar polarizability; dipolar dispersion; dipolar polarization in solids; ionic polarizability; electronic polarizability; classical and quantum treatment; piezoelectricity; ferroelectric crystals; polarization catastrophy; Second order transition; first order transition; Anti-ferroelectricity Ferroelectrics domains.

4. The Electron Distribution in Insulators and Semiconductors: Fermi distribution; simplified model of an insulator; improved model for an insulator and intrinsic semiconductor; models for an impurity semiconductor; thermionic emission form semiconductors; electronic degeneracy in semiconductors. Hall effect in semiconductors.

5. Magnetic Properties of Solids: Quantum theory of paramagnetism; paramegnetic susceptibility of conduction electrons; applications of magnetic ions in solids; effect of the crystal field; Van Vleck Paramagnetism; Pauli paramagnetism; Nuclear paramagnetism; Concepts of Ferromagnetism, Anti-ferromagnetism and ferrimagnetism, Curie-Weiss law; Spinwaves; Magnetic relaxation and resonance phenomenon.

6. Superconductivity: Introduction, zero resistance; Meissner effect, critical field, two fluid model; intermediate states; type I and type II superconductors; isotope effect; thermodynamics of superconductivity; London equation.

7. Defects and Dislocation in Solids: Point defects in solids; lattice vacancies; Schottky defect; Frenkel defect; diffusion; color centers; order- disorder transformation; dislocations; shear strength in single crystals; slip; Burgers vectors; stress field of dislocation; dislocation densities; dislocation multiplication and slip; strength of alloys; dislocation and central growth.

8. Photoconductivity and luminescence: Historical survey: photo conducting materials; electron transition in photoconductors; general mechanism; photosensitivity; capture cross section; Simple model of a photoconductor; Exciton, Absorption, Trapping and its effect. Luminescence: Models of luminescence; comparison with experiment; thallium activated alkali halides, Electron luminescence. **(60 Lectures)**

REFERENCES

1. A.J. Dekker	Solid State Physics
2. C. Kittel	Introduction to solid state physics
3. B.S. Saxena, R c Gupta & P N Sexena	Fundamentals of Solid State Physics
4. M A Omar	Elementary Solid State Physics
5. M J Buerger	Elementary Crystallography
6. Azaroff	Introduction to Solids.
7. Ashcroft & Mermin	Solid State Physics

PHYS 406: NUCLEAR PHYSICS-II

5 Questions x 20   100 Marks   4 hours   4 Credits

1. The two nucleon problem: Ground and excited states of deuteron, *neutron-proton* and *proton-proton* scattering at law energy, scattering length, effective range theory, Coherent and incoherent scattering, exchange forces.

2. Nuclear Models: Liquid drop model, Semi-empirical mass formula, nuclear fission based on liquid drop model, nuclear shell model, Spin-orbit interaction, Application of the extreme single particle shell model-spin, parity, magnetic moment, quadruple moment.

3. Nuclear reactions: Partial wave analysis fro cross sections, Compound nucleus hypothesis, discrete levels: level width and life time, Breit-Wigner formula.

4. Neutron physics: Sources of neutrons, Interaction of neutrons with matter, Thermal neutron, Moderation of neutrons, Cross sections for neutron induced reactions.

5. Nuclear Fission and Fusion: Nuclear fission and fusion processes, fissile and fertile material, mass and energy distribution of fission fragments, release of energy from fission, Prompt and delayed neutrons, Chain reaction, basic working principle of a reactor, reactor materials.

6. Interaction of ionizing radiation with matter: Energy lost by charged particles, Range, Stopping power, Bremsstrahlung, Modes of interactions of electromagnetic radiation with matter.

7. Particle Accelerators: Linear accelerator, Cyclotron, Betatron .

8. Nuclear Detectors: Scintillation detector, HPGe detector, Neutron detector.

(60 Lectures)

REFERENCES

1. J. B. Paul	Nuclear and Particle physics
2. Roy and Nigam	Nuclear physics
3. Blatt and Weisskopf	Theoretical Nuclear Physics
4. Elton	Nuclear Physics,
5. Burcham	Nuclear physics
6. H.A. Enge	Introduction to Nuclear Physics

PHYS-407: COMPUTATIONAL PHYSICS

5 Questions x 20 **100 Marks** **4 hours** **4 Credits**

1. Introduction: Scientific computation, Computing Software Basics, Errors in Computation: estimation and propagation.
2. Solution of Non-linear equation: Bisection method, False position method: Newton-Raphson method, the secant method, convergence of algorithms.
3. Computation with matrices: Systems of Equations and Matrix Inversion: Exact Methods - Gauss Elimination and Back Substitution, Householder Transformation, LU Decomposition, Recursion Method; Iterative Methods: Jacobi Method, Gauss-Seidel Method.
4. Matrix Eigenvalue Problems: Schrödinger's equation, General Principles, Full Diagonalisation, The Generalised Eigenvalue Problem, Partial Diagonalisation, Sturm Sequence, Sparse Matrices and the Lanczos Algorithm.
5. Sample Applications: Thermal Conduction in 1D, Potential Equation in 2D.
6. Interpolation and Curve Fitting: Interpolation and extrapolation, Newton's forward and backward difference interpolation, Lagrange's interpolation, Least Square fit to a polynomial, smoothing, minimizing function.
7. Numerical Differentiation and Integration: Derivatives from differences, higher order derivatives; Trapezoidal and Simpson's 1/3 rule for numerical integration, Newton-Cotes formula, Gaussian quadrature.
8. Ordinary Differential Equations (ODE): Euler's method, Runge-Kutta 4th order method, Predictor-Corrector method; System of differential equations and higher-order differential equations, Sample application with Newton's equation of motion, e.g., equation of an oscillator.
9. Partial Differential Equations: Types of equations, Finite difference method for partial differential equation. **(60 Lectures)**

REFERENCES

1. Numerical Mathematical Analysis	Scarborough
2. Data Reduction and Analysis for the Physical Sciences	Philip R. Bevington, McGraw-Hill
3. Applied Numerical Analysis 6/e	Curtis F. Gerald and Patrick O. Wheatley, Pearson Education, Asia, 1999.
4. Numerical Mathematical Analysis	Scareborough.
5. Teach Yourself C/C++	Herbert Scshildt.
6. Computer Organization	Hays
7. Computer Organization	Hamacher
8. Data Communication	Stalling
9. Micro Computer & Microprocessor based system design	Rafiquzzaman.

PHYS-408: PHYSICS PRACTICAL-IV

250 Marks **24 hours** **10 Credits**

Each student is to perform 4 **experiments; 2 one day experiments on electronics** and **2 one day experiments from other fields**. Each experiment shall be of **6 hours** duration.

Marks distribution:

(i) Class performance including Lab note Book		= 50
(ii) 4 experiments each of 6 hours duration	(4x50)	= 200
Total		**= 250**

Marks distribution for each of the 6-hours experiment:

(i) Theory	= 10
(ii) Procedure + Data collection (5+10)	= 15
(iii) Calculations + Result	= 10
(iv) Discussion	= 5
(v) Viva on experiment	= 10
Total	**= 50**

LIST OF EXPERIMENTS

ELECTRONICS

1. Microwave-1 Wavelength measurement & Radiation pattern.
2. Microwave-2 Effect of humidity, Reflection, Transmission.
3. Construction and study of Astable multivibrator..
4. Construction and study of Monostable multivibrator.
5. Construction and study of Bistable (Flip Flop) Multivibrator.
6. Design of an low pass filter and study of its performance.
7. Design of an band pass filter and study of its performance.
8. Design of an high pass filter and study of its performance.

NUCLEAR, HEALTH AND REACTOR PHYSICS

1. Range of alpha particle in air.
2. End-point energy of Beta radiation.
3. Resolving time of G.M.Tube.
4. Attenuation Coefficient of gamma radiation.
5. Calibration of Nai(Tl) detector and determination of unknown energy.
6. Franck-Hertz Experiment.

SOLID STATE PHYSICS

1. Calibration of electromagnet and determination of Hall voltage
2. Calibration of electromagnet and show variation of Hall-current with position of Hall probs.
3. Measurement of susceptibility of $MnSO_4$ solution.
4. E.S.R.Experiments.
5. Measurement of band-gap of Semiconductor sample.

SEMICONDUCTOR PHYSICS

1. To determine/draw the characteristic curves of a FET.
2.To determine the effects of temperature on Collector leakage current (I-CBO) for a Ge and a Si-transistor.
3. To determine the characteristics and efficiencies of a solar cell in dark, diffuse light and Sun rays.
4. To determine the reverse saturation current I, and ideality factor Eta of a P-N junction.

COMPUTATIONAL PHYSICS

1. Combinational logic design using IC.
2. Design of ring counter using FF IC.
3. Parallel to serial conversion of data using MUX.
4. Logic function generation using MUX.
5. Assembley language programming.