DEPARTMENT OF PHYSICS

UNIVERSITY OF CHITTAGONG

SYLLABUS FOR M.S IN PHYSICS
SESSION: 2011-2012; 2012 - 2013

The Master of Science (M.S) Course in Physics is divided into two groups:

Group A: General group
Group B: Thesis group

The course shall be of one year duration and shall consist of 600 marks (24 credits) in total.

(Group A)

General group Students of this group shall choose 4 theoretical courses from the prescribed courses with the approval of the academic committee of the Department. Each course contains 75 marks (3 Credits). Laboratory course contains 200 marks (8 Credits) of which 160 marks for experimental work and 40 marks for experimental viva. Total marks for group A will be distributed as follows:

			Marks	Credits
1. Four theoretical courses	4x75	=	300	12
2. Laboratory course	(160+40)	=	200	08
3. Class record/Tutorial/Field work/etc.	50	=	50	02
4. General Viva	50	=	50	02
	Grand Total	=	600	24

(Group B)

Thesis group The student of this group shall be selected by the Departmental Academic Committee on the basis of the results of four year B.Sc. (Hons.) examination. Students of this group shall take four theoretical courses of which one course must be related to the research work of the thesis. The remaining three courses may be taken from the prescribed courses with the approval of the academic committee of the Department. The dissertation carries 150 marks and thesis viva 50 marks. The total marks distribution for the group B is as follows:

			Marks	Credits
1. Four theoretical Courses (1 course related to thesis work)	4×75	=	300	12
2. Thesis and thesis viva	150 + 50	=	200	08
3. Class record/Tutorial/Field work/etc.	50	=	50	02
4. General Viva		=	50	02
	Grand Total	=	600	24

Medium of Instruction: The medium of instruction and examination shall be English.

Courses: The following courses shall be offered in the M.S program.

COURSE CODE	COURSE TITLE
PHYS 501	Advanced Quantum Mechanics
PHYS 502	Advanced Electronics & Telecommunication
PHYS 503	Advanced Nuclear Physics
PHYS 504	Condensed Matter Physics
PHYS 505	Atmospheric Physics
PHYS 506	Reactor, Radiation & Health Physics

PHYS 507	Semiconductor Devices & Technology
PHYS 508	Computational Physics
PHYS 509	Geophysics and Geophysical Prospecting
PHYS 510	Astrophysics and Cosmology
PHYS 511	Material Physics
PHYS 512	Medical Physics
PHYS 513	Renewable Energy
PHYS 514	Superconductivity
PHYS-515	Quantum Field Theory
PHYS 516	Physics Practical
PHYS 517	Class record/Tutorial/Field work/etc.
PHYS 518	General Viva

Course Details: Details of the above courses are given below-

PHYS 501: Advanced Quantum Mechanics **(Total lectures-60)**
Full Marks: 75 **Examination duration: 04 hours**
Credit: 03 **Five questions to be Answered**

1. Introduction to Advanced Quantum Mechanics: Schroedinger wave equation; Stationary states, The Heisenberg equations of motion, Poisson brackets, Integral of motions and symmetry conditions, Group theory in quantum mechanics, The form of the Schroedinger equation in different coordinate systems.

2. Scattering theory: General formulation of scattering theory, Classical and quantum scattering, Asymptotic condition, Moller's operators, Problem of asymptotic completeness, Definition of one particle scattering operator and its unitarity, Energy conservation, S-matrix, T-matrix, Representation of S and T-matrix in the configuration space and in the momentum space, Relation between Green's function and T-matrix, Lippman-Schwinger equations for two and three particle systems.

3. Quantum Theory of Systems consisting of Identical Particles: Schroedinger equation for a system consisting of identical particles, Elementary theory of the ground state of two electron atoms, Excited state of helium atom, Self-consistent Hartree-Fock field, The statistical Thomas-Fermi method, The Periodic system.

4. Second Quantization for Bosons and Fermions: Second quantization of a field corresponding to Bosons, Second quantization of the meson field, Application of second-quantization method of systems of interacting Bosons, Occupation number representation for Systems of non-interacting Fermions for small energies, Systems of Fermions interacting through pair forces, Bogolyubov's canonical transformation, Quantization of the electron-positron field.

5. Interaction of radiation with matter: Maxwell's equations; plane electromagnetic waves, Classical formulation of Lagrangian and Hamiltonian equations of motions, Classical radiation field equations, Quantization of fields, creation, annihilation and number operators in both Bose and Fermi statistics; Planck's distribution formula.

Books Recommended

1. Quantum Mechanics: A.S. Davydov.
2. Scattering Theory: John.R. Taylor, John Wiley & Sons.
3. Scattering theory and Waves: R.G. Newton
4. Quantum Mechanics: P.M.A. Dirac
5. Modern Quantum Mechanics: J. Sakurai
6. Quantum Mechanics: Cohen (Part I & II)

PHYS 502: Advanced Electronics and Telecommunication (Total lectures-60)
Full Marks: 100 **Examination duration: 04 hours**
Credit: 04 **Five questions to be Answered**

1. Analysis of Passive Circuits using Laplace Transform: Time-domain circuit and frequency-domain (complex frequency) circuit, reduction of one to another through Laplace transform and its inverse, transfer function, poles and zeros, impulse and step response, time-domain behaviour from s-plane, stability, natural and forced response, Bode plots.

2. Active Filters: Filters: types and specifications, Filter transfer function, Butterworth and Chebyshev filters, first order filter functions.

3. BJT: Large-signal model: Ebers-Moll model, Analysis of active mode and saturation mode of operation using EM model; Internal capacitances of the BJT, High-frequency hybrid-π model, cut off frequency.

4. MOSFET: Sturcture and physical operations of the enhancement-type MOSFET, derivation of I_D-V_{DS} relationship, p-channel and depletion- type MOSFET, MOSFET internal capacitances and high frequency model.

5. MOS Digital Circuits: An overview of digital circuit design, Logic gate characterization, Design and performance analysis of the CMOS inverter, CMOS logic gate circuits.

6. Optoelectronics: Electro-optic, magneto-optic and acousto-optic effects; Photodetectors: thermal, thermoelectric detectors; Photon devices: Photoemissive devices, Photomultipliers, image intensifiers, phototransistors; Optical fiber waveguides.

7. Instrumentation: Transducers; Capacitive transducers- advantages and disadvantages, piezoelectric transducers, Hall effect transducers. Magnetoresistance effect, digital displacement transducers: tachometer, Seismic transducers, Ultrasonic flow transducers, Remote sensing, Instrumentation with operational amplifiers.

8. Modern Telecommunication: Digital communication system, information & coding theory, Error correction and coding, Internet work, networking SMDS – Coupled modes in optical wave guides, Periodic & Optical filters, Optical solution Propagation, system design and applications.

9. Network performance analysis: Queuing theory, Network and quenching controlled and random access techniques in data net multimedia and simulation

Books Recommended

1. Electronic devices and circuit Theory: Boylestad & Nashelsky
2. Introduction to Circuits for Electrical and Computer Engineering:J W Nelssin and Susan A. Reidel,
   Prentice-Hall
3. Transform Analysis and Filters: Leonard J. Geiss, Prentice Hall, 1989
4. Microelectronic Circuits: A.S. Sedra and K.C. Smith, Oxford University Press, 1998
5. Electrical and Electronic Measurement and Instrumentation: A.K. Shawney
6. Optoelectronics: An Introduction, 2/e: J. Wilson & J.F.B. Hawkes, Prentice-Hall of India, 2001
7. Operational Amplifiers and Linear Integrated Circuits, 6/e: R.F.Coughlin & F.F.Driscoll, Pearson Education, 2001
8. Telecommunications Engineering: J. Dunlop & D.G. Smith, Chapman and Hall, 1994

PHYS-503: Advanced Nuclear Physics **Total Lectures: 60**
Full Marks-75 **Examination duration: 4 hrs.**
Credit:03 **Five question shall be answered.**

1. **The two nucleon problem:**
   Reciprocity theorem, Phenomenology of two-nucleon potential, Yukawa potential, Meson theory of nuclear force.

2. **Nuclear Model:**
   Collective model – nuclear vibration and rotations, Quadrupole deformation.

3. **Compound nucleus reaction:**
   Ghoshal's experiment, continuum theory, Statistical theory for cross-sections, level density, evaporation model, pre-equilibrium model, reactions with heavy ions.

4. **Optical model:**
   Optical potentials, Kapur-Peierls Dispersion formula, Lane, Thomas and Wigner model, strength function

5. **Direct Reaction:**
   Semi-classical model, kinematics of stripping and pick-up reactions, theory of stripping and pick up reactions, Distorted-Wave Born approximation.

6. **Electromagnetic Interactions with nuclei:**
   Multi-pole expansion, sources of multi-pole radiation, selection rules, quantum mechanical treatment of transition probabilities, internal conversion, Angular distributions of γ transition and angular correlations.

7. **Nuclear Analytical Techniques:**
   Neutron activation analysis, neutron radiography, PIXE, PIGE, Accelerator mass spectrometry.

8. **Particle Physics:**
   Classification and properties of elementary particles, conservation laws, production and decay of pions, muons and hyperons, resonance particles, Baryons, Quarks, Introduction to Weinberg-Salam theory.

Books Recommended:

1. Nuclear Physics: Roy R. R. and Nigam B. P
2. Theory of Nuclear Structure: Pal M. K
3. Introduction to Nuclear Reaction: Satchler G. R
4. Introductory Nuclear theory: Elton LRB
5. Structure of the Nucleus: Preston M. A and Bahaduri R
6. Glashow-Salam-Weinberg theory: A. M Harun-ar-Rashid
7. Weak Interaction and Modern Particle Physics- H. Georgi (Benjamin/Cummings, Menlo Park, CA 1984).

PHYS-504 : Condensed Matter Physics **Total Lectures: 60**
Full Marks : 75 **Examination Duration: 04 Hours**
Credits : 03 **Five Questions to be Answered**

1. **Beyond The Independent Electron Approximation:** Review on free electron theory and nearly free electron theory; The Hartree equations; The Hartree-Fock equations; Screening; Thomas-Fermi theory of screening; Lindhard theory of screening, Fermi-Liquid theory.

2. **Band Structure of Solids:** Introductory remarks on band theory: formation of energy bands in a periodic potential, Fermi surface, The Plane wave Method; Tight-binding method; Cellular Method; Orthogonalized Plane Wave (OPW) method; Pseudopotential method; Augmented plane wave method, Koringa-Kohn-Rostoker (KKR) Green Function Method.

3. **Magnetic Properties of Solids:** Review on diamagnetism and paramagnetism; Introductory remarks on Ferro, Anti-ferro and Ferrimagnetism; Weiss theory of Ferromagnetism; The exchange interaction; The Heisenberg model; The Bloch Wall; Origin of domains; Neel model of Antiferromagnetism; Neel model of Ferrimagnetism; Spin waves; Hamiltonian in spin-wave variables; Magnon heat capacity; The Bloch $T^{3/2}$ law; Magnons in anti-ferromagnets; Zero-point energy..

4. **Theoretical Aspects of Superconductivity:** London equation; London penetration depth; Coherence length; Flux quantization; Electron-Phonon interaction; BCS theory of superconductivity; The Cooper pair; Existence of energy gap; BCS ground state energy; Electron tunneling and Josephson effect.

5. **Plasmons, Polaritons And Polarons:** Dielectric function of the electron gas, Plasma optics; Dispersion relation for electromagnetic waves; Longitudinal Plasma oscillation; Plasmons, Electrostatic screening; Mott metal insulator transition; Polaritons; LST relation ; Polarons

6. **Laser Physics** : Basics of Lasers, Properties of laser Beams, Laser Systems, **A**pplications of Lasers,

Books Recommended

1. Solid State Physics: C. Kittel.
2. Solid State Physics: A. J. Dekker.
3. Solid State Physics: S. O. Pillai.
4. Quantum Theory of Solids: C. Kittel.
5. Solid State Physics: Ashcroft and Mermin.
6. Electrons and Phonons: J. M. Ziman.
7. Augmented Plane Wave Method: T. R. Louck.
8. Many Particle Physics: G. D. Mahan.
9. Introduction to Solid State Theory: O. Madelung.
10. Solid State Theory: W. A. Harrison,
11. Magnetism : Chikazumi
12. Electronic Processes in Non-Crystalline Materials: N.F. Mott and E. A. Davis.
13. Novel Applications of Lasers, Editor, H. B. Bohidar, New Age Publications, New Delhi, India.
14. Fiber Optics and Lasers, by Ajoy Ghatak, K Thyagarajan, Publisher Mc Millan India LTD.
15. Lasers and Non Linear Optics, by Laud, B.B, Publisher New Age International publisher, New Delhi, India.

PHYS-505: Atmospheric Physics
Full Marks: 75
Credit: 03

1. Structure and composition: Classification, and Composition of the atmosphere, composition in upper layers (ionosphere, DEF layers), stratification, Basic laws, geopotential and geopotential height, lapse rates, moisture variables, atmospheric diagrams, dissociation,instability.
2. Cloud Physics: Cloud formation, growth of cloud droplets by diffusion & coalescence, precipitation and formation.
3.Dynamic Meteorology: Basic equation of motion, geostrophic approximation, thermal wind, PBL and Eckmann equation.
4. Synoptic meteorology : Techniques of synoptic analysis, air mass and its production, fronts, depression, temperature field, transformation of air mass.
5.Ozone physics: Qzone in the earth's atmosphere, vertical distribution of Ozone decay, dynamics & transport of ozone , green house gases, measurements of ozone.
6. Tropical meteorology: Tropical depression & its Classification, weather system, monsoon & its classification.
7.Climatology: Factors of climatic formation, climatic classification, Theories of climate change.
8. Radiation: Absorption of atmospheric gases, green house effect.
9. Satellite meteorology: Orbits,nephanalysis.

Books recommended

1. Meteorology - Understanding the Atmosphere: Thomson Brooks/Cole, 2002.
2. General Meteorology: HR Byers, McGraw–Hill Book Company.
3. An Introduction to Atmospheric Physics: R G Fleagle and J A Businger; Academic Press.
4. An Introduction to Dynamic Meteorology: JR Holton.
5. A Short Course in Cloud Physics: RR Rogers, Pergamon Press.
6. Meteorology: GJ Haltiner and Martin; McGraw- Hall Book Company.
7. Monsoon Meteorology: CS Ramage; Academic Press.
8. The Practice of Weather Forecasting; Wickhaum Her Majesty's Stationary Office.
9. Physics of the Upper Atmosphere: JA Ratcliffe; AP
10. Radiation in the Atmosphere: KY Kondratyev; AP
11. Tropical Meteorology: H Reihl McGraw-Hill Book Company.
12. Methods in Climatology, Vol 1 &Vol. 2: I. V. Conrad & LW Pollak, Harvard University Press.

PHYS-506: Reactor, Radiation and Health Physics **(Total lectures-60)**
Full Marks: 75 **Examination duration: 04 hours**
Credit: 03 **Five questions to be Answered**

A. Reactor Physics

1. Neutrons: Nuclear Reactions with neutrons; Neutron cross section and neutron flux; Energy release from fission; Energy distribution of fission neutrons; four factor formula and neutron Multiplication; Prompt and Delayed neutrons.

2. Nuclear Reactor systems: General Features and types of Nuclear Reactors; Power Reactors; ordinary water moderated Reactors; Heavy water moderated Reactors; Organic cooled reactors; sodium graphite reactors; gas cooled reactors; Fast Breeder Reactors.

3. Fluid-Fuse Reactors: Aqueous homogeneous Reactors; Molten salt Reactors; Liquid Metal Fuel Reactors; Fluid-Fuel Fast Reactors.

4. Research, Test and Training Reactors: High-Flux Test Reactors; Flux-Trap Reactors; Pulsed Test Reactors; Medium-Flux Research Reactors; Low-Flux Training Reactors.

5. Reactor Theory: The Steady state: The Criticality Condition; One-group Critical equations The Two-group Critical equation; The Age-Diffusion method; The Critical Size; Non-Leakage Probability; The effective Multiplication factor; Reflected Reactors; Homogeneous Reactor Systems; Heterogeneous Reactor Systems.

6. The Non-Steady Nuclear Reactor: Thermal life time and generation time; Time-Dependent Reactor Equation; Excess Reactivity and Reactor Period; Effect of delayed Neutrons; Negative Reactivities ; The In hour equation.

7. Conditions affecting the Reactivity: Effect of Temperature changes on Reactivity; Effects of Fission Products Accumulation; Fuel Depletion and Fuel Production; Fission Product Poisoning.

8. Heat Removal: Thermal Problems in Reactor Design of Cooling system; Heat Sources in Reactor system; Heat Transmission Principles; Reactor Coolants; Heat Transfer to boiling liquids; comparison of heat transfer characteristics of coolants.

9. Reactor Materials: Radiation effects on materials; Structural Materials; Moderator and Reflector materials; coolant circuit and choice of Materials.

B. Radiation And Health Physics

1. **Interaction:** Interaction of Ionising and Electromagnetic Radiations with Matter.
2. **Personal Dosimetry:** Film Badge;TLD, merits and demerits; purpose of personnel dosimetry; Area monitoring; Portable radiation dose rate meter.
3. **Biological effects of Radiation:** Somatic and genetic effects;stochastic and Deterministic effects; Effective half life of radioisotopes within biological being.
4. **Radiation shielding:** Purpose and necessity of radiation shielding; shielding of an X-ray(Diagnostic/Therapeutic) room shielding of a research room, Shielding of a radiotherapy room; Shielding of a radioactive waste chamber area.
5. Industrial applications of Ionising radiation in leak detection; In Agriculture; Radio-isotopas as Radio Tracers.
6. **Radio ganging:** Principles and Techniques; Radio gauging standardisation and calibration; Radio gauging accuracy and semitivity static and continuous radio gauge.
7. **Radioactive Analysis:** Principle and Theory; neutron Activation Analysis.
8. **Safety Measures:** In Transportation of Radioactive materials; In Nuclear accident.

Books recommended

1. The Elements of Nuclear Reactor theory: Glastone and Edlund
2. Nuclear Reactor Physics: S. E. Liverhant
3. Principle of Radiation and Protection.: Morgan Turner
4. Introduction to Health Physics: H. Cember and T. E. Johnson.
5. Radioisotope Measurement applications in Engineering: R.P.Gardner
6. The atomic nucleus: R.D.Evans
7. Principle of Radioactive protection: Knolls.
8. An Introduction to Radiation Protection: A. Martin and S. A. Harbison.

PHYS-507: **Semiconductor Devices and Technology** **(Total lectures-60)**
Full Marks: 100 **Examination duration: 04 hours**
Credit: 04 **Five questions to be Answered**

1. Device Physics: Electrical, Electronic and optical (i.e. opto-electronic) properties of elemental and compound semiconductor; Energy band gap, band type, band structure calculation, effect of doping, temperature, carrier concentration mobility etc. Review of P-N junction theory, bipolar, unipolar devices; configuration and their characteristics. Power transistor, FET, MOSFET, IGFET and their application. Metal semiconductor junction; contacts-Ohmic and Schottkey etc. microwave devices. Measurement of barrier height, contact resistance, and sheet resistance resistivity and other transport parameters. Optoelectronics-photoconductivity, phototransistor-LED, LCD, and solar cell-PVT. Transferred electronic device, memory devices both volatile and non-volatile. Semiconductor laser-intrinsic and their advances.

2. Device Technology: Silicon extraction process. Crystal growth, junction formation technology. Oxidation, lithography, diffusion, etching, Ion-implementation. Thin film fabrication technology, MBE and other processes and hybrid technology and their comparative study and realization of monolithic IC and hybrid circuit for diode, transistor, resistance and capacitor etc. Thin film-electrical and optical properties, mobility galvanometric, surface effects. Thin film optics, size effect, ad absorption and absorption phenomena.

3. **Device Characterization:** (i) Changes of band gap, Broadening and Narrowing, effect M.b. shift, hetero structure, quantum dot, Quantum wire, Energy level and band structure. Theory of surface and contacts, surface potential in equilibrium, condition of channel change understrong inversion in non-equilibrium; Si-surface changes of state, Radiation effects, distribution of impurity/Impurity redistribution phenomenon at Oxidized Si and other semiconductors.

(ii) Semiconductor and device characterization: Electron microscopy; SEM, TEM and STM micro structural and micro composition, surface, roughness, size effect analysis; determination of particle size and depth technology etc. Electron spectroscopy; XPS, Auger, ESXPS; DLTS, electron Paramagnetic Resonance, EPR, ESR, Study of defect states in the surface, effect of dopant material.

Books recommended

1. Physics of Semiconductor Devices (2^{nd} Ediftion): S.M. Sze.
2. Semiconductor Devices; Physics and Technology: S.M.Sze.
3. Optoelectronics: P. Bhattacharya.

PHYS 508 : Computational Physics **(Total lectures-60)**
Full Marks: 75 **Examination duration: 04 hours**
Credit: 03 **Five questions to be Answered**

1. Introduction: Scientific computation, Computing Software Basics, Errors in Computation: estimation and propagation.

2. Interpolation and Curve fitting: Interpolation with splines, Bezier curves; Curve fitting by least squares, Smoothing and Optimization.

3. Ordinary Differential Equations (ODE): Initial Value Problems of First Order: Euler-Cauchy Algorithm, Stability and Accuracy of Difference Schemes, Explicit methods, Implicit methods, Leap-Frog method, Runge-Kutta method, Predictor-Corrector method and Intrinsic method.
Initial Value Problems of Second Order: Verlet Method, Predictor-Corrector Method for second order ODE, Nordsieck Formulation of the PC Method, Runge-Kutta Method for second order ODE, Symplectic Algorithms, Numerov's Method.
Boundary Value Problems: Shooting Method, Relaxation Method.
Sample application: Classical Electrons in a Magnetic Field.

4. Computation with matrices: Systems of Equations and Matrix Inversion: Exact Methods - Householder Transformation, LU Decomposition, Recursion Method; Iterative Methods: Iterative Improvement, Jacobi Relaxation, Gauss-Seidel Relaxation (GSR).
Matrix Eigenvalue Problems: Schrödinger's equation, General Principles, Full Diagonalisation, The Generalised Eigenvalue Problem, Partial Diagonalisation, Sturm Sequence, Sparse Matrices and the Lanczos Algorithm.
Sample Applications: Thermal Conduction in 1D, Potential Equation in 2D.

5. Partial Differential Equations (PDE): Hyperbolic Equations: Wave equations, A Simple Algorithm, An Improved Algorithm -- the Lax method, Non-Linear Equations, Leapfrog Scheme, Lax-Wendroff Scheme.
Parabolic Equations: Diffusion, A Simple Method, The Dufort-Frankel Method, Euler Method, Crank-Nicholson Scheme.
Elliptic Equations: Laplace's equation, Relaxation and Multigrid Techniques, *Alternating Direction Implicit* (ADI) Method for the Potential Equation, Fast Fourier Transform Method (FFT), Cyclic Reduction.

6. Monte Carlo method and Simulation: Random Number Generators, Monte-Carlo Integration, The Metropolis Algorithm: The Ising model, Thermodynamic Averages; Quantum Monte-Carlo; Molecular Dynamics: General Principles.
Sample Applications: The Ising Model, Quantum Monte Carlo Calculation.

Books recommended

1. Computational Physics - An Introduction: Franz Vesely , Plenum 1994 and Kluwer 2001
2. An Introduction to Computational Physics: Tao Pang, Cambridge University Press, 1997
3. Numerical Recipes in C *The Art of Scientific Computing* 2/e: W. Press, S. Teukolsky, W. Vellering
   and B. Flannery, Cambridge University Press, 1992
4. Computational Physics, 2/e: Nicholas J. Giordano and Hisao Nakanishi, Prentice Hall
5. Computational Physics *Problem solving with computers*, 1/e: Rubin H. Landau and M.J.Paez, ..

6. Data Reduction and Analysis for the Physical Sciences: Philip R. Berington, ……
7. Applied Numerical Analysis 6/e: Curtis F. Gerald and Patrick O. Wheatley, Pearson Education, Asia, 1999
8. Lapack Numerical Library *ftp://unix.hensa.ac.uk./pub/netlib/lapack/
9. Numerical Algorithms Group *http://www.nag.co.uk:70/

PHYS-509: Geophysics & Geophysical prospecting **(Total lectures-60)**
Full Marks: 75 **Examination duration: 04 hours**
Credit: 03 **(2+3=5) questions.**

Part A: Geophysics

1. Composition of the earth: Minerals and rocks; geochronology; Age of the earth.

2. Temperature of the earth: Surface temperature; gradient; sources of earth's heat; Variation of temperature with depth; Heat flow measurements; the results of heat flow measurements.

3. Seismology: Transmission of seismic waves, stress and strain; Elasticity and the moduli; Equation of motion; Time-distance curve; The effect of boundaries; Ray geometry and the inversion of time distance curves; special velocity distribution; Major discontinuities of the earth and their properties.

4. Gravimetry: Gravity and potential; Absolute and relative measurements of gravity; Figure of the earth; clairaut's theorem; International gravity formula; The geoid; Precession of the equinoxes; Crystal structure and isostacy.

5. Geomagnetism: The magnetism of the earth; Measurement of the magnetic field; The main field and its causes; The secular variation; The diurnal variation; Rock magnetism and pale magnetism. **(25 Lectures)**

Part B : Geophysical Prospecting

1. Seismic Method: Instruments and field procedure; The reflection and Refraction methods; Corrections to arrival times; convolution and synthetic seismograms; Decomolution ; Transformation of reflection and refraction time into geological structure.

2. Gravity method: Gravimeters; Field procedure; Correction to gravity observations. The Bouguer anomaly; Density determination; Interpretations; Limitation of gravity interpretation; Depth determination; Determination of total mass; Vertical derivative of gravity.

3. Magnetic method: The static magnetic field; Magnetic properties of rocks; Instruments of magnetic surveying; Field procedure; The interpretation of magnetic anomalies; geological features; Anomalies of sheets and prisms; Smith rule.

4. Other methods: (a) *Electrical method:* Electrical properties of rocks; self potential method; resistively method. (b) *Nuclear method:* Radioactivity of rocks and minerals; Radiation detector and field procedure; Radiation detector and field procedure; Radiocarbon dating; Airborne radioactivity measurements; Field operation and interpretation. **(35 Lectures)**

Books recommended

1. Introductionto Geophysics Mantle Core and Curst:Garland,G.D.
2. Introduction to Geophysics : Howell, B.F
3. Physics of the Earth: Stacey, F.D.
4. Principles of Applied Geophysics : Parasnis, D.S.
5. Applied Geophysics : Telford, W.M. et.al.

PHYS-510: Astrophysics and Cosmology **(Total lectures-60)**
Full Marks: 75 **Examination duration: 04 hours**
Credit: 03 **Five questions to be Answered**

1. Introduction: Stellar magnitude sequence, absolute magnitude and the distance modulus, the celestial coordinates, luminosities of stars, statistical parallax.

2. Classification of Stars: Saha's equation of thermal ionisation, Harvard system of spectral classifications, the luminosity effect on stellar spectra, the H-R diagram, relativistic equation of stellar structure, binary star, white dwarf, neutron star, pulsar, black hole, rotating black hole and Kerr metric.

3. Galaxies: Formation and classification of galaxies, rotation of the galaxy, the general structure and mass of the galaxy, density wave theory, quasars, cosmic ray.

4. Cosmology: Introduction, cosmological principle, red-shift and expansion of the universe, FRW metric, energy-momentum tensor for various forms of matter, CMBR.

5. Models of the Universe: Big-Bang model, initial condition of the universe, monopole problem, production of light elements, primordial abundances and primordial nucleosynthesis.

6. Standard Cosmology: The Friedmann equation, Hubble's law, the expansion age of the universe, thermodynamical entropy production and horizon problem.

7. Structure Formation: Neutrino problem, Hot and Cold dark matter, Ω-problem, quantum cosmology and Brane cosmology.

Books recommended

1. The early Universe : R. Kolb and M. S. Turner
2. An introduction to Astrophysics : B. Basu
3. An introduction to General Relativity: S.K. Bose
4. Gravitation and Cosmology - Principle and Applications of General Theory of Relativity: S.Weinberg
5. Introduction to Cosmology: J.V. Narlikar
6. Tensors, Relativity and Cosmology: Eric. A. Lord
7. Text Book of Astronomy and Astrophysics: V. Bhatia

PHYS-511: Material Physics **(Total lectures-60)**
Full Marks: 75 **Examination duration: 04 hours**
Credit: 03 **Five questions to be Answered**

1. Introduction: Types of metal alloys; Ferrous alloys; Nonferrous alloys; Formation of metals: Forming operations, Costing; Techniques; Annealing processes Heat treatment of Steels; Precipitation hardening; Hydrocarbon molecules; polymer molecules; Chemistry of polymer molecules; Molecular weight, molecules shape, molecular sheeted molecular configuration; Thermoplastic and thermosetting polymers, copolymer's, polymer crystallite; Polyner crystals; Depects in polymers; Behaviour in polymer's; Deformation and strengthening of polymers.

2. Solids: Defect structures in alkalihalide crystals: Electron-excess centres; The F-centre, the Fi-centres the F3-centre; the impurity related centres, the VK centre, The H-centres, K and L bands. Mechanism of defect production in alkali-halide crystals; seitz model. the varley mechanism, The click model. The herch and podey model, Sekf-trapped exciton mechanism.

3. Corrosion: Electro-chemical corrosion of metals: Oxidation deduction reaction, standard Electrode Half cell Potentials for metals, Gavatic cells; Types of corrosion, Oxidation of metals, Corrosion control.

4. Surface And Interfaces of Solid Materials: Surface as interface physics; Definition and importance of surface, Preparation of well-defined surface and rifestaces, surface structure; energy, work function, electron-emission absorption.

5. Characterisation of surfaces and Interfaces: Auger electron spectroscopy (AES), X-ray photoemission Spectroscopy (XPS), Electron-energy loss Spectroscopy (EELS), Low energy electron diffraction (LEED), High-energy electron diffracting (RHEED), Microscopy: STM/AFM (AFM/STM).

6. Magnetic spectroscopy: Basic theory of magnetic phenomenon and allied topics, UV-IR, EPR and NMR spectroscopy, application of solid state and semiconductors.

7. Transient spectroscopy: Impurity and defect centers in semiconductors, deep levels in semiconductors (in si, ge ga as etc.) Methods of straying defect canters in semiconductors.

Books Recommended

1. Materials Science: Anderson, Leaver, Rawentings, Alexander
2. Materials Science and Engineering: V.Raghavan
3. Foundation of Materials Science and Engineering: W.F. Smith
4. Elements of Materials Science and Engineering: L.H. Van Vack
5. Materials Science and Engineering: W.D. Callister. Jr.
6. Surfaces and interfaces of Solid Materials: H. Luth
7. Semiconductor Surfaces and Interfaces: W. Monch
8. Modern Techniques of Surface Science: D.P. Woodruft and T.A. Detchar

PHYS-512: Medical Physics **(Total lectures-60)**
Full Marks: 75 **Examination duration: 04 hours**
Credit: 03 **Five questions to be Answered**

1. Physics of The Human Body: Introduction - Forces on and In the body; Energy, work and power of the body; The physics of the lungs and the breathing; Physics of the cardiovascular system-Major components of the cardiovascular system, work done by heart, blood pressure, blood. flow; Electricity within the body-Nervous system of the neuron, Electrical potential of nerves, Electromyogram, Electrocardiogram, artificial pacemaker.

2. Radiation Blo-Physics: The Cell: Effects of Radiation on the cell, radiation effects on cell structure and function, primary site of radiation damage; cell survival curves. The in vitro survival curve, the in vivo survival curve, chromosomes and cell divisions, radiation induced chromosomes and aberrations; The deposition of radiant energy linear energy transfer(LET); Relative biological effectiveness(RBE). The RBE for different cells and tissues.

3. Radiation Biochemistry: General radiation chemistry-Direct vs indirect effect, radiation chemistry yied, information of free radicals, radiochemistry of water, hydrogen peroxide formation; radiation effects on simple chemical systems-Interaction of radicals with a single solute, interaction of free radicals with several solute, direct vs indirect effect in aqueous solution; reaction in aqueous inorganic solution; reaction in aqueous organic solution; macromolecular reactions; radiation effects on molecules of important biological systems-Proteins, enzymes, nucleic acids, lipids, carbohydrates.

4. Radiation Detection: Types and sources of ionising Radiation; Gamma ray and x-ray interaction in matter; ionization; beam description, beam Attenuation coefficients, Energy transfer coefficient, Energy absorption co-efficient; Interaction of photons with matter- Coherent scattering, Photoelectric effect, Comption effect, Pair production, Photonuclear interactions, Total mass attenuation coefficient; Measurement of ionising radiation-kerma, Relation of kerma to energy fluence for photons, absorbed dose Exposure, calculation of dose from exposure, Absorbed dose in any medium; Free-Air Ionization chambers-Current mode, Pulse mode, Determination of exposure with ionizations chamber, Bragg-

Gray cavity theory; TLD-The thermoinminescence process, Phosphors, Randall-wilkins Theory, Trap stability, TLD Readers, TLD forms, Calibration, Advantages and disadvantages.

5. Modern Imaging Techniques: Production of X-rays - The X-rays tube, Basic X-ray circuit, Physics of X-ray production, X-ray energy spectrum, Operating characteristics; Xray Imaging: contrast, sharpness, resolution, films, cassettes, imaging intensifier; **Ultrasound:** nature, productions, Design, image acquisition and storage, image quality; **Gamma camera:** Gamma camera its collimator and quality control, principles, choice of' radionuclide and radiopharmaceuticals, imaging and function, test on thyroid gland, liver, spleen, kidney, lunges, brain, heart, bone.

6. Physics of Radiotherapy: Clinical Radiation Generators- Superficial and deep therapy (basic idea), Cobalt 60 unit (in brief); Functions used in Dose calculation- Phantom, Percentage Depth Dose (PDD), Back scattering Factor (BSF),Peak scatter factor, Tissue Air-Ratio (TAR), Scatter-Air--Ratio, Tissue-Maximum-Ratio (TMR), Factors affecting PDD, BSF, TAR, TMR, Inverse square law, Relation between TAR & PDD, Equivalent fields; Treatment planning-Isodose chart, Isodose curve, surface, Parameters of isodose curves, Wedge filters, Isocentric Techniques, Wedge field Techniques.

7. Radiation Protection: Dose equivalent, Background radiation, Low levels radiation effects, Maximum permissible dose equivalent, Current Radiation Protection Standards, Structural shielding Design, Radiation Protection surveys, Radiation Protection Instruments(Ionization chamber, Geiger-Muller counter, Solid State detectors), Equipment survey, Area survey, Portable survey meters, Personnel monitoring.

Books Recommended

1. Radiobiology for the Radiologist: Hall. Eric J. And Giaccia. A. J.; Harper and Row. Publishers
2. Medical Physics: Cameron J.R. and Skofronik J.G. Wiley New York, USA
3. The Physics of' the Radiology: Johns H.E, and Cunningham J.R. Charles C Thomas
4. Radiation Biology: Casarett A.P. Prentice Hall, Inc Englewood Cliffs, New Jersey, USA

PHYS-513: Renewable Energy **(Total lectures-60)**
Full Marks: 75 **Examination duration: 04 hours**
Credit: 03 **Five questions to be Answered**

1. Introduction: Introducing Renewable energy system; energy ecology and environment (E3-equation), Fossil fuels and climate change, energy in a sustainable future. Present solution of world/global energy problem and understanding of Bangladesh's present needs of energy. energy analysis & economic aspects.

2. Solar radiation: availability, estimation/computation and measurement; global/total, diffuse and beam-radiation, pyranometry and Pyrheliometry, monsoon and other effect on solar radiation.

3. Solar thermal energy conversion: Basic principle and Application of Flate-plate and Focusing/concentrating type of solar collector, evacuated tube collector, solar thermal system-Hot water system, distillation, solar still, solar cooker, solar pond, solar dryer, and passive cooling standard testing procedure.

4. Review of solar cell and PV module: panel and photovoltaic technology (PVT) and their standard testing procedure. Photovoltaic system components technologies-electric energy storage systems, inverter technologies, charge regulator and system control, power conditioning system, maximum power point tracker. PV system design, stand alone system load estimation, battery sizing,

module/Array sizing and other related component sizing and system wiring. Hybrid system. PV/Dissel generator system and PV/wind system. Status of such system in Bangladesh. Grid connected system: Roof top grid connected PV system, PV/wind grid connected system. Installation and troubleshooting.

5. Hydroelectricity/Hydropower: a brief history of water power. Types of hydroelectric plant, the Francis turbine, Propellers-small scale hydropower (mini-micro-pico) and its present & future prospects in the world.

6. Wind energy: Introduction, estimation wind speed characteristics of the site, relative wind speed. Wind turbine types-Horizontal and vertical and environmental impact.

7. Bioenergy: Introducing biomass, bio fuels and biogas. Renew ability, origin and sustainability of the photosynthetic process. Energy swimming, the sources of bio energy. Gasification, alcoholic fermentation. Fuel cells and fuel cells cycle-basic thermodynamic system or cycles in the bio power generation, biomass based system power, combined cycle and cogeneration power plant. Energy from waste material.

8. Geothermal energy: Introduction origin and renewability, history and basic geophysical and geological process involved, geothermal exploration, well drilling and fluid extraction, Utilization of geothermal energy. Heat pump, geothermal field of the world. The physics of tsunami and its present status.

9. Energy conversion system: Introduction, Ocean, thermal, tidal, wave and animal energy conversion technology; wave energy resources Fixed floating and Tethered devices, wave energy research and development around the world, estimation of wave energy resources of Bangladesh, grid connected wave energy.

Books Recommended:

1. Solar Engineering of thermal processes - J. A Duffie and W. A. Beckmann
2. Treatise on Solar Energy, Volum 1&2 - H.P.Garg.
3. Solar Energy utilization- G.D.Rai.
4. An introduction to solar Enery for scientists and Engineers - S. Wieder.

PHYS-514: Superconductivity **(Total lectures-60)**
Full Marks: 75 **Examination duration: 04 hours**
Credit: 03 **Five questions to be Answered**

1. **Introduction:** Superconductivity- historical overview, Transition temperature; Classification of superconductors; type-I and type-II superconductors, low and high temperature superconductors, Superconducting materials; structural aspects, nomenclature.
2. **Basic phenomena of Superconductivity:** Critical magnetic field, Meissner- Ochsenfeld effect, London equation; london penetration depth, Josephson effect,Energy gaps in superconductor.
3. **Thermodynamic & magnetic properties of Superconductor:** Entropy, Heat capacity; Magnetic flux quantization, magnetic relaxation in HTSCs ,Flux pinning and critical current density , Flux Flow and Flux Creep model; Thermally activated flux flow (TAFF) model . Critical state model.
4. **Phenomenological G-L theory of Superconductivity:** G-L order parameter, Free energy expansion and minimization; Basic G-L equations, Solution for fundamental lengths (ξ,λ) in superconductor ,Critical current (Jc) and Upper critical field (Hc2), Anisotropic superconductor; G-L model, Lawrance – Doniach model.

5. **Microscopic BCS theory of Superconductivity:** Introduction; Isotope effect , Concept of electron -phonon interaction ,Theory of bound electron pair – Cooper pair, The BCS ground state, Self consistent equation, Formula for Transition temperature , Energy gap equation.
6. **Quantum effect :** Quantum mechanical tunnel effect; Josephson junction, Shapiro effect, Pendulum analog, Flux quantization; Fluxoid, the Little – Park experiment , Consequence of flux quantization -SQUID ,Quantum resistance and Diffraction phenomena in superconductor.
7. **Fluctuation effect in Superconductor:** Time dependent G-L equation for fluctuation phenomena; Order parameter Fluctuation, Heat capacity and Diamagnetism ,Paraconductivity; Theoretical model, Evaluation of related parameters , Measurement techniques for HTSCs.
8. **Superconductor Device and Application:** Superconducting devices; Superconducting Taps, Thin films, Transmission Cables, Motors and Generators, Technological Applications ; SQUIDs , MAGLEV, SMES, TES.

Book recommended

1. **I**ntroduction to Superconductivity (1st and 2nd edition): M Tinkham
2. Superconductivity: C.P. Poole , Jr. Horacio, A.Farach , Richard J. Creswick.
3. The Physics of Superconductor ; V.V. Schmidt
4. Superconductivity of Metals & Alloys: P.G.De Gennes.
5. Superfluidity & Superconductivity: D.R. Tilley and J. Tilley.
6. Hamd Book of Superconductivity: C.P. Poole, Jr.
7. Solid state Physics: M. Wahab.
8. Theory of Superconductivity : J.M. Blatt.
9. Elements of Solid State Physics : J.P. Srivastava
10. Solid State Physics: S.O. Pillai.
11. Modern Physics: S.L.Kahani and Shubhra Kakani .
12. Solid State Physics : C. Kittle.
13. Superconductivity – an introduction (unpublished) : M.R. Islam.

PHYS-515: Quantum Field Theory **(Total lectures-60)**
Full Marks: 75 **Examination duration: 04 hours**
Credit: 03 **Five questions to be Answered**

1. Classical Field Theory: Action principle, Euler-Lagrange equations, Hamiltonial Formalism, Poisson brackets, Noether's theorem.
2. Quantization of Scalar Field: Equation of motion, field and canonical quantization, Fourier decomposition of fields, complex scalar field, creation and annihilation operators, particles and anti-particles.
3. Quantization of Dirac field, Dirac equation, plane wave solution of Dirac equation, Fourier decomposition of the field,
4. Quantization of electromagnetic field, problems with quantization
5. The S-matrix expansion: Evaluation operator, S-matrix, Wick's theorem, Feynman diagram.
6. Introduction to gauge theories with SU(n) as gauge group, Higgs Mechanism, spontaneous symmetry breaking, elements of Salam- Weinberg theory, quantum electrodynamics.

Books Recommended

1. A. Lahiri & P.B.Paul: A first Book of Quantum Field theory.
2. Bjorken & Drell: Relativistic Quantum Fields.
3. N.N. Bogoliubov & D.V.Shirkov: Quantum Fields.
4. K. Huang: Quarks Leptons & Gauge Fields.
5. S. M. Bilenky: Introduction to Feynman Diagrams.

PHYS-516 : PHYSICS PRACTICAL

Four experiments of 6 hours duration each shall be done by a student in M.S. examination. Any experiment to be set up in future may be included in the syllabus

Advanced Electronics and Instrumentation:

1. Measurement of L.C.R and Q of a coil at high frequencies and at microwave frequencies.
2. To plot SCR (SN050) characteristics under different gate current condition and to obtain V-BRFO (maximum forward breakdown voltage)
3. To study the charecteristics of a piezoelectric transducer and a ceramic transducer.
4. Experiment on operational Amplifier..
5. LED characteristics: (i) To demontrate the operation of typical visible LED. (ii) To demonstrate the operation of an IC 7 segment decoder- driver and a 7- segment LED decimal display.
6. To demonstrate the operation and application of microprocessors.
7. Digital/ Analog converter (DAC) ckts: (i) Understandings of basic concepts and theories of digital to analog conversion.
8. Analog/ Digital converter (ADC) circuits.

Nuclear Physics:

9. Analysis of NaI (Tl)/HPGE gamma-ray spectra.
10. Calculation of some nuclear properties by computer programs.
11. Age determination by carbon rating
12. Determination of the binding energy of Helium

Solid State Physics:

13. Estimation of absorption co-effiicient and optical band gap from absorption edge of an amorphous semiconductor.

14. Superconductivity : determination of the transition temperature of a high -Tc superconductor and observation of Meissner effect.

15. Superconductivity - Influence of induced voltage on current and magnetic field.

16. X-ray crystallography - determination of lattice constants of crystrals by Laue diagrams and Debye Scherrer photos.

Atmospheric Physics:

17. Prepare (i) Pressure chart and (ii) Temperature chart and analyse them. Calculate wind speed from pressure chart at 10 different points.

18. Prepare (i) Pressure chart and (ii) cloudiness chart & analyse them. Calculate wind speed at 10 different points from pressure chart.

19. Prepare (i) Pressure chart and (ii) humidity chart & analyse them. Calculate wind speed at 10 different points from pressure chart.

20. (a) Prepare a diagnostic chart for the given data of pressure & analyse it. Also analyse pressure tendency data.
    Prepare a prognostic model for 24 hours and analyse it.
    (b) Calculate wind speed at 10 different pts for both diagnostic and prognostic charts.

21. (a) prepare a pressure chart with the given data and analyze it. Find out wind speed at .10 different points in between 20^0 and 25^0 latitude.
    (b) Prepare a synoptic chart for the given rainfall data and compare it with pressure chart, analyze it.
    (c) Plot the pressure data for the given month for Bangladesh and Calculate wind speed at 10 different points.

Semiconductor Physics & devices:

22. Measurement /Calculation of energy band gap of the elemental/compound semiconductor.
23. Study of transport parameters of semiconductor sample.
24. Determination of optical constants of nonabsorbing semiconductor thin film.

Computational Physics:

25. Write codes for implementing different numerical techniques for solving matrix related problems.

26. Write codes for implementing different numerical techniques for solving ordinary differential equations.
27. Write codes for implementing different numerical techniques for solving Partial differential equations.
28. Write codes for Monte Carlo simulation

Geophysics:

29. To calculate auto-correlation, cross-correlation and power spectrum from the given set of data using computer programming.

Renewable Energy:

30. Computation, measurement and analysis of solar radiation data and determination of global, diffuse & beam radiation for solar enegy utilization.

31. Performance study of photvoltaic system.

32. Measurment of absorptance and emittance of solar selective surfaces.