KOHIMA SCIENCE COLLEGE

(An Autonomous Government P.G. College)

JOTSOMA, NAGALAND

Revised

SYLLABUS OF M.SC. PHYSICS

2023

SEMESTER	**COURSE CODE**	**COURSE TITLE**	**CREDITS**
I	MPHC 1.11	Classical Mechanics	5+1
	MPHC 1.21	Quantum Mechanics-I	5+1
	MPHC 1.31	Mathematical Physics	4
	MPHC 1.41	Statistical Mechanics	5+1
	MPHC 1.32	Mathematical Physics	2
II	MPHC 2.11	Electrodynamics	4
	MPHC 2.21	Quantum Mechanics- II	5+1
	MPHC 2.31	Nuclear & Particle Physics	4
	MPHC 2.41	Condensed Matter Physics	4
	MPHC 2.12	Electrodynamics	2
	MPHC 2.32	Nuclear & Particle Physics	2
	MPHC 2.42	Condensed Matter Physics	2
	MPHC 3.11	Embedded Systems: Introduction To Microcontrollers	4
	MPHC 3.21	Atomic & Molecular Spectroscopy	4
	MPHC 3.12	Embedded Systems: Introduction To Microcontrollers	2
	MPHC 3.22	Atomic & Molecular Spectroscopy	2
	MPHD 3.11(a)	Nano Science	4
	MPHD 3.11(b)	Remote Sensing of the atmosphere	4
	MPHD 3.11(c)	High Energy Physics	5+1
	MPHD 3.21(a)	Astronomy and Astrophysics	4
	MPHD 3.21(b)	Digital Signal Processing	4
	MPHD 3.21(c)	Plasma Physics	5+1
	MPHD 3.12(a)	Nano Science	2
	MPHD 3.12(b)	Remote Sensing of the atmosphere	2
	MPHD 3.22(a)	Astronomy and Astrophysics	2
	MPHD 3.22(b)	Digital Signal Processing	2
IV	MPHC 4.11	Computational Physics	4
	MPHC 4.21	Experimental Methods	4
	MPHC 4.12	Computational Physics	2
	MPHC 4.22	Experimental Methods	2
	MPHD 4.11(a)	Atmospheric Physics	4
	MPHD 4.11(b)	Applied Dynamics	5+1
	MPHD 4.11(c)	Communication Electronics	4
	MPHD 4.11(d)	Bio Physics	4
	MPHD 4.12(a)	Atmospheric Physics	2
	MPHD 4.12(c)	Communication Electronics	2
	MPHD 4.12(d)	Bio Physics	2
	MPHD 4.21	Dissertation	6

MPHC 1.11
CLASSICAL MECHANICS
Theory Credit: 5
Tutorial Credit: 1
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UNIT I (Variational Principle & Lagrangian Formulation):

Mechanics of a particle, mechanics of a system of particles, constraints, classification of constraints, degrees of freedom, generalized coordinates,generalized displacement, generalized velocity, acceleration, momentum, force and potential ,D'Alembert's principle,Lagrange's equations, Hamilton's principle,calculus of variation,variational principle,Euler's-Lagrange differential equation, simple application of Euler's-Lagrange differential equation, shortest distance between two points in a plane (Geodesics),the brachistochrone problem, Lagrangian for a charged particle in an electromagnetic field, gyroscopic forces, non -conservative forces, Lagrange's equation of motion for an Atwood's machine, Lagrange's equation of motion for a bead sliding on a uniformly rotating wire in a force free space, Lagrange's equation of motion for one dimensional motion, time period of a simple pendulum by using Lagrange's equation of motion, Lagrange's equation of motion for a compound pendulum, Limitations of Newton's Laws, and advantages of Lagrangian approach over Newtonian mechanics, advantages of variational principle formulations.

UNIT II (Central force problem, Kinematics of a rigid body & the rigid body equations of motion):

Central force problem, reduction to the equivalent one body problem, the equation of motion and first integrals, Kepler's laws of planetary motion, classification of orbits, Virial theorem, scattering in a central force field, differential scattering cross section, impact parameter, Rutherford scattering.
Kinematics of a rigid body, the independent coordinates of a rigid body, Generalized coordinates for a rigid body motion, orthogonal transformations, Euler angles, Euler's theorem on the motion of a rigid body, Chasles' theorem, rate of change of a vector
Rigid body equations of motion, angular velocity of a rigid body, angular momentum of rigid body, tensors, Inertia tensor and the moment of inertia, moments and product of inertia, eigen value of the Inertia tensor and the principal axes transformation, principal moment of inertia, diagonalization of matrix, secular equation of inertia tensor, torque free motion of a rigid body, heavy symmetrical top with one point fixed.

UNIT III (Small Oscillations):

Small oscillations, formulation of the problem, the eigen equation and the principal axes transformation frequencies of free vibration and normal coordinates, free vibrations of a linear tri atomic molecule, stable and unstable equilibrium, dynamic and metastable equilibrium, normal mode, normal coordinates, theory of small oscillation for two coupled oscillators, Lagrange's equation of motion for small oscillations, normal coordinates and normal frequencies of vibration, normal mode of vibrations, application of the theory of small oscillations to a systems with few degrees of freedom like a parallel pendulum and double pendulum.

UNIT IV (Special theory of relativity & Hamilton equation of motion):

Basic postulates of the special theory of relativity, Lorentz transformations, velocity addition, metric tensors, Lagrangian formulation of relativistic mechanics, covariant Lagrangian formulations.

Legendre transformation and the Hamilton equations of motion, cyclic coordinates, Routh's procedure, principle of least action, Hamiltonian formulation in classical mechanics, physical significance of Hamiltonian, applications of Hamilton's equations of motion for simple pendulum, compound pendulum, linear Harmonic oscillator, two dimensional isotropic harmonic oscillators, Hamiltonian for a charged particle in an electromagnetic field, advantages of introducing Hamiltonian formulation.

UNIT V (Canonical Transformations& Hamilton- Jacobi theory):

Canonical transformations, point transformations, Conditions for a canonical transformation, generating function, first, second third and fourth form of generating function, harmonic oscillator, Poisson brackets and properties, invariance of Poisson's brackets under canonical transformation, Hamilton's equation in Poisson bracket notation, Liouville's theorem.

Hamilton-Jacobi equation, the harmonic oscillator problem as an example of Hamilton - Jacobi method, ignorable coordinates.

Recommended Books and References:

1. Classical Mechanics – H. Goldstein, 2nd Edition, Addison-Wesley Pub. Co.
2. Classical Electrodynamics_ J.D. Jackson, 3rd Edn., 1998, Wiley.
3. Mechanics- L.D. Landau and E.M. Lifschz (pergamon).
4. Classical Mechanics- J.W. Muller-Kirsten (world Scientific,2008).
5. Classical Mechanics of particles and Rigid bodies – Kiran C. Gupta, New Age international (P) Ltd., 2008
6. Classical Mechanics – S.L. Gupta, V. Kumar and H.V. Sharma, Pragati Prakashan Publishers, Meerut, India (2010).
7. Classical mechanics – P.S. Joag and N.C. Rana, Tata McGraw - Hill Education (2001).
8. Classical Mechanics – J.C. Upadhyaya, Himalaya Publishing House, India (2010).

MPHC 1.21
QUANTUM MECHANICS-I

Theory Credit: 4

UNIT I **Review of Basic Concepts:** Schrödinger equation and Statistical Interpretation of the Wave Function; Expectation Values of Discrete and Continuous quantities; Normalization of the Wave Function and conservation of Probability; Momentum and Ehrenfest's Theorem. Uncertainty Principle. Postulates of quantum mechanics.
Stationary States– 1: Infinite square well, One Dimensional Linear Harmonic Oscillator – Algebraic Method (Operator Method) and Analytical Method. Free Particle, its position and momentum representation, Dispersion Relation, Gaussian Wave Packet.

UNIT II **Stationary States–** 2: Dirac Delta potential and its bound state wave function. Dirac-Delta Well and Scattering, Finite Square Well, Brief Introduction to the Scattering Matrix and Transfer Matrix.
Formalism of Quantum Mechanics – 1: Hilbert Space, Observables and Hermitian Operators, Eigenfunctions of a Hermitian Operator. Generalised Statistical Interpretation. Uncertainty Principle, Minimum Energy Wave packet, Energy-time Uncertainty.

UNIT III **Formalism of Quantum Mechanics** – 2: Dirac's Notation. Virial Theorem. Coherent States of the Harmonic Oscillator. Extended Uncertainty Relation, Translation of Space, Time and their Generators.
Stationary States in Three Dimensions: Commutation Relations of Position and Momentum in Three Dimensions. The Spherical Potential Well. Schrodinger Equation in spherical coordinates, Hydrogen atom in Spherical Coordinates, Detailed solutions for the Eigen Values and Eigen Functions, Hydrogen Spectrum.

UNIT IV **Review of Angular Momentum**: Ladder Operators, Eigen Functions and Eigen Vectors. Uncertainty Principle for the Components of the Angular Momentum. Rigid Rotator- Eigen values and Eigen Functions. Spin ½ systems and Pauli's Spin Matrices. Electron in a Magnetic Field and Larmor Precession. Matrix representation of J in $|jm\rangle$ basis. Addition of Angular Momenta, Singlet and Triplet States. Clebsch-Gordon Coefficients.

UNIT V **Identical Particles**: Two Particle Systems, Schrodinger Equation, Energy Eigenvalues for Positronium and Muonic Hydrogen. Bosons and Fermions, Exclusion Principle. Exchange forces. Slater's Determinant. Atoms - Helium Atom, Para and Ortho Helium, Periodic Table and Hund's Three Rules.

Recommended Books and References:

1. *Introduction to Quantum Mechanics* - *David J Griffiths*
2. *Quantum Mechanics* -*L. Schiff.*
3. *Quantum Mechanics* -*S.N.Biswas.*

4. *Quantum Mechanics* -*A.K.Ghatak and S.Lokanathan.*
5. *Introductory Quantum Mechanics* -*R.L.Liboff.*
6. *Principles of Quantum Mechanics* -*R. Shankar.*
7. *Quantum Mechanics: Concepts and applications* -*N.Zettili*

MPHC 1.31
MATHEMATICAL PHYSICS
Theory Credit: 4

UNIT I Fourier Transform Fourier integral theorem, Fourier sine and cosine integral, Fourier complex integral, Fourier transform, Fourier sine and cosine transform, properties of Fourier transform, Perseval theorem, Fourier transform derivative, application of Fourier transform to solve differential equation , evaluation of integral and boundary value problems(1-D wave and heat flow equation).

UNIT II Laplace transform Laplace transform, properties of Laplace transform, Laplace transform of elementary functions, Laplace transform of derivative f(t), Laplace transform of derivative of order n, Laplace transform of integration of f(t), Laplace transform of some special functions(periodic function , gamma function , Bessel functions Jo(x) and J1(x), Convolution theorem, inverse Laplace transform, properties of inverse Laplace transform, solution of differential equations using Laplace transform.

UNIT III Tensors n-dimensional space, sub space, subscript, superscript, Einstein summation convention, dummy suffix, real suffix, transformation of coordinates, Kronecker delta, contravariant vector, covariant vector, definition of tensor, gradient tensor field, addition and subtraction of tenors, multiplication of tensors, inner product, contraction, symmetric and anti-symmetric tensor, quotient law, reciprocal symmetric tensor, metric, gij as a second rank covariant symmetric tensor, Christioffel symbol of first and second kind, tensor law of transformation of Christioffel symbol.

UNIT IV Special functions Legendre DE and polynomial, Generating Function ,Orthogonality, simple recurrence relations, Bessel DE, Generating Function, simple recurrence relations Bessel function of First kind, Bessel function for integral, half integral orders, Neumann functions, Hankel functions, modified Bessel equation, spherical Bessel function , Characteristic of various Bessel functions, Hermite DE, One dimensional linear harmonic equation as Hermite equation, energy quantization and zero point energy, Laguerre DE,

UNIT V Group and symmetry Elementary properties of groups, uniqueness of solution, Subgroup, Centre of a group, Co-sets of a subgroup, cyclic group, Permutation/Transformation. Homomorphism and Isomorphism of group, Classes, Some special groups with operators. Matrix Representations: Reducible and Irreducible, characters, Great Orthogonality theorem and its consequences, Character table. Symmetry elements, Operations, Planes, Reflections, Inversion Center, Proper and Improper axes and rotations, Equivalence, Symmetry and Optical Isomerism, Symmetry point groups, Classes of Symmetry operations, Systematic procedure for symmetry classification of molecules and applications.

Recommended Books and References:
1. Mathematical Methods for Physicists: Weber and Arfken, Academic Press.
2. Introduction to Mathematical Physics: Charlie Harper, Prentice Hall India Learning Pvt Ltd
3. Mathematical Methods in Physical Sciences: Mary L Boas, Wiley India Pvt Ltd
4. Mathematical Methods for Physicists: A Concise Introduction: Tai L. Chow, Cambridge Univ. Press.
5. Elements of Group Theory for Physicists by A. W. Joshi, 1997, John Wiley.

6. Group Theory and its Applications to Physical Problems by Morton Hamermesh, Dover
7. Mathematical Physics: B. D. Gupta, Vikas Publication House Pvt Ltd
8. Mathematical Physics: B. S. Rajput, Pragati Prakashan
9. Mathematical Physics: H.K. Dass, S Chand
10.Special Functions by E.D Rainville

MPHC 1.41
STATISTICAL MECHANICS

Theory Credit: 5
Tutorial Credit: 1

UNIT I **Classical Statistical Mechanics:** Statistical basis of thermodynamics, probability calculations, thermodynamic probability, macrostates and microstates, statistical definition of entropy, Boltzmann relation for entropy and Gibb's paradox, phase space and Liouville's theorem (classical), micro-canonical ensemble, Maxwell velocity distribution**,** canonical ensemble, system in canonical ensemble, calculation of thermo dynamical quantities, partition function, classical systems, energy fluctuations in canonical ensemble, system of harmonic oscillators, thermodynamics of magnetic system, negative temperature.

UNIT II **Quantum Statistical Mechanics:** Grand canonical ensemble, equilibrium between a system and a particle, energy reservoir; Grand partition function and derivation of thermodynamics; Fluctuations, density operator, density matrix , time dependence of density matrix, density matrix in microcanonical, canonical and grand canonical ensembles, Quantum Liouville's equation, quantum statistical microcanonical, canonical and grand canonical ensembles and their partition functions, ideal gas in microcanonical ensemble, Statistical weights and occupation number, distribution for ideal Bose, Fermi and Maxwell-Boltzmann gases.

UNIT III **Ideal Fermi and Bose Systems:** Ideal gas in quantum mechanics, Statistics of occupation numbers, Thermodynamic behaviour of an ideal Bose gas, phenomenon of Bose Einstein condensation, Thermodynamics of blackbody radiation and
Planck's radiation law, Thermodynamic behavior of an ideal Fermi gas, concept of Fermi energy, mean energy of fermions at absolute zero, Boltzmann limit of Boson and Fermions gases, Fermi energy as a function of temperature, behaviour of specific heat with temperature, Einstein and Debye's theory of specific heat of solids, Thermodynamic equilibrium of white dwarf stars.

UNIT IV **Non-Equilibrium Statistical Mechanics:** Fluctuations and irreversible process. Fluctuations in ensambles, Brownian motion: as a random walk (EinsteinSmoluchowski theory), as a diffusion process; Langevin theory of Brownian motion; Fluctuation dissipation theorem, motion of fluctuating force and Fokker-Planck equation, Spectral analysis of fluctuation- Wiener-Khintchine relations. Electrical noice and Niquist theorem,

UNIT V **Phase transition:** Triple point, Phase transition, Vander Walls equation and phase transition, symmetry, order of phase transitions and order parameter, critical point, critical exponent and their scaling, Elementary ideas on Ising model, one dimensional Icing model, Yang and Lee Theory of phase transition, Landau's mean-field theory of phase transition, symmetry breaking. Heisenberg models of ferromagnetism, Bethe approximation

Recommended Books and References:

1. Statistical Mechanics, R.K Patharia& P.D Beal, 3rd Edition, Elsevier 2011.
2. Statistical Mechanics, K Huang, 2nd edition, Wiley Indra Edition, 2009.
3. Statistical Physics of Particles, Karden M., Cambridge University Press, 2007.
4. Statistical mechanics, J.K. Bhattacharjee.
5. Statistical mechanics – Satya Prakash, Kedar Nath Ram Nath publication 2008.
6. Statistical mechanics- Loknathan and Gambhir
7. Statistical mechanics- Gupta, Kumar and Sharma, Pragati Edition
8. Statistical mechanics- Eisner and Sharma Agarwal.

MPHC 1.32 Laboratory Physics Credit: 2

Scilab/C++/matlab (or equivalent) based code/simulations/experiments on Mathematical Physics problems .

The teacher in charge can add or delete any experiment in this list but replace it with another of the same level.

1. Plotting of Legendre, Hermite, Laguerre polynomials and Beseel function of first kind.
2. Orthogonality of Hermite and Laguerre polynomial (using integration)
3. Fourier transform of some functions.
4. Laplace transform of some functions.
5. Integral transform FFT of e^{-x^2}
6. Plotting of wave functions vs position for particle in 1-D box.
7. Plotting of wave functions vs position for linear harmonic oscilatter..
8. Evaluation of Eigen value and eigen vector.
9. Solution of time independent equation for ground and first excited state of H – atom for the potential $V = \frac{1}{4\pi\epsilon_o}\frac{e^2}{r}$.

References Books:

1. Schaum's outline of Programming with C++. J.Hubbard, 2000, McGraw-Hill Publication
2. Numerical Recipes in C: The Art of Scientific Computing, W.H. Pressetal., 3rdEdn., 2007, Cambridge University Press.
3. Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press
4. An introduction to computational Physics, T.Pang, 2nd Edn.,2006, Cambridge Univ. Press
5. Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific & Engineering Applications: A. VandeWouwer, P. Saucez, C. V. Fernández.2014 Springer.
6. Scilab (A Free Software to Matlab): H. Ramchandran, A.S. Nair. 2011 S. Chand & Co.

7. Scilab Image Processing: L.M.Surhone.2010 Betascript Publishing ISBN:978-613345927
8. www.**scilab**.in/textbook_companion/generate_book/291

SEMESTER – II

MPHC 2.11
ELECTRODYNAMICS

Theory Credit: 4

UNIT I Boundary Value Problems & Potential Formulation:(a) Review on the following topics (derivations are not required): Gauss's law, Biot-Savart law, Ampere's theorem, electromagnetic induction, dielectrics and conductors, Maxwell's equations. (b) Poisson's and Laplace's equations, solution of Laplace's equation in cartesian, spherical and cylindrical coordinates, Green Reciprocity theorem, electromagnetic scalar and vector potential function, Lorentz condition, gauge transformation, coulomb and Lorentz gauge, inhomogeneous wave equation in terms of electromagnetic potentials, D' Alembert equation, gauge invariance, Lorentz force in terms of electromagnetic potentials.

UNIT II Electromagnetic Waves Propagation: Propagation of electromagnetic waves in vacuum, plane electromagnetic waves in isotropic and anisotropic non-conducting medium, plane electromagnetic waves in a conducting medium, reflection and transmission of electromagnetic waves at normal and oblique incidence, reflection and transmission of electromagnetic wavesat a conducting surface, the frequency dependence of permittivity.

UNIT III Wave Guides & Resonant Cavities: wave guides, wave between parallel conducting planes, cylindrical cavities and waveguides, boundary conditions in Electromagnetic (EM) waves, propagation of electromagnetic waves along a hollow conducting pipe, perfectly conducting wave guide, transverse magnetic (TM) mode, transverse electric(TE) mode, transverse electric and magnetic mode (TEM), modes of the guide, rectangular wave guide, TE and TM mode for rectangular wave guide, rectangular resonant cavity for TE and TM mode, resonant frequency of the rectangular cavity, resonant cavity, circular waveguide, solutions of wave equation for circular waveguide, TE and TM modes of circular waveguide. .

UNIT IV Retarded Potential & Radiation: Retarded potentials, retarded potential solution of the inhomogeneous wave equation, green function, retarded solution for scalar and vector potentials, radiation from an oscillating electric and magnetic dipole, radiation from a localized oscillating source, Lienard-Wiechert Potentials and fields from a point charge, Larmor's formula and its relativistic generalization, linear and circular relativistic motion, radiation reaction, Abraham-Lorentz formula

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UNIT V Relativistic Electrodynamics: Postulates of the special theory of relativity, Lorentz transformation equations, Minkowski four dimensional space time continuum, Lorentz transformation of space and time in four vector form, concept of invariant interval, space like, time like and light like interval, space – time diagram, Lorentz conditions in covariant form, invariance of Maxwell's field equation under Lorentz transformation, equation of continuity in covariant form, electromagnetic field tensors in terms of electromagnetic potential, electromagnetic anti symmetric tensor, Lorentz transformation of electric and magnetic fields.

Recommended Books and References:

1. Introduction to Electrodynamics, D.J. Griffiths, 3rd Ed., 1998, Benjamin Cummings.
2. Classical Electrodynamics, J.D. Jackson,3rdEdn., m1998, Wiley.
3. Elements of Electromagnetics, M.N.O. Sadiku, 2001, Oxford University Press.
4. Fundamentals of Electromagnetics, M.A.W. Miah, 1982, Tata McGraw Hill
5. Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer
6. Foundations of Electromagnetic Theory, Ritz, J. R. and Millford, F. J. Prentice Hall India
7. Electromagnetism, Slater, J. C., and Frank, N. H., Dover Publications, 2011
8. Fundamentals of Electromagnetism, Miah, W., Tata McGraw Hill, 1982
9. Feynman Lecture Series Volume II, 4. Feynman, R. P., Addison Wesley Longman
10. Principles of Electrodynamics, Melvin Schwart, Dovers publication,198.7

MPHC 2.21
QUANTUM MECHANICS-II

Theory Credit: 5
Tutorial Credit: 1

UNIT I **Time Independent Perturbation Theory:** Non degenerate Perturbation Theory, First-Order Theory, Second-Order Energies. Degenerate Perturbation Theory, Two-Fold Degeneracy, Higher-Order Degeneracy, Fine Structure of Hydrogen-Relativistic Correction and Spin-Orbit Coupling, Stark effect, Zeeman Effect (Weak, strong & intermediate effect). Hyperfine Splitting.

UNIT II **Time-Dependent Perturbation Theory:** Two-Level Systems. Sinusoidal Perturbations. Rabbi Flopping Frequency. Emission and Absorption of Radiations, Incoherent Perturbations. Spontaneous Emission, Lifetime of Excited States, Selection Rules. Magnetic Resonance. Adiabatic approximation- sudden approximation.

Unit III **Variational Principle:** Ground State Energy for Harmonic Oscillator, Delta Function Potential, and particle in a box. Triangular Trial Wave Function in Infinite Well.Ground State of Helium, Hydrogen Molecular Ion.

UNIT IV **WKB Approximation:** Basic principles and applications to particle in a box, harmonic oscillator, hydrogen atom. WKB approximation: Qualitative development and condition for validity of WKB approximation, Bohr's quantization condition, Applications to tunneling such as alpha particle, field emission. Einstein's coefficients.

UNIT V **Scattering:** Classical Scattering Theory, Hard Sphere Scattering, Differential Scattering Cross-Section, Total Cross Section. Rutherford Scattering.Quantum Scattering.Partial Wave Analysis, Rayleigh's Formula, Quantum Hard-Sphere Scattering.Phase Shifts.Born Approximation – First Approximations, Low-Energy Soft-Sphere Scattering, Yukawa Scattering, Born Series.

Recommended Books and References:

1. Quantum Mechanics – Leonard I Schiff, McGraw-Hill
2. Introduction to Quantum Mechanics – David J Griffiths, Prentice Hall
3. Principals of Quantum Mechanics – P A M Dirac, Oxford University Press
4. Quantum Mechanics – Eugene Merzbacher, John Wiley & Sons
5. Quantum Mechanics – A Ghatak and S Lokanathan, Trinity Press
6. A Textbook of Quantum Mechanics – Mathews and Venkatesan, McGraw Hill
7. Advance Quantum Mechanics – B S Rajput, Pragati Prakashan
8. Quantum Mechanics – M P Khana, Har-Anand Publications

MPHC 2.31
NUCLEAR AND PARTICLE PHYSICS
Theory Credit: 4

UNIT I **Nuclear properties:** Nuclear Properties, Measurement of Nuclear size and estimation of R_0, Deuteron system and its characteristic, Estimate the depth and size of (assume) square well potential, Nuclear Forces, Characteristics of Nuclear forces-Ground state of deuteron, scattering cross-sections, qualitative discussion of neutron-proton and proton-proton scattering at low energies-charge independence, spin dependence and charge symmetry of nuclear forces-exchange forces and tensor forces-Meson theory of nuclear forces (Yukawa's potential), Spin-orbit strong interaction between nucleon, double scattering experiment

UNIT II **Nuclear Decay:** Review of alpha decay, introduction to Beta decay and its energetic, Energy release in Beta-decay, Fermi's theory of β-decay, Information from Fermi– curie plots, Comparative half lives, selection rules: Fermi and G-T transitions, Gamma decay, energies of gamma decays, selection rules multipole radiation, Selection rule for gamma ray transitions, Detection and properties of neutrino, Properties of Neutrino, helicity of Neutrino, Qualitative discussion on Parity violation in beta decay and Wu's Experiment.

UNIT III **Nuclear Reactions:** Review of nuclear reactions and conservation laws, cross section (σ), mean free path, definition/expression for σ, Low energies , Discrete and Continuum Region, Discrete region Resonance scattering, Derivation of the resonance cross section from phase shift description of cross section, Transmission through a square well and resonances in continuum, Continuum Region, Bohr's compound nucleus model, and its experimental verifications, Statistical parameters and their estimates for the continuum region. Direct Reactions, resonance reaction, qualitative discussion on Pre-equilibrium reactions.

UNIT IV **Nuclear Models:** Microscopic Models, Fermi-Gas Model: Symmetry, surface and Coulomb energy; Deformed shell model, Nilsson Hamiltonian, Single-particle energies in a deformed potential, Shell corrections and the Strutinski method, Hartree-Fock approximation: general variational principle, Hartree-Fock equations and applications, Review of Liquid drop model and mass formulas, Fission barriers and types of fission; Parameterization of nuclear surface deformations, Prolate and oblate shapes, collective models, vibrational and rotational levels.

UNIT V **Elementary Particle Physics**: Introduction to the elementary particle Physics, The Eightfold way, the Quark Model, the November revolution and aftermath, The standard Model, Revision of the four forces, cross sections, decays and resonances, Introduction to Quantum Electrodynamics, Introduction to Quantum Chromo dynamics. Weak interactions and Unification Schemes (qualitative description), Revision of Lorentz transformations, Four-vectors, Energy and Momentum, Parity**,** Charge conjugation, Time reversal, Qualitative introduction to CP violation and TCP theorem, discovery of K-mesons, and hyperons Gellmann and Nishijima formula and Charm, Elementary ideas of CP and CPT invariance, SU(2), SU(3) multiples.

Recommended Books and References:

1. Nuclear Physics - D.C. Tayal, Himalaya Publishing Co. (Bsc level)
2. Introduction to Nuclear Physics - Harald A. Enge.
3. Concepts of Nuclear Physics - Bernard L.Cohen.
4. Introduction to High Energy Physics - D.H.Perkins.
5. Introduction to Elementary Particles - D.Griffiths.
6. Nuclear Physics - S.B.Patel, Wiley Eastern Ltd. Bsc level
7. Introductory Nuclear Physics - Kenneth S. Krane, John Wiley (1988).
8. Physics of Nuclei and Particles - E. Segre.
9. Elements of Nuclear Physics - M.L.Pandya, R.P.S Yadav
10. Basic Nuclear Physics - B.N.Srivastava.

MPHC 2.41

CONDENSED MATTER PHYSICS

Theory Credit: 4

UNIT I **Lattice Vibrations And Specific Heat Of Solids Lattice vibration:** Einstein and Debye theory of specific heat of solids, Dispersion relation in linear monoatomic and diatomic liner lattices, quantization of lattice vibration-phonon, Free electron theory of metals: The free electron gas, thermal conductivity and electrical conductivity, Wiedemann-Franz law, Limitation offree electron theory in metals, electronic specific heat.

UNIT II **Energy Bands In Solids:** Bloch theorem , Kronig Penny model (band theory of solids), Motion of electrons in periodic potential, effective mass of electrons and holes, Distinction between metals, insulators and semiconductors, nearly free electron approximation, the tight binding approximation, application to a simple cubic crystal.

UNIT III **Elements of Semiconductor Physics:** Intrinsic and extrinsic semiconductors, mobility, drift velocity and conductivity of intrinsic semiconductor, density of carriers in intrinsic and extrinsic semiconductors, recombination processes, Variation of Fermi level with temperature and carrier concentration, conductivity and their variation with temperature, direct and indirect band gap semiconductors, Hall effect and magnetoresistance.

UNIT IV **Superconductors and Dielectrics:**
Superconducting materials, Types of superconductors, Meissner effect, London equation and penetration depth, Isotope effect, Flux quantization and Josephson effect, BCS theory, Applications of superconductors.
Concept of local field, The electronic, ionic and orientation polarizabilities, measurement of dielectric constant of a solid, Clausius-Mosotti relation, relation between dielectric constant and refractive index.

UNIT V **Magnetic materials:**
Dia, para and ferro magnetism, Langevin theory of dia and para magnetism, Curie-Weiss law, Pauli paramagnetism, Weiss theory of Ferromagnetism, Heisenberg's exchange interaction, elements of ferrimagnetism and antiferromagnetism, Neel temperature

Recommended Books and References:

1. Kittel, C., Introduction to Solid State physics 7th Edition (Wiley, Eastern Ltd., 1996).
2. Dekker, A. J., Solid State Physics (Macmillan India Ltd., 2003).
3. Ashcroft, N. W. & Mermin, N. D., Solid State Physics (Saunders, 1976).
4. Ibach, H. & Luth, H., Solid State Physics, (Springer-Verlag).
5. Azaroff, L.V., Introduction to Solids, (Tata McGraw Hill, 1977).
6. Pillai, S.O., Solid State Physics, (New Age International Publishers).
7. Ziman, J.M., Principles of theory of solids (Cambridge University Press)
8. Omar, M. A., Elementary Solid State Physics (Pearson).

MPHC 2.12
ELECTRODYNAMICS (PRACTICAL)

Practical Credit: 2
Each Student is expected to perform at least 5-6 experiments out of the following list:

1. To verify the Stefan`s law of radiation and to determine Stefan's constant.
2. To determine the Boltzmann constant using V-I characteristics of PN junction diode.
3. To determine the wavelength and velocity of ultrasonic waves in a liquid (Kerosene Oil, Xylene, etc.) by studying the diffraction through ultrasonic grating.
4. Study of microwaves characteristics through different dielectric medium.
5. To study the reflection, refraction of microwaves
6. To study the magnetic parameters of a magnetic material by hysteresis loop tracer.
7. Study of temperature variation of refractive index of a liquid using hollow prism and laser source.

Computational Lab

8. Applications of Smith Chart:

a) Admittance calculations on any transmission line, on any load.

b) Impedance calculations on any transmission line, on any load.

c) Calculation of the length of a short circuited piece of transmission line to provide a required capacitive or inductive reactance.

9. Generate Electromagnetic Wave using software.

10. To study the radiation pattern for a simple Dipole antenna.

11. To study propagation of wave using Rectangular Waveguide

12. To study impedance match using software.

13. To calculate phase & group velocity.

14. To plot radiation pattern of dipole antenna.

15. To plot radiation pattern of monopole antenna.

Recommended Books and References:

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
3. A Text Book of Practical Physics, I.Prakash& Ramakrishna, 11thEd., 2011, Kitab Mahal.
4. Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer

MPHC 2.32

NUCLEAR AND PARTICLE PHYSICS (PRACTICAL)

Practical Credit: 2

This course aims at experiments in Basics Nuclear Physics. Each Student is expected to do at least 70% of the listed experiments. The teacher in charge has the flexibility to add / delete any experiments per the needs of the course.

1. Study of the characteristics of a GM tube and determination of its operating voltage, plateau length/ slope etc.

2. Verification of inverse Square law for gamma rays.

3. Estimation of efficiency of the GM detector for gamma Source / Beta Source.

4. To study Beta particle range and Maximum Energy (Feather analysis).

5. Backscattering of Beta particles.

6. Production and attenuation of Bremsstrahlung.

7. Study of energy resolution characteristics of a scintillation Spectrometer as a function of applied high Voltage and to determine the best operating Voltage.

8. Study of Energy Cs-137 Spectrum and calculation of FWHM and resolution for given Scintillation detector.

Recommended Books and References:

1. Radiation Detection and Measurement G. F. Knoll, John Wiley (1988).
2. Nuclear Electronics P. W. Nicholson, Wiley, London (1974)

MPHC 2.42
CONDENSED MATTER PHYSICS (PRACTICAL)

Practical credit: 2

N.B: In certain situation the concern teachers may take the liberty to replace a given experiment(s) by a similar type of experiment(s) depending upon the available resources.
1. To measure the magnetic susceptibility of Solids.
2. To measure the Dielectric Constant of dielectric Materials with Frequency.
3. To draw BH curve of Fe using Solenoid & determine energy loss from Hysteresis.
4. To measure the resistivity of a semiconductor (Ge) with temperature by four-probe method (room temperature to 150oC) and to determine its band gap.
5. To determine the Hall coefficient of a semiconductor sample.

Recommended Books and Recommended Books and References:

1. Advanced practical physics for students , B.L. Flint and H.T. worsnop, 1971, Asia publishing House.
2. Advanced level Physics Practical's, Michael Nelson and Jon M. Ogborn, 4th edition, reprinted 1985, Heinemann Educational Publishers.
3. A text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal.
4. Elements of solid state Physics, J.P. Srivastava, 2nd Ed., 2006, Prentice Hall of India.

SEMESTER – III

MPHC 3.11
EMBEDDED SYSTEMS: INTRODUCTION TO MICROCONTROLLERS

Theory Credit: 4

UNIT I Embedded system introduction: Introduction to embedded systems and general purpose computer systems, architecture of embedded system, classifications, applications and purpose of embedded systems, challenges & design issues in embedded systems, operational and non-operational quality attributes of embedded systems, elemental description of embedded processors and microcontrollers.
Review of microprocessors: Organization of Microprocessor based system, 8085μp pin diagram and architecture, concept of data bus and address bus, 8085 programming model, instruction classification, subroutines, stacks and its implementation, delay subroutines, hardware and software interrupts.

UNIT II **8051 microcontroller**: Introduction and block diagram of 8051 microcontroller, architecture of 8051, overview of 8051 family, 8051 assembly language programming, Program Counter and ROM memory map, Data types and directives, Flag bits and Program Status Word (PSW) register, Jump, loop and call instructions.

8051 I/O port programming: Introduction of I/O port programming, pin out diagram of 8051 microcontroller, I/O port pins description & their functions, I/O port programming in 8051 (using assembly language), I/O programming: Bit manipulation.

UNIT III Programming: 8051 addressing modes and accessing memory using various addressing modes, assembly language instructions using each addressing mode, arithmetic and logic instructions, 8051 programming in C: for time delay & I/O operations and manipulation, for arithmetic and logic operations, for ASCII and BCD conversions.

UNIT IV **Timer and counter programming**: Programming 8051 timers, counter programming.

Serial port programming with and without interrupt: Introduction to 8051 interrupts, programming timer interrupts, programming external hardware interrupts and serial communication interrupt, interrupt priority in the 8051.

Interfacing 8051 microcontroller to peripherals: Parallel and serial ADC, DAC interfacing, LCD interfacing.

UNIT V **Programming Embedded Systems**: Structure of embedded program, infinite loop, compiling, linking and locating, downloading and debugging.

Embedded system design and development: Embedded system development environment, file types generated after cross compilation, disassembler/ decompiler, simulator, emulator and debugging, embedded product development life-cycle, trends in embedded industry.Introduction to Arduino: Pin diagram and description of Arduino UNO. Basic programming.

Recommended Books and References:

1. Embedded Systems: Architecture, Programming & Design, R.Kamal, 2008,Tata McGraw Hill
2. The 8051 Microcontroller and Embedded Systems Using Assembly and C, M.A. Mazidi, J.G. Mazidi, and R.D. McKinlay, 2nd Ed., 2007, Pearson Education India.
3. Embedded microcomputor system: Real time interfacing, J.W.Valvano, 2000, Brooks/Cole
4. Microcontrollers in practice, I. Susnea and M. Mitescu, 2005, Springer.
5. Embedded Systems: Design & applications, S.F. Barrett, 2008, Pearson Education India
6. Embedded Microcomputer systems: Real time interfacing, J.W. Valvano 2011, Cengage Learning

MPHC-3.21
Atomic and Molecular Spectroscopy

Total Credits: 4

UNIT I **Atomic Spectra:** Electromagnetic Spectrum. Types of spectra. Bohr atomic model and assumptions, Hydrogen spectrum. Sommerfeld theory of hydrogen atom: Sommerfeld elliptical orbits, total energy, relativistic correction. Fine structure of H_{α} and He^{+} line. Vector atom model: quantum numbers and its significance for complete atom, angular momenta of atom, spectral terms, distribution of electrons in shells and subshells, magnetic moments of an atom and Lande's g factor, Larmor's theorem, spin-orbit interaction, selection rules for many electron atoms. Hyperfine structure of spectral lines, Isotope shift, Width of spectral lines

UNIT II **Effects of magnetic and electric fields on Atomic spectra:**Zeeman Effect: Experimental study, Classical interpretation of Normal Zeeman effect, Vector model and Normal Zeeman effect Vector model and anomalous Zeeman effect, Paschen-Back effect. Lande's factor for two valence electron system. Quantum mechanical treatment of Zeemanand Paschen- Back effect. Stark effect

UNIT III **Molecular structure:**, Variation method of chemical bonding and its application, LCAO-MO wave functions, comparison of molecular orbital (MO) and valence bond (VB) theories, Hydrogen molecule ion, Hydrogen molecule, Born Oppenheimer approximation, Rotation and vibration of diatomic molecule, Moment of inertia and bond length of diatomic and linear triatomic molecule, quantum theory of Raman effect

UNIT IV **Molecular spectra:** Types of molecular energy states and associated spectra, Types of spectra Electronic spectra, Frank-Condon principle, Pure rotational spectra: rotational energy levels of diatomic molecule as rigid rotator, energy levels and rotational constant on applying Schrodinger's equation, Diatomic molecule as non-rigid rotator, pure rotational Raman spectra, Vibrational spectra: Vibrating diatomic molecule as a harmonic oscillator, Vibrational- rotational spectra, Vibrating diatomic molecule as an harmonic oscillator.

UNIT V **Spin resonance spectroscopy:** Nature of spinning particles, interaction between spin and a magnetic field, population of energy levels, Larmor precession, Nuclear magnetic resonance (NMR): energy levels, chemical shift, relaxation mechanisms, application of NMR in medicine. Electron spin resonance (ESR): interaction with magnetic field, g factor, relaxation mechanism, fine and hyperfine structure of ESR, double resonance in ESR. Nuclear quadrupole resonance (NQR): quadrupole nucleus, principle, transitions for axially symmetric and non-axially symmetric system with respect to integral and half integral spin, Mössbauer spectroscopy: Mössbauer effect, recoiless emission and absorption, chemical shift, magnetic hyperfine interaction.

Recommended Books and References:

1. Introduction to Atomic Spectra – H E White, McGraw-Hill
2. Fundamentals of Molecular spectroscopy – Colin N Banwell and Elaine M McCash, McGraw-Hill
3. Fundamentals of Molecular Spectroscopy – Walter S Struve, John-Wiley & Sons

4. Mössbauer Spectroscopy – N N Green wood and T C Gibb, Chapman and Hall Ltd
5. Nuclear Magnetic Resonance – E R Andrew, Cambridge University Press
6. Molecular Spectra and Molecular Structure – G Herzberg, Prentice Hall
7. Elements of Spectroscopy – Gupta, Kumar, Sharma, Pragati Prakashan
8. Molecular Structure and Spectroscopy – G Aruldhas, PHI Learning Private Limited

MPHC 3.12
EMBEDDED SYSTEMS: INTRODUCTION TO MICROCONTROLLERS (PRACTICAL)

Practical Credit: 2

1. To find that the given numbers is prime or not.
2. To find the factorial of a number.
3. Write a program to make the two numbers equal by increasing the smallest number and decreasing the largest number.
4. Use one of the four ports of 8051 for O/P interfaced to eight LED's. Simulate binary counter (8 bit) on LED's.
5. Program to glow the first four LEDs then next four using TIMER application.
6. Program to rotate the contents of the accumulator first right and then left.
7. Program to run a countdown from 9-0 in the seven segment LED display.
8. To interface seven segment LED display with 8051 microcontroller and display 'HELP' in the seven segment LED display.
9. To toggle '1234' as '1324' in the seven segment LED display.
10. Interface stepper motor with 8051 and write a program to move the motor through a given angle in clock wise or counter clockwise direction.
11. Application of embedded systems: Temperature measurement, some information on LCD display, interfacing a keyboard. Arduino based programs and experiments:
12. Make a LED flash at different time intervals.
13. To vary the intensity of LED connected to Arduino
14. To control speed of a stepper motor using a potential meter connected to Arduino
15. To display "PHYSICS" on LCD/CRO.

Recommended Books and References:

1. Embedded Systems: Architecture, Programming& Design, R.Kamal, 2008,Tata McGraw Hill
2. The 8051 Microcontroller and Embedded Systems Using Assembly and C, M.A. Mazidi, J.G. Mazidi, and R.D. McKinlay, 2nd Ed., 2007, Pearson Education India.
3. Embedded Microcomputor System: Real Time Interfacing, J.W.Valvano, 2000, Brooks/Cole
4. Embedded System, B.K. Rao, 2011, PHI Learning Pvt. Ltd.

Embedded Microcomputer systems: Real time interfacing, J.W. Valvano 2011, Cengage Learning

MPHC 3.22
ATOMIC AND MOLECULAR SPECTROSCOPY (PRACTICAL)

Practical Credit: 2
Each Student is expected to perform at least 5-6 experiments out of the following list:

1. To study the absorption spectrum of iodine vapour and to calculate electronic energy gap, vibrational energies and force constant for its excited state.
2. To study fine structure of Hg spectral lines using constant deviation spectrometer.
3. To determine the value of Rydberg constant with the help of grating spectrometer using hydrogen gas discharge tube.
4. Study of Zeeman Effect.

Computational lab (by using SCILAB)

1. Analysis of atomic spectra.
2. Analysis of electronic spectra of molecule and liquid.
3. Analysis of rotational spectra of molecule and liquid.
4. Analysis of vibrational spectra of molecule and liquid.

Recommended Books and References:

1. BSc. Practical Physics – C L Arora
2. Experiments in Modern Physics – Mellissino
3. Advance Practical Physics – Worsnop and Flint.

DISCIPLINE SPECIFIC ELECTIVE 1

MPHD 3.11(a)
NANOSCIENCE

Theory Credit: 4

UNIT I ***Nanoscale systems and*** **Nanomaterials*:*** Increased surface to volume ratio, 1D, 2D and 3D nanostructure (nanodots, thin films, nanowires, nanorods), quantum confinement, Carbon based materials (Fullerenes, carbon nanotubes (CNT), nanobuds), Inorganic nanotubes, nanoshells, Quantum well, Quantum wires, Quantum dots, Dendrimers, biological nanomaterials, diamondoids, Smart nanomaterials.

UNIT II **Properties of Nanomaterials:** Size dependence of properties, Properties of Nanomaterials (Chemcal reactivity, solubility, melting point, electronic energy levels), electrical conductivity (Surface scattering, change of electronic structure, Quantum transport, effect of microstructure), Superparamagnetism, electron confinement, Integrated optics, Optical properties (Surface Pasmon Resonance, Quantum size effects), Mechanical properties, Thermodynamics properties

UNIT III **Synthesis of nanomaterials:** Bottom up and Top down approache, Lithography (electron beam lithography, nanoimprint lithography, Dip pen nanolithography), Sputtering, Physical vapour deposition (PVD), Chemical vapour deposition (CVD), Sol-gel film deposition, Hydrothermal synthesis, Synthesis of carbon nanotubes (Arc-evaporation method, Laser ablation)

UNIT IV **Characterization of nanomaterials:** X-ray Diffraction (XRD), Fourier transform Infrared (FTIR) spectroscopy, UV-Vis Spectroscopy, Scanning Tunnelling Microscope (STM), Atomic force microscopy (AFM), Scanning electron microscopy (SEM), Energy dispersive analysis of X-rays (EDAX), Transmission Electron Microscopy TEM, Raman spectroscopy, X-ray photoelectron spectroscopy (XPS).

UNIT V **Applications of Nanomaterials:** Molecular and nanoelectronic, Microbial fuel Cells, Hydrogen Storage, Nanomedicine, Biological application, Catalysis, Pollution control and filteration, Photonic Nanocrystals and Integrated Circuits, Nanomaterials in Communication sector.

Recommended Books and References:

1. “Nanostructured materials and nanotechnology”, Concise Edition, Editor:-Hari Singh Nalwa; Academic Press, USA (2002).
2. “Hand book of Nanostructured Materials and Technology”, Vol.1-5, Editor:Hari Singh Nalwa; Academic Press, USA (2000).
3. Nanoscale characterization of surfaces & interfaces, N John Dinardo, Weinheim Cambridge: Wiley-VCH, 2nd ed., 2000.
4. “Carbon nanotubes: preparation and properties”, Editor: - T.W. Ebbesen, CRC Press, USA (1997).
5. Nanotechnology, Thomas Varghese, K.M. Balakrishna

MPHD 3.11(b)
REMOTE SENSING OF THE ATMOSPHERE

Theory Credit: 4

UNIT I **Satellite Meteorology:**Remote Sensing, Principles of Remote Sensing, Application in Meteorology, Introduction to Satellite Meteorology including Orbital Mechanics.) Meteorological Satellites, Polar Orbiting, Geostationary satellites, Current and future meteorological satellites of the world. Payloads on Meteorological Satellites, NOAA, INSAT -3D, Metop.

Processing of data from Imagers, INSAT Meteorological Data Processing System (IMDPS). Generation of images in various channels. Retrievals of meteorological products from the imager data including water vapor. Atmospheric motion vectors, Sea Surface Temperature and Upper Troposphere Humidity (UTH), Outgoing Long wave Radiation (OLR), Quantitative Precipitation Estimates (QPE), Rainfall, Fog, Minor atmospheric constituents/aerosols/ Fire /smoke,

UNIT II Principles of Sounding, Processing of data from Infrared and Microwave Sounders. Retrieval of products from sounder, Vertical temperature, humidity and ozone profiles. Interpretation of Satellite images of various channels and identification of typical clouds and weather systems from cloud imageries, use of various satellite derived products, satellite Bulletin and its interpretation. Tropical cyclone, its identification and grading using Dvorak's technique.

UNIT III Radar Meteorology Radar principles. Doppler Radar, Wind profiler, MST Radar, LIDARS Scattering of microwaves by precipitation / precipitating particles. Scattering by a sphere, Scattering by rain and ice crystals. Minimum detectable power, receiver noise, radar equation for a point target, part played by various parameters in the radar equation. Radar equation for an extended target. Practical importance of radar set constants and the radar cross section. Effect of wavelength, wave lengths commonly used. Types of scans used in weather radar, their merits. Classification of radar echoes. Convective and stratiform types, bright band echo from lightening, tornadoes, squall lines.Study of severe storms and cyclones, Measurement of rate and amount of precipitation, effect of circular polarization, use of circular polarization in weather radar research, non-precipitating / precipitation echoes, super-refraction, limitations of weather radar.

UNIT IV Doppler radar Doppler radar principles and its limitations. Doppler principle of velocity measurement, unambiguous velocity and range. Doppler dilemma. Spectrum width. Introduction to DWR (Physical visualisation/inspection), RAINBOW workstation.

Principles of dual polarized doppler radar. Advantages over conventional doppler radar techniques. Radar base products and derived products Introduction to reflectivity products and their utilization. Detection of turbulence, shear, gust front, microburst, and tornado, , icing hail probability and hail size, determination and tracking, TC structure, intensity, rainfall distribution and other parameters, inputs for storm surge prediction

UNIT V **Digital Image Processing:** Basic principal of Digital Image Processing,Digital Image, Digital Image data formats, Enhancement techniques, Gray scales, Pseudo Color Images. Band sequential; Band Interleaved and its characteristics. Image processing systems considerations and characteristics – Image enhancements techniques – Image reduction and magnification, contrast enhancements, rationing, spatial filtering, edge enhancements.

MPHD 3.11(C)
HIGH ENERGY PHYSICS

Theory Credit: 5
Tutorial Credit: 1

UNIT I Four fundamental interactions, classification, Classification of elementary particles by masses, interactions and conserved quantum numbers, selection rules for particle decays and scattering, Particle detectors and accelerators, cloud and bubble chambers, emulsion techniques, electronic detectors, proportional counters, fixed target and collider machines, basic idea of cyclotron and synchrotron, Relativistic energy, momentum relation, Klein-Gordon equation, solutions of the equation, probability conservation problem, relation with negative energy states.

UNIT II Dirac equation, algebra of matrices, conservation of probability, solutions of Dirac equation, helicity and chirality, Lorentz covariance, bilinear covariant, trace relations and similar identities, C, P and T invariance of the Dirac equation,structureoftheQEDLagrangian,gaugeinvarianceandconservedcurrent,scalar electrodynamics, Feynman rules for QED (no derivation), Feynman diagram calculation for $e^+ e^- \longrightarrow \mu^+ \mu^-$.

UNIT III phase space integration, Møller and Bhabha scattering, polarization vectors, Compton scattering and pair creation/annihilation, Klein-Nishina formula, concept of multi-loop diagrams(no computation), momentum integral, UV and IR singularities, idea of regularization, running coupling constant, Isospin and strangeness, introduction to unitary groups, generators, Casimir invariants, fundamental and adjoint representations, root and weight diagrams, meson and baryon octets, baryon decuplet and the prediction of the Ω^-, Gell-Mann-Nishijima formula.

UNIT IV Product representations and irreps, symmetry group, Young tableaux, quark model, meson and baryon wave functions, elastic scattering off a point particle, form factors, Rosen bluth formula, Breit frame, inelastic scattering, structure functions, dimensionless variables. Bjorken scaling, parton model, structure function sin terms of PDFs, Callan, Gross relation, kinematic regions, valence and sea quarks, gluons.

UNIT V Beta decay, Fermi and Gamow-Teller transitions, current-current form of weak interactions, Fermi constant, unitarity violation at high energies, Intermediate vector boson, $W^{\pm}$bosons, requirement of conserved currents, muon decay, pion decay, form facto, Parity violation, intrinsic parity, parity conservation in strong and electromagnetic interactions, parity violation in weak interactions, maximal parity violation, flavour Mixing and CP Violation, ,Cabibbo hypothesis, kaondecays, theta, taupuzzle, regeneration experiment, GIM mechanism, CKM matrix and quark mixing.

Recommended Books and References:

1. Introduction to Elementary Particles, by D. Griffiths (Wiley 1987).

2. Quarks and Leptons, by F. Halzen and A.D. Martin (Wiley 1984).
3. Particle Physics, by B.R. Martin and G. Shaw (Wiley 2008).
4. Quarks and leptons : An introductory course in Modern Particle Physics - Francis Halzen andAlan D Martin.
5. Gauge Theory of Elementary Particle Physics – Ta-Pei Cheng and Ling Fong Li.
6. Quantum Field Theory - L H Ryder.
7. Relativistic Quantum Fields - James D Bjorken and Sidney D Drell

MPHD 3.21(a)
ASTRONOMY AND ASTROPHYSICS

Theory Credit: 4

UNIT I **Positional astronomy:** Basics of spherical trigonometry, the celestial sphere, circles on celestial sphere, cardinal points, Equinoctial points, spherical triangle Motions of earth- spin, revolution, obliquity, tilt, eccentricity. seasons, solstices, constellationsGeographic coordinate systems, Astronomical coordinate systems-equatorial, ecliptic and galatic. Diurnal motion of stars, circumpolar star. Measurement of time, sidereal time, apparent solar time, mean solar time, equation of motion.

UNIT II **Astronomical Measurements and Telescopes:**
Astronomical distances ,mass and time and their measurement, flux and luminosity , apparent and absolute magnitudes, distance modulus, color index, Steller temperature and spectral classification, H-R diagram**.**
Basic optical definitions for astronomy (magnification, light gather power, resolving power, diffraction limit, atmospheric windows), optical telescopes(Types of reflecting telescopes, telescope mounting, space telescopes, detectors and their use with telescopes types of detectors- photographic plates, photo multiplier tube (PMT),charge couples devices(CCD), detection limits with telescopes.

UNIT III **Solar system:** The sun: solar parameters, solar photosphere, solar atmosphere, chromospheres, corona, solar activity, physical characteristics of sun-rotation, magnetic field, granulation, sunspots, other chromatic activities, Inner planets Jovian planets, dwarf planets.
Asteroids: classification, origin, Comets: physical nature, classification, origin, Meteors and meteorites.

UNIT-IV **Stars and Galaxies**
Star clusters: open and globular, Binary stars, type of binaries, variable stars, Cepheid variables, period-luminosity relation.
Galaxies: Galaxy Morphology, Hubble classification of galaxies- Elliptical spiral and lenticular galaxies. The Milky way galaxies its morphology.

UNIT V **Stellar structure and evolution:** Virial theorem, hydrostatic equilibrium, integral theorem on pressure, density and temperature, polytropes gas sphere, Lane-Eamden equation and its solutions,

Stellar evolution: H-R diagram, Chandrashekar limit -neutron star, white dwarf black hole, Hayashi phase, main sequence, Horizontal branch and red giant and asymptotic giant branches.

Recommended Books and References:

1. R.C. Smith Observational Astrophysicvs; CUP 1995
2. F. Shu,The Physical universe: an introduction to Astronomy; Unversy Science Books, Saualito
3. C.R. Kitchin,Astrophysicaltechniques;Adam Hilger,1984
4. Text Book of Spherical Astronomy – W.M.Smart
5. R.J. Tayler,Thestars:their structure and evolution; CUP 1994.
6. H.Harwit,Astrophysical concepts: Springer Verlag 1988.
7. M.S. Longair, High energy Astrophysics,Vols I and II ; CUP
8. G.B. Rtbicki and A.P. Lightman, Radiative Processes in Astrophysics;wiley-VCH
9. Modern Astrophysics, B.W. Carroll and D.A. Ostlie, Addison-Wesley Publishing co.
10. Fundamentals of Astronomy (fourth Edition), H. Karttunen et al. Springer
11. Textbook of Astronomy and Astrophysics with elements of cosmology, V.B. Bhatia, Narosa Publication.
12. An Introduction to Astrophysics, B. Basu, T Chattopadhyay and S.N. Biswas.PHI learning private limited.

MPHD 3.21(b)
DIGITAL SIGNAL PROCESSING

Theory Credit: 4

UNIT I **Discrete-Time Signals and Systems:** Classification of Signals, Transformations of the Independent Variable, Periodic and Aperiodic Signals, Energy and Power Signals, Even and Odd Signals,Discrete-Time Systems, System Properties. Impulse Response, Convolution Sum; Graphical Method; Analytical Method,Properties of Convolution; Commutative; Associative; Distributive; Shift; Sum Property System Response to Periodic Inputs, Relationship Between LTI System Properties and the Impulse Response; Causality; Stability; Invertibility, Unit Step Response.

UNIT II **Discrete-Time Fourier Transform:** Fourier Transform Representation of Aperiodic Discrete-Time Signals, Periodicity of DTFT, Properties; Linearity; Time Shifting; Frequency Shifting.

Differencing in Time Domain; Differentiation in Frequency Domain; Convolution Property. The z-Transform: Bilateral (Two-Sided) z-Transform, Inverse z-Transform, Relationship Between z-Transform and Discrete-Time Fourier Transform, z-plane, Region-of-Convergence; Properties of ROC, Properties; Time Reversal; Differentiation in the z-Domain; Power Series Expansion Method (or Long Division Method); Analysis and Characterization of LTI Systems; Transfer Function and Difference-Equation System. Solving Difference Equations.

UNIT III **Filter Concepts**: Phase Delay and Group delay, Zero-Phase Filter, Linear-Phase Filter, Simple FIR Digital Filters, Simple IIR Digital Filters, All pass Filters, Averaging Filters, Notch Filters.

Discrete Fourier Transform: Frequency Domain Sampling (Sampling of DTFT), The Discrete Fourier Transform (DFT) and its Inverse, DFT as a Linear transformation, Properties; Periodicity; Linearity; Circular Time Shifting;Circular Frequency Shifting; Circular Time Reversal; Multiplication Property; Parseval's Relation, Linear Convolution Using the DFT (Linear Convolution Using Circular Convolution), Circular Convolution as Linear Convolution with aliasing.

UNIT IV **Fast Fourier Transform**: Direct Computation of the DFT, Symmetry and Periodicity Properties of the Twiddle factor (WN), Radix-2 FFT Algorithms; Decimation-In-Time (DIT) FFT Algorithm; Decimation-In-Frequency (DIF) FFT Algorithm, Inverse DFT Using FFT Algorithms.

Realization of Digital Filters: Non Recursive and Recursive Structures, Canonic and Non Canonic Structures, Equivalent Structures (Transposed Structure), FIR Filter structures; Direct-Form; Cascade-Form; Basic structures for IIR systems,Direct-Form I.

UNIT V **Finite Impulse Response Digital Filter**: Advantages and Disadvantages of Digital Filters, Types of Digital Filters: FIR and IIR Filters; Difference Between FIR and IIR Filters, Desirability of Linear-Phase Filters, Frequency Response of Linear-Phase FIR Filters, Impulse Responses of Ideal Filters, Windowing Method; Rectangular; Triangular; Kaiser Window, FIR Digital Differentiators.

Infinite Impulse Response Digital Filter: Design of IIR Filters from Analog Filters, IIR Filter Design by Approximation of Derivatives, Backward Difference Algorithm, Impulse Invariance Method.

Recommended Books and References:

1. Digital Signal Processing, Tarun Kumar Rawat, 2015, Oxford University Press, India
2. Digital Signal Processing, S. K. Mitra, McGraw Hill, India.
3. Modern Digital and Analog Communication Systems, B.P. Lathi, 1998, 3rd Edn. Oxford University Press.
4. Fundamentals of Digital Signal processing using MATLAB, R.J. Schilling and S.L. Harris
5. Fundamentals of signals and systems, P.D. Cha and J.I. Molinder, 2007, Cambridge University Press.
6. Digital Signal Processing Principles Algorithm & Applications, J.G. Proakis and D.G. Manolakis, 2007, 4th Edn., Prentice Hall.

MPHD 3.21(c)
PLASMA PHYSICS

Theory Credit: 5
Tutorial Credit: 1

UNIT I **Fundamentals of Plasma Physics:** Plasma State: Ionized gas, Saha's ionization equation; Collective degrees of freedom, Definition of Plasma, Concept of Plasma temperature, Debye shielding, Quasi-neutrality, Plasma parameters, Plasma approximation, Natural existence of Plasma.

Single-particle motion: Dynamics of charged particles in electro-magnetic fields, Particle drifts, EXB drifts, Grad-B drift, Curvature drift, Polarization drift, Adiabatic invariants and their technological applications.

Kinetic theory of Plasma: Vlasov equations, Solution of linearized Vlasov equation, Langmuir waves, Ion-sound waves, Wave-particle interaction and Landau damping.

Fluid theory of Plasma: Plasma oscillations, Electron-acoustic waves, Ion-acoustic waves Electrostatic ion-waves perpendicular to magnetic field, Electromagnetic waves perpendicular to magnetic field.

UNIT II **Plasma Generation:** Basic principles of gas discharge physics: Electrical breakdown, Generation of thermal and nonthermal plasma, DC and RF (radiofrequency) discharges, Microwave discharge, Dielectric barrier discharge. Fundamentals of vacuum technology: Vacuum pumps- rotary, diffusion and turbo-molecular pumps, Low pressure measurement systems in laboratory plasma- pressure gauges. Plasma diagnostic methods: Electric probes (Langmuir and emissive probe), Electric probe characteristics and measurement of plasma parameters (plasma potential, electron & ion density, electron temperature etc.), Magnetic probes, Mass and optical spectroscopy.

UNIT III **Application of Plasma**: Thermonuclear fusion- present status and problems, Requirements for fusion plasmas- confinement, beta, power and particle exhaust, Tokamak fusion reactors. Dusty plasma in laboratory and space, Dust charging processes, Waves in dusty plasma, Dust crystal. Laser plasma interaction, Inertial confinement, High-harmonic generation, Laser wakefield electron accelerator, X-ray laser. Plasma engineering, Industrial applications of plasma.

UNIT IV **Nonlinear Plasma Physics:** Nonlinear Debye shielding, Evacuation of the Debye sphere, Basics of exotic plasma effects: Plasma as exotic medium, Shielding in three spatial dimensions.

Weakly nonlinear processes: Concept of nonlinearity and dispersion, Weakly nonlinear and weakly dispersive waves, Wave energy alteration with dispersion and dissipation mechanisms, Shock & soliton formation, Nonlinear wave equations and asymptotic integrations.

Strongly nonlinear processes: Excitation of strongly nonlinear and strongly dispersive waves, Energy integral methods, Nonlinear coherent structures in complex plasmas, Astrophysicalcosmic-space applications.

UNIT V **Plasma in space:** Introduction to the interstellar medium: Neutral and ionized gas, gaseous nebulae, HII regions, supernova remnants, photo-dissociation regions, different phases of the interstellar medium: cold neutral medium, warm neutral and ionized medium, hot medium, diffuse clouds, dense clouds, Radiative processes: Radiative transfer, emission and absorption coefficients, emission and absorption lines, the role of thermal and free electrons

MPHD 3.12(a)
NANO SCIENCE (PRACTICAL)

Practical Credit: 2

List of Experiments

1. Synthesis of semiconductor nanoparticles
2. Characterization of thin films using XRD and particle size determination using Scherrer's formula, lattice parameters, Strains etc.
3. Determine the average particle size and elemental analysis from FESEM and EDS images
4. Surface morphological characterization of nanomaterials from AFM images
5. Surface morphological characterization of nanomaterials from TEM images
6. Analysis of UV/Vis Absorption spectrum of nanomaterials
7. Analysis of Photoluminescence spectrum of nanomaterials
8. Analysis of FTIR image spectrum of nanomaterials
9. Determination refractive index, thickness and band gap of a semiconductor sample using UV-VIS-NIR Spectroscopy

Recommended Books and References:

1. Bellan, P. M., Fundamentals of Plasma Physics, 1st edition (Cambridge University Press, 2008)
2. Chen, F. F., Introduction to Plasma Physics and Controlled Fusion, 2nd edition, Vol. 1, (Plenum, New York, 1984)
3. Nicholson, D.R., Introduction to Plasma Theory (Wiley, USA, 1983).
4. Swanson, D. G., Plasma Waves (IoP, Bristol, 2003).
5. Bittencourt, J. A., Fundamentals of Plasma Physics (Springer, New York, 2004).
6. Cap, F. F, Handbook on Plasma Instabilities (Academic Press, New York, 1976).
7. Hutchinson, I. H., Principles of Plasma Diagnostics, 2nd edition, (Cambridge University Press, 2002)
8. Shukla, P. K. and Mamun, A. A., Introduction to Dusty Plasma Physics (IoP, Philadelphia, 2001)
9. Vinod, K., Astrophysical Plasmas and Fluids (Springer, New Delhi, 1998)
10. Piel, A., Plasma Physics: An Introduction to Laboratory, Space and Fusion Plasmas (Springer, Heidelberg, 2010).
11. Pecseli, H. L., Waves and Oscillations in Plasmas (CRC Press, New York, 2013).

MPHD 3.12(b)
REMOTE SENSING OF THE ATMOSPHERE (PRACTICAL)

Practical Credit: 2

1. To simulate thebrightness temperaturefrom the radiance observations atvarious spectral bands.
2. Interpretation of Satellite images of various channels and identification of typical clouds and weather systems from cloud imageries
3. Tostudy theoftemperaturesounding observationsfrom a geostationary satellite
4. Tostudy theofhumiditysounding observations from a geostationary satellite
5. To computeradar reflectivity factor from the rain DSD observations.
6. To compute the rain intensity and rain accumulationfromthe time series data of rain DSDs.
7. Identify thebright band structurefrom the reflectivityprofilesduring the stratiform rain.
8. To estimate the height and width of the bright band from the Micro rain radar observations.
9. Identify the convective core region and startiform region from thevolume observation from DWR.
10. Develop a empirical Z-R relation for a given set of radar and rain intensity observations

Recommended Books and References:

1. Radar Observation of the Atmosphere ByBattan (1973),
2. Polarimetric Doppler Weather Radar By Bringi and Chandrasekar (2001), , Cambridge Press
3. Doppler Radar and Weather Observations By Doviak and Zrnic (1984, 1993), , Academic Press
4. Radar in Meteorology, Atlas (1990), AMS (Battan Memorial volume)
5. Radar and Atmospheric Science: A Collection of Essays in Honor of David Atlas (2003), AMS
6. Theory of Satellite Orbit in the Atmosphere by King Hele
7. Numerical Analysis by Shastri
8. Weather Satellite by L.F. Hubert
9. Meteorological Satellite by W.K. Widger
10. A guide to Earth Satellite by D. Fishlock
11. Advances in Satellite Meteorology by VinnichenkoGoralik
12. Satellite meteorology by Henri W. Brandli
13. Satellite Meteorology - WMO Technical Notes No. 124 and 153.
14. Satellite Meteorology, by R.R. Kelkar AS-19-L:

MPHD 3.22(a)
ASTRONOMY AND ASTROPHYSICS (PRACTICAL)

Practical Credit: 2

1. Use of Stellarium software. Read all sky charts and determine the alt –azimuth of stars.
2. Estimation of sun spot drift rate using images of sunspots.

3. H-R diagram plotting using B-V colour index and distance estimation.
4. Plotting of Period Luminosity curve for Cepheid variables using data and estimate the distance .
5. Measuring the angular size of galaxies and estimating the distance of galaxies using small angle formula.
6. Constructing a Hubble diagram using data and estimating Hubble constant.
7. Calculation of telescope parameters like F ration ,magnification, true filed of view resolution etc.
8. Plotting of solution of Lame Emden equation.
9. Installation of HEAsoft/IARF software and plotting light curve.

Note:
Also, the above list is tentative, changes in the list of experiments may be made, depending on the availability of the equipment and other considerations

MPHD 3.22(b)
DIGITAL SIGNAL PROCESSING (PRACTICAL)

Practical Credit: 2

Scilab based simulations experiments based problems like

1.Write a program to generate and plot the following sequences:(a) Unit sample sequence δ(n), (b) unit step sequence u (n), (c) ramp sequencer(n) , (d) real valued exponential sequence x(n)$(0.8)^n$ u(n) for0 ≤n ≥ 50.

2.An LTI system is specified by the difference equation Y(n) = 0.8 y(n-1)+x(n)
   (a) DetermineH($e^{j\omega}$)
   (b) Calculate and plot the steady state responseto y_{ss}(n)tox(n) =cos(0.5πn) u(n)

3.Given a casual system y(n) =0.9y(n-1)+x(n)
   (a) FindH(z) and sketch its pole-zero plot
   (b) Plot the frequency response$|H(e^{j\omega})|$ and $\angle H(e^{j\omega})$

4.Design a digital filter to eliminate the lower frequency sinusoid of x (t) =sin7t + sin200t. The sampling frequency is 500 Hz. Plot its pole zero diagram, magnitude response, input and output of the filter.

5. Using a rectangular window, design a FIR low pass filter with a pass band gain of unity, cutoff frequencyof 1000 Hz and working at a sampling frequency of 5 KHz. Take the length of the impulse response as 17.

6.Design a FIR filter to meet the following specifications
   Pass band edge Fp = 2 KHz;Stopband edge Fs = 5 KHz
   Passband attenuationAp= 2dB;Stopband attenuation As =42 dB;
   Sampling frequency Fs = 20 KHz

7.The frequency responseof a linear phase digital differentiator is given by

$$H_d(e^{j\omega}) = j\omega(e^{-j\tau\omega})|\omega| \leq \pi$$

   Using a Hamming window of length M= 21, design a digital FIR differentiator. Plot the amplitude response.

SEMESTER – IV

MPHC 4.11
COMPUTATIONAL PHYSICS

Theory Credit: 4

UNIT I **Introduction of Numerical analysis & Algebraic Equations:** Introduction to numerical analysis, the need for numerical analysis and its limitations, Concept of different types of errors with examples, propagation of errors, Maclaurin's series, Taylor's series for two dimensional function, polynomial evaluation, **difference table** and error corrections, Solution of transcendental equations, Solving an equation with Newton-Raphson method and bisection methods, comparison of their limitations,

UNIT II **Matrices and Linear Algebraic Equations:** systems of linear equations, manipulation of matrix, Gauss Elimination method, Gauss Seidel iteration method, concept of pivoting, partial and complete pivoting, complete pivoting, Solution of linear equations, Gauss-Jordan elimination, matrix inversion, Eigen values and Eigen vectors.

UNIT III **Interpolation & Curve Fitting:** Concept of interpolation, linear interpolation, quadratic interpolation, Lagrange's interpolation, Richardson's extrapolation, Newton's interpolation, Sterling formula
Curve fitting, least square method, curve fitting for a straight line, curve fitting for a power law equation.

UNIT IV **Numerical Differentiation and Integration:** The concept of numerical differentiation and integration, Derivative using Newton's forward and backward and Sterling's central difference formula
Integration method- Newton-Cotes formula, Trapezoidal and Simpson's 1/3 and 3/8 rules and their relation to interpolation, Gauss quadrature 2 point and 3 point.

UNIT V **Differential Equations:** Solution of ordinary differential equations (ODEs), concept of finite differencing, Solution of a first order ODE with Euler's method and its limitations, Taylor's series method, need for a higher-order method — solution of a first order ODE with Runge-Kutta method, predictor-corrector methods, Milne's predictor corrector method,
Partial differential equations (PDEs), the concept of initial and boundary value problems, finite differencing approximation to partial differential equation -Laplace and Poisson equations.

Recommended Books and References:

1. K. E. Atkinson, Numerical Analysis, John Wiley (Asia) (2004).
2. S. C. Chapra and R. P. Canale, Numerical Methods for Engineers, Tata McGraw Hill(2002).
3. J. D. Hoffman, Numerical Methods for Engineers and Scientists, 2nded. CRC Press,Special Indian reprint (2010).

4. J. H. Mathews, Numerical Methods for Mathematics, Science, and Engineering,Prentice Hall of India (1998).
5. S. S. M. Wong, Computational Methods in Physics, World Scientific (1992).
6. W. H. Press, S. A. Teukolsky, W. T. VerllingandB. P. Flannery, Numerical Recipes in C, Cambridge (1998).
7. Numerical Recipes,W H Press et al. (Cambrideg University Publication).
8. Introduction to Numerical Methods T. R. McCalla
9. An Introduction to Numerical AnalysisK. E. Atkinson.

MPHC 4.21
EXPERIMENTAL METHOD

Theory Credit: 4

UNIT I **Measurements:** Accuracy and precision. Significant figures. Error and uncertainty analysis. Types of errors: Gross error, systematic error, random error. Statistical analysis of data (Arithmetic mean, deviation from mean, average deviation, standard deviation, chi-square) and curve fitting. Guassian distribution.

Signals and Systems: Periodic and aperiodic signals. Impulse response, transfer function and frequency response of first and second order systems. Fluctuations and Noise in measurement system. S/N ratio and Noise figure. Noise in frequency domain. Sources of Noise: Inherent fluctuations, Thermal noise, Shot noise, 1/f noise

UNIT II Shielding and Grounding: Methods of safety grounding. Energy coupling. Grounding. Shielding: Electrostatic shielding. Electromagnetic Interference.

Transducers & industrial instrumentation (working principle, efficiency, applications): Static and dynamic characteristics of measurement Systems. Generalized performance of systems, Zero order first order, second order and higher order systems. Electrical, Thermal and Mechanical systems. Calibration.

UNIT III Transducers and sensors. Characteristics of Transducers. Transducers as electrical element and their signal conditioning. Temperature transducers: RTD, Thermistor, Thermocouples, Semiconductor type temperature sensors (AD590, LM35, LM75) and signal conditioning. Linear Position transducer: Strain gauge, Piezoelectric. Inductance change transducer: Linear variable differential transformer (LVDT), Capacitance change transducers. Radiation Sensors: Principle of Gas filled detector, ionization chamber, scintillation detector.

UNIT IV Digital Multimeter: Comparison of analog and digital instruments. Block diagram of digital multimeter, principle of measurement of I, V, C. Accuracy and resolution of measurement.

Impedance Bridges and Q-meter: Block diagram and working principles of RLC bridge. Q-meter and its working operation. Digital LCR bridge.
Oscilloscope: Block diagram and working principles of CRO

UNITV Vacuum Systems: Characteristics of vacuum: Gas law, Mean free path. Application of vacuum. Vacuum system- Chamber, Mechanical pumps, Diffusion pump & Turbo Modular pump, Pumping speed, Pressure gauges (Pirani, Penning, ionization.

Recommended Books and References:

1. Measurement, Instrumentation and Experiment Design in Physics and Engineering, M. Sayer and A. Mansingh, PHI Learning Pvt. Ltd.
2. Experimental Methods for Engineers, J.P. Holman, McGraw Hill
3. Introduction to Measurements and Instrumentation, A.K. Ghosh, 3rd Edition, PHI Learning Pvt. Ltd.
4. Transducers and Instrumentation, D.V.S. Murty, 2nd Edition, PHI Learning Pvt. Ltd.
5. Instrumentation Devices and Systems, C.S. Rangan, G.R. Sarma, V.S.V. Mani, Tata McGraw Hill
6. Principles of Electronic Instrumentation, D. Patranabis, PHI Learning Pvt. Ltd. Electronic circuits: Handbook of design & applications, U.Tietze, Ch.Schenk, Springer.
7. Signals and system A. Anand Kumar

MPHC 4.12
COMPUTATIONALPHYSICS (PRACTICAL)

Practical Credit: 2

Write a algorithm for a given exercise and execute the algorithm by using a computer programming of choice (Fortran/C/C++/SCILAB)

1. To find the root of a given equation f(x) =0in the interval [a,b] by any one of the following method (a).Bisection method (b) Newton-Raphsen method.
2. To solve the given linear systems AX=Bbyany one of the following methods (a) Gauss-Seidel iteration.(b) Gauss-Jordan elimination.(c)matrix inversion.
3. Find out the eigen values and eigen vectors of a given matrix.
4. Find a interpolated value for a any given set of data by any one of the following method (a)linear interpolation. (b) quadratic interpolation. (c) Lagrange's interpolation. (d) Richardson's extrapolation.(e) Newton's interpolation.(f) Aitken's interpolation.
5. Integrate a given function or series by any given method (a) Limits method (b). Extrapolation method.
6. Integrate a given function by any one of a given method (a) Quadrature formula (b). Trapezoidal rule (b) Simpson' s rule
7. Solve a given ODE by any one of the given method (a) Eulers method (b)Euler-Richardson method,(c). Taylor series method(d). Runge-Kutta method.
8. Solve a given parabolic partial differential equation (Heat equation)by any given method.
9. Solve a given elliptic partial differentia lequation (Laplace /Poisson/Helmholtz equation)by any given method.

Recommended Books and References:

1. K. E. Atkinson, Numerical Analysis, John Wiley (Asia) (2004).

2. S. C. Chapra and R. P. Canale, Numerical Methods for Engineers, Tata McGraw Hill(2002).
3. J. D. Hoffman, Numerical Methods for Engineers and Scientists, 2nded. CRC Press,Special Indian reprint (2010).
4. J. H. Mathews, Numerical Methods for Mathematics, Science, and Engineering,Prentice Hall of India (1998).
5. S. S. M. Wong, Computational Methods in Physics, World Scientific (1992).
6. W. H. Press, S. A. Teukolsky, W. T. VerllingandB. P. Flannery, Numerical Recipes in C, Cambridge (1998).
7. Numerical Recipes,W H Press et al. (Cambrideg University Publication).
8. Introduction to Numerical Methods T. R. McCalla
9. An Introduction to Numerical AnalysisK. E. Atkinson.
10. Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A. VandeWouwer, P. Saucez, C. V. Fernández. 2014 Springer ISBN: 978-3319067896
11. A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3rd Edn., Cambridge University Press

MPHC 4.22
EXPERIMENTAL METHOD (PRACTICAL)

Practical Credit: 2

Experimental Techniques
1. An exercise for the statistical analyses of a given set of data.
2. Determine output characteristics of a LVDT & measure displacement using LVDT
3. Measurement of Strain using Strain Gauge.
4. Measurement of level using capacitive transducer.
5. To study the characteristics of a Thermostat and determine its parameters.
6. Study of distance measurement using ultrasonic transducer.
7. Calibrate Semiconductor type temperature sensor (AD590, LM35, or LM75)
8. To measure the change in temperature of ambient using Resistance Temperature Device (RTD).
9. Create vacuum in a small chamber using a mechanical (rotary) pump and measure the chamber pressure using a pressure gauge.
10. Comparison of pickup of noise in cables of different types (co-axial, single shielded, double shielded, without shielding) of 2m length, understanding of importance of grounding using function generator of mV level & an oscilloscope.
11. To design and study the Sample and Hold Circuit.
12. Design and analyze the Clippers and Clampers circuits using junction diode
13. To plot the frequency response of a microphone.
14. To measure Q of a coil and influence of frequency, using a Q-meter.
15.

Recommended Books and References:
1. Electronic circuits: Handbook of design and applications, U. Tietze and C. Schenk, 2008, Springer
2. Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1990, Mc-Graw Hill
3. Measurement, Instrumentation and Experiment Design in Physics & Engineering, M. Sayer and A. Mansingh, 2005, PHI Learning.

MPHD 4.11 (a)
Atmospheric Physics

Theory Credits: 4

UNIT I: Thermodynamics of the Atmosphere:
Thermodynamics of dry air, equation of state for dry air, specific gas constant & specific volume, thermodynamic process, isothermal process, isobaric process, isochoric process, adiabatic process, potential temperature, entropy, specific entropy, isentropic process, Poisson's equation for pressure and temperature, equation of state for water vapor, moist air, Moisture variables, virtual temperature, pseudo- adiabatic process, Clausius – Clapeyron equation, equivalent temperature, equivalent potential temperature, thermodynamic diagrams, Tephigram diagram (T-φ gram) and its application. Hydrostatic equilibrium, Hydrostatic equation, parcel method, vertical stability and instability of the atmosphere, determination of the stability of an air parcel, stable equilibrium, unstable equilibrium and neutral position for unsaturated and dry air, equilibrium states for saturated air parcel, condition for absolute instability, conditional adiabatic instability, Tropical convection.

UNIT II:Cloud Physics and Atmospheric Electricity:
Cloud classification, Formation of cloud, cloud droplet growth by condensation, curvature effect, homogeneous and heterogeneous nucleation, cloud condensation nuclei, hydroscopic & hydrophobic cloud condensation nuclei, Raoult's Law, Kelvin equation, Kohler equation, cold & Warm cloud, droplet growth by collision and coalescence process, ,ice nucleation, Bergeron-Findeisen process, virga,freezing rain, lifting condensation level(LCL), LFC, thunderstorms, role of Convective Available Potential Energy (CAPE) and Convective Inhibition Energy (CINE) in thunderstorm development, brief idea about mesoscale convective systems and cyclone, Atmospheric ionization, fair weather electricity, global electrical circuit, atmospheric ions, mobility of ions, conductivity, gross structure of thunderstorms, basic characteristics of electrification theories, Lightning discharge and mechanism.

UNIT III: Dynamic Meteorology:
Inertial and non-inertial frame, fundamental forces, real and pseudo force, Body and surface force, basic equations of fundamental forces, Pressure gradient force, gravitational force, viscous force, centrifugal force, gravity force and Coriolis force, structure of the static Atmosphere, pressure as a vertical coordinate, total differentiation, temperature advection, cold advection, total differentiation of a vector in a rotating frame,- vectorial form of the momentum equation in rotating frame, component equation in spherical coordinates, scale analysis, scale of atmospheric motions, Scale analysis of the equation of motion, scale analysis of the horizontal momentum equations, the geostrophic approximation and the geostrophic wind, Rossby number, hydrostatic approximation, equation of continuity, thermodynamic energy equation, isobaric coordinate, thermal wind, vorticity, Reynolds and Froude numbers. vorticity and divergence, Bjerknese circulation theorem and applications.

UNIT IV: Planetary (Atmospheric) BoundaryLayer, Atmospheric Waves & Atmospheric Instability (Synoptic Scale Motion):
Structure, evolution and properties of planetary boundary layer, atmospheric turbulence, the Boussinesq approximation, planetary boundary layer, mixing length theory, Ekman layer, surface layer, modified Ekman layer, Richardson number.
Linear Perturbation Theory, the perturbation method, gravity waves, Internal gravity waves, inertia waves, Rossby waves.
Atmospheric instability, hydrodynamic instability, barotropic instability, baroclinic instability, Necessary condition of barotropic and baroclinic instability, Kelvin-Helmholtz instability.

UNIT V: General Circulation, tropical dynamics and Numerical Modeling:
General circulation, Hadley circulation, zonally averaged circulation, zonal and meridional components of drag owing to small eddies, mean meridional motion, advantage of zonally averaged circulation, conventional eulerian mean, transformed eulerian mean, eddy potential vorticity, eliassen-palm flux, mean meridional and eddy transport of momentum and energy angular momentum budget, sigma coordinate, Newton's second law in its angular momentum form in isobaric coordinates, ferrel's cells & polar cells, single cell model, three cell model, meridional circulation model.
Tropical dynamics, tropical monsoon, walker circulation, El NINO and the southern oscillation (ENSO)& LANINA, MJO (Madden-Julian oscillation)
Basic principles of Numerical Weather Prediction model, primitive equation model, brief idea about parameterization schemes & Data assimilation, concepts of ocean – atmosphere coupled models.

Recommended Books and References:

1. Fundamental of Atmospheric Physics – Murry L Salby; Academic Press, Vol 61, 1996
2. The Physics of Atmosphere – John T. Houghton; Cambridge University press; 3rd edn. 2002
3. An Introduction to dynamic meteorology – James R Holton; Academic Press, 2004
4. A Short course in cloud physics (3rd Edition) - R.R. Rogers& M.K. Yau ; Internationalseriesin naturalphilosophy;v.113,Elsevier,1989.
5. Atmospheric Sciences: An introductory Survey by J.M. Wallace and P.V. Hobbs,Academic Press.
6. Radar for meteorological and atmospheric observations – S Fukao and KHamazu, Springer Japan, 2014.

MPHD 4.11(b)
APPLIED DYNAMICS

Theory Credit: 5
Tutorial Credit: 1

UNIT I **Introduction to Dynamical systems:** Definition of a continuous first order dynamical system. The idea of phase space, flows and trajectories. Simple mechanical systems as first order dynamical systems: the free particle, particle under uniform gravity, simple and damped harmonic oscillator. Sketching flows and trajectories in phase space; sketching variables as functions of time, relating the equations and pictures to the underlying physical intuition.

UNIT II **Different dynamical systems:**
In Biology: Population models e.g. exponential growth and decay, logistic growth, species competition, predator-prey dynamics, simple genetic circuits.
In Chemistry: Rate equations for chemical reactions e.g. auto catalysis, bistability
In Economics: Examples from game theory. Illustrative examples from other disciplines.
Fixed points, attractors, stability of fixed points, basin of attraction, notion of qualitative analysis of dynamical systems, with applications to the above examples. Computing and visualizing trajectories on the computer using software packages. Discrete dynamical systems. The logistic map as an example.

UNIT III **Introduction to Chaos**: Examples of 2-dimensional billiard, Projection of the trajectory on momentum space. Sinai Billiard and its variants. Computational visualization of trajectories in the Sinai Billiard. Randomization and ergodicity in the divergence of nearby phase space trajectories, and dependence of time scale of divergence on the size of obstacle. Electron motion in mesoscopic conductors as a chaotic billiard problem. Other examples of chaotic systems; visualization of their trajectories on the computer. Self similarity and fractal geometry:

UNIT IV **Introduction to Fractals:** Fractals in nature,trees, coastlines, earthquakes, etc. Need for fractal dimension to describe self-similar structure. Deterministic fractal vs. self-similar fractal structure. Fractals in dynamics – Serpinski gasket and DLA. Chaos in nonlinear finite-difference equations- Logistic map: Dynamics from time series. Parameter dependence- steady, periodic and chaos states. Cobweb iteration. Fixed points. Defining chaos- aperiodic, bounded, deterministic and sensitive dependence on initial conditions. Period- Doubling route to chaos. Nonlinear time series analysis and chaos characterization: Detecting chaos from return map. Power spectrum, autocorrelation,Lyapunov exponent, correlation dimension.

UNIT V **Elementary Fluid Dynamics:** Importance of fluids: Fluids in the pure sciences, fluids in technology. Study of fluids: Theoretical approach, experimental fluid dynamics, computational fluid dynamics. Basic physics of fluids: The continuum hypothesis- concept of fluid element or fluid parcel; Definition of a fluid- shear stress; Fluid properties- viscosity, thermal conductivity, mass diffusivity, other fluid properties and equation of state; Flow phenomena- flow dimensionality, steady and unsteady flows, uniform & non-uniform flows, viscous & inviscid flows, incompressible & compressible flows, laminar and turbulent flows, rotational and irrotational flows, separated & unseparated flows. Flow visualization - streamlines, path lines, Streaklines.

Recommended Books and References:

1. Nonlinear Dynamics and Chaos, S.H. Strogatz, Levant Books, Kolkata, 2007
2. Understanding Nonlinear Dynamics, Daniel Kaplan and Leon Glass, Springer.
3. An Introduction to Fluid Dynamics, G.K.Batchelor, Cambridge Univ. Press, 2002
4. Fluid Mechanics, 2nd Edition, L. D. Landau and E. M. Lifshitz, Pergamon Press, Oxford, 1987.

MPHD 4.11(c)
COMMUNICATION ELECTRONICS

Theory Credit: 4

UNIT I Electronic communication: Introduction to communication – means and modes. Need for modulation. Block diagram of an electronic communication system. Brief idea of frequency allocation for radio communication system in India (TRAI). Electromagnetic communication spectrum, band designations and usage. Channels and base-band signals. Concept of Noise, signal-to-noise (S/N) ratio

UNIT II Analog Modulation: Amplitude Modulation, modulation index and frequency spectrum. Generation of AM (Emitter Modulation), Amplitude Demodulation (diode detector), Concept of Single side band generation and detection. Frequency Modulation (FM) and Phase Modulation (PM), modulation index and frequency spectrum, equivalence between FM and PM, Generation of FM using VCO, FM detector (slope detector), Qualitative idea of Super heterodyne receiver.

UNIT III Analog Pulse Modulation: Channel capacity, Sampling theorem, Basic Principles- PAM, PWM, PPM, modulation and detection technique for PAM only, Multiplexing Digital Pulse Modulation: Need for digital transmission, Pulse Code Modulation, Digital Carrier Modulation Techniques, Sampling, Quantization and Encoding. Concept of Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK), Phase Shift Keying (PSK), and Binary Phase Shift Keying (BPSK).

UNIT IV Introduction to Communication and Navigation systems:Satellite Communication– Introduction, need, Geosynchronous satellite orbits,geostationary satellite advantages of geostationary satellites. Satellite visibility, transponders (C - Band), path loss, ground station, simplified block diagram of earth station. Uplink and downlink

UNIT V Mobile Telephony System – Basic concept of mobile communication, frequency bands used in mobile communication, concept of cell sectoring and cell splitting, SIM number, IMEI number, need for data encryption, architecture (block diagram) of mobile communication network, idea of GSM, CDMA, TDMA and FDMA technologies, simplified block diagram of mobile phone handset, 2G, 3G and 4G concepts (qualitative only).GPS navigation system (qualitative idea only).

Recommended Books and References:
1. Electronic Communications, D. Roddy and J. Coolen, Pearson Education India.
2. Advanced Electronics Communication Systems- Tomasi, 6th edition, Prentice Hall.
3. Electronic Communication systems, G. Kennedy, 3rd Edn., 1999, Tata McGraw Hill.
4. Principles of Electronic communication systems – Frenzel, 3rd edition, McGraw Hill
5. Communication Systems, S. Haykin, 2006, Wiley India
6. Electronic Communication system, Blake, Cengage, 5th edition.
7.Wireless communications, Andrea Goldsmith, 2015, Cambridge University Press

MPHD 4.11(d)
Bio-Physics

Theory Credit: 4

UNIT I **Photochemistry:** Interaction of photons with chemical compounds, photosensitive chemicals, photo induced electronic transitions in organic molecules, quantum yield, photo induced chemical reactions in air (troposphere, stratosphere, other spheres), examples, reaction mechanisms and applications, Chemiluminescence.

UNIT II **Photosynthesis:** The phenomenon and types, Chlorophyll molecules, Chloroplasts, Photochemical Systems, Electron Transport Processes, Vision, Molecular Mechanism of Photoreception, Bioluminescence, Bacteriorhodopsin.

UNIT III. **Radiation in Environment:** (i) Ionizing & Non-Ionizing Radiations and their origins; Dose Measurement; (ii) Nuclear Radiation: Nuclear structure & stability, Radio-Isotopes, Radioactive decay kinetics. (iii) Electromagnetic Radiations and classification.

UNIT IV. **Radiation Biophysics:** (a) X-Ray: Effects on Bio-macromolecules. (b) Gamma Radiation: Molecular Effects of Gamma Radiation, Radiation Chemistry of Water, (c) Ultraviolet Radiation: Effects on Bio-macromolecules & Molecular Structures. (d) Alpha & Beta Radiations: Effects on Cells and Organelles. (e) Radiation Hazards & Protection: Radiation Effects and Genetics. use of radiations in cancer & other diseases.

UNIT V **Environmental Biophysics:** Introduction toEcosystem: Physical Environment, Geological Environment and Biosphere. Ecosystem Analysis:Population Dynamics, Prey-Predator Models Environmental Stress: Depletion of Oxygen Pressure with altitude.

Suggested readings:

1. Nuclear Physics, Theory and Experiment by Roy R.R& Nigam B.P. (Wiley)
2. Introductory Nuclear Physics by Halliday D, (John Wiley)
3. Biological Effects of Radiation by Coggle J.E.. (Taylor & Francis).
4. Molecular Theory of Radiation Biology by Chadwick K.H. &Leenbouts H.P. (Springer Verlag)
5. Introduction to Radiological Physics and Radiation Dosimetry by Atlik F.H. (John Wiley)
6. An Introduction to Environmental Biophysics by Campbell, Gaylon S., Norman, John M. (Springer)

MPHD – 4.12 (a)
ATMOSPHERIC PHYSICS (PRACTICAL)

Credits: 2

N.B:

a. The concern teacher can replace a given experiment(s) by a similar type of experiment(s) depending on the available resources.
b. A student is required to perform a minimum of seven (07) experiments.

1. To measure the dew point temperature and relative humidity with the help of wet and dry bulb temperature.
2. Compute the mixing ratio, saturation mixing ratio, relative humidity, vapour pressure and saturation vapour pressure from the Skew T- log P diagram.
3. Compute the equivalent temperature, potential temperature and equivalent potential temperature and virtual temperature from the Skew T- log P diagram.
4. Compute wet -bulb potential temperature from the Skew T- log P diagram.
5. Find out the lifting condensation level (LCL), convection condensation level (CCL), convection temperature, Level of free convection (LFC) and equilibrium level (EL) from the Skew T-log P diagram.
6. Compute the CAPE and CIN from the Skew T-log P diagram.
7. Find out the type of instability of the air parcel for a given height profile of temperature and dew point temperature by using the Skew T-log P diagram.
8. Compute the surface -parcel heating case, lifted surface-parcel, lifted upper-level parcel case and energy determination.
9. Analyses of cloud tops and bases, forecasting convective cloud tops and bases and forecasting stratiform cloud tops and bases.
10. Determine the thickness of a Layer.
11. Computation of divergence and vorticity by finite difference technique.
12. Computation of verticalvelocity using equation of continuity.
13. To compute (for one minute interval) the number density, rainfall intensity, liquid water content of a rainfall event by using Joss-Waldvogel disdrometer.
14. To compute (for more than one minute interval) the number density, rainfall intensity, liquid water content of a rainfall event by using Joss-Waldvogel disdrometer.
15. To compute (for one minute interval) the number density, rainfall intensity, liquid water content of a rainfall event by using Joss-Waldvogel disdrometer.
16. To compute (for more than one minute interval) the number density, rainfall intensity, liquid water content of a rainfall event by using Joss-Waldvogel disdrometer.
17. To compute (for one minute interval) the radar reflectivity and weighted mean diameter of a rainfall event by using Joss-Waldvogel disdrometer.
18. To compute (for more than one minute interval) the radar reflectivity and weighted mean diameter of a rainfall event by using Joss-Waldvogel disdrometer.
19. To compute (for more than one minute interval) the number density, rainfall intensity, liquid water content of a rainfall event by using parsivel disdrometer.
20. To compute (for one minute interval) the number density, rainfall intensity, liquid water content of a rainfall event by using parsivel disdrometer.
21. To compute (for more than one minute interval) the number density, rainfall intensity, liquid water content of a rainfall event by using parsivel disdrometer.
22. To compute (for one minute interval) the radar reflectivity and weighted mean diameter of a rainfall event by using parsivel disdrometer.
23. To compute (for more than one minute interval) the radar reflectivity and weighted mean diameter of a rainfall event using parsivel disdrometer.
24. Analyze the given rain DSD spectrum during various types of rain.
25. Analyze the height profile of radar reflectivity and rain intensity by using micro rain radar (MRR) observations.

MPHD 4.12(c)
COMMUNICATION ELECTRONICS (PRACTICAL)

Practical Credit: 2

1. To design an Amplitude Modulator using Transistor
2. To study envelope detector for demodulation of AM signal
3. To study FM - Generator and Detector circuit
4. To study AM Transmitter and Receiver
5. To study FM Transmitter and Receiver
6. To study Time Division Multiplexing (TDM)
7. To study Pulse Amplitude Modulation (PAM)
8. To study Pulse Width Modulation (PWM)
9. To study Pulse Position Modulation (PPM)
10. To study ASK, PSK and FSK modulators

MPHD 4.12(d)
Bio-Physics (Practical)
Practical Credit : 2

1. Studying UV absorption spectra of DNA and protein, and effect of heat denaturation.
2. Studying secondary/tertiary structure of proteins through CD spectroscopy.
3. Studying interaction of dyes with DNA through fluorescence spectroscopy.
4. Studying dynamics of chlorophylls I& II through absorption spectroscopy.
5. Effect of light on Vitamins A (retinol) through spectroscopic methods.

DISCIPLINE SPECIFIC ELECTIVE 4

MPHD 4.21
DISSERTATION

Credits: 6
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The objective of dissertation is to expose the students to the techniques of research methodology, critical analysis and manner of identifying and consulting available literature Every student shall have to carry out work on an assigned topic in any branch of Physics in consultation with the supervisor allotted by the department.

The student should be exposed to lab work, collection of data and its presentation, literature survey to give him/her a glimpse of research training.

The result of work shall be written and submitted in form of thesis. The guidelines for the format of the thesis can be accessed by the student from examination branch.

The evaluation of dissertation shall be in form of power point presentation and followed by viva-voce as per the guidelines of the examination committee of the College.