

Department of Physics
University of Kerala



M.Sc PROGRAMME IN PHYSICS
SYLLABUS
(Under credit and Semester system w.e.f. 2017 Admissions)

DEPARTMENT OF PHYSICS
UNIVERSITY OF KERALA
M.Sc. PROGRAM IN PHYSICS
(Specialization: Applied Electronics)
(Under Credit and Semester System with effect from 2017 admissions)

Program Objectives:

- To provide well defined study of theoretical and experimental physics to impart in depth understanding in fundamental aspects of all core areas of Physics
- To equip the student to pursue research and development in any areas of theoretical, experimental computational physics.
- To impart special training in different areas of electronics
- To bridge the gap between text book knowledge and practical problems through well designed laboratory sessions.
- To introduce the student to the scientific research methodology, literature survey, technical writing, assimilation and dissemination of results, etc. through a project work.

Program Structure

Semester No	Course Code	Credits	Subject
I	PHY-C- 411	4	Mathematical Physics - I
	PHY-C412	4	Classical Mechanics
	PHY-C-413	4	Electrodynamics
	PHY-C- 414	4	Electronic Devices and Circuits
	PHY-C-415	4	Lab: Basic Electronics
II	PHY-C-421	4	Mathematical Physics – II
	PHY-C- 422	4	Quantum Mechanics – I
	PHY-C-423	4	Thermal and Statistical Physics
	PHY-C- 424	4	Atomic and Molecular Physics
	PHY-C- 425	4	Lab: Advanced Physics
III	PHY-C- 431	4	Quantum Mechanics – II
	PHY-C-432	4	Solid State Physics
	PHY-C- 433	4	Nuclear and Particle Physics
	PHY-E- 434	4	Computational Methods
	PHY-E-435	4	Digital Electronics and Microprocessors
IV	PHY-E-441	4	Communication Electronics and Instrumentation
	PHY-E- 442	3	Solid State Electronic Devices
	PHY-E-443	4	Lab: Advanced Electronics
	PHY-D-444	6	Project
Extra Departmental Elective Courses			
I	PHY-X-411	2	Foundations of Astronomy

Semester I

Course Code: PHY-C-411

Course Title: MATHEMATICAL PHYSICS I

Credits: 4

Aim: To equip the students for using basic mathematical methods for solving complex physical problems.

Objectives: To provide basic understanding of vector space and matrices, curvilinear coordinates various techniques for solving differential equations and the Fourier and Laplace Transforms for different applications.

Course Content

MODULE I

Vector Spaces and Matrices: Postulates – linear independence-subspace- ordered dimensions- Euclidian vector space- reciprocal basis- Hilbert space- linear equations- Eigen value problem- orthogonal matrices – Hermitian matrices and Unitary matrices – Diagonalization of matrices – Eigen vector and Eigen values – normal modes of vibration – singular matrices- inverse of matrix

MODULE II

Curvilinear Coordinates: Orthogonal curvilinear coordinates- Differential vector operator- Gradient, divergence, curl and Laplacian in Cartesian, cylindrical and spherical polar coordinates.

Partial Differential Equations: Linear second order partial differential equations – Solutions of partial differential equations- separation of variables- solution of wave equations.

MODULE III

Gamma, (Γ), Beta (β) and Delta (δ) functions: Gamma functions – Gauss λ functions, values of $\Gamma(1/2)$ – β functions- connection between β and Γ functions- Error function – Dirac delta function – representation of δ function – properties.

MODULE IV

Legendre differential equations: Series solution – Rodrigues formula for $P_n(x)$ - Generating function for $P_n(x)$ – Orthogonality of Legendre polynomials – Orthogonality of associate Legendre polynomial.

Bessel's equation: Series solution- Bessel function of second kind – Generating function for $J_n(x)$ – Bessel's integral representation – Recurrence formula for $J_n(x)$ – Orthogonality of $J_n(x)$ – Spherical Bessel function.

MODULE V

Hermite differential equation: Series solution – Rodrigues formula for Hermite polynomial $H_n(x)$ – recurrence relation for Hermite polynomial- Generating function – Orthogonality of Hermite equation.

Laguerre's differential equation: Series solution – generating function - $L_n^m(x)$ - Rodrigues formula- Associate Laguerre's function of integral order.

MODULE VI

Fourier series and Integrals: Periodic series and integrals – Periodic functions – Fourier series – Euler Fourier series- Convergence of Fourier series and Dirichlet's condition, half range Fourier series – change of interval – identity- integration and differentiation of Fourier series – Fourier integrals and Transforms – Application of the solution in one dimension – alternative form of Fourier sine and cosine series.

Laplace Transform: Definition – Existence – derivatives- elementary functions – periodic function – functions defined by integrals.

References

- Arfken & Webber (2005). Mathematical Methods for Physicists, Academic Press, 6thed.
- Ghatak, A. K. et al. (2012). Mathematical Physics: differential equations and transform theory, Macmillan & Co. Ltd., 1sted.
- Pipes L.A. & Harvill L.R. (1982). Applied Mathematics for Engineers and Physicists, McGraw-Hill Book Company, 3rd ed.
- Rajput, B. S. (2001). Mathematical Physics, Pragati Prakashan, 15thed.

Additional References

- GNU Scientific Library – Reference Manual: *Special Functions*
<https://www.gnu.org/software/gsl/manual/html.../Special-Functions.html>
- <https://www.physicsforums.com/threads/when-to-use-laplace-fourier-series-transforms.192535/>
- Laplace and Fourier Transforms
www.cambridge.org/us/features/chau/webnotes/chap2laplace.pdf
- MIT 18.06 Linear Algebra Spring 2005 - *Video Lectures*.NET
videolectures.net › ... › MIT Open Courseware
- NIST Digital Library of Mathematical Functions
dlmf.nist.gov/

Semester I

Course Code: PHY-C-412

Course Title: CLASSICAL MECHANICS

Credits: 4

Aim: To equip the students for analysing mechanical problems beyond the Newtonian formulation.

Objectives: To introduce analytical methods of mechanics based on generalised coordinates momenta and solve the practical problems using these concepts.

Course Content

MODULE I

Review of Newtonian Formulation: Space, Time, Reference frames – inertial, non-inertial, Galilean transformation, System of particles, Conservation laws, Limitations of Newtonian formulation.

Lagrangian Formulation of Mechanics: Generalize coordinates – constraints, virtual displacement, principle of virtual work, d'Alemberts principle, Lagrange's equation of motion, simple applications of Lagrange's equation, Generalized momenta, Cyclic coordinates, Routhe's procedure, Symmetric properties and conservation laws, Hamilton's principle, Lagrange's equations from Hamilton's principle, Non-conservative systems-Rayleigh dissipation function, Non-holonomous system – Lagrange's method of undetermined multipliers.

MODULE II

Hamiltonian Dynamics: Description of motion in phase space, Hamiltonian of a dynamical system, Hamilton's equations, Integrals of Hamilton's equations, Canonical transformations, Generating function, Poisson bracket, phase space and Liouville's theorem.

MODULE III

Hamilton- Jacobi formulation: Hamilton-Jacobi equation- Harmonic oscillator as an example- separation of variables in Hamilton-Jacobi equation – Action-angle variable- Kepler problem.

MODULE IV

Two-body Central Force Problem: Two body problem and reduced mass, general properties of central force motion, effective potentials and classification of orbits, inverse square law of force – Kepler's laws of planetary motion, Newton's laws of gravity from Kepler's Laws, Stability of circular orbits, Hyperbolic orbits and Rutherford's scattering.

MODULE V

Linear Oscillations: Potential energy and equilibrium , Stability expression of potential energy function in a power series, Oscillations of a system with one degree of freedom, Normal coordinates, Coupled harmonic oscillator, Linear symmetric triatomic molecule, General ideas of transition from discrete to continuous system, The wave equation.

MODULE VI

Motion of Rigid Bodies: The independent coordinates of a rigid body, Euler's angles, rotational kinetic energy and angular momentum, Euler's equation of motion, motion of a torque free symmetric top, motion of heavy symmetric top with one point fixed.

References

- Aruldas, G. (2012). Classical Mechanics, Prentice - Hall of India, 1sted.
- Bhatia, V.B. (1997). Classical Mechanics with introduction to non-linear oscillations and chaos, Narosa Publishing House, 1sted.
- Goldstein, Herbert, et al. (2012). Classical Mechanics, Pearson Education, 3rded.
- Rana, N.C. &Joag, P.S (2011). Classical Mechanics, Tata McGraw-Hill Publishing Co., 1sted.
- Vimal Kumar Jain (2009), Classical Mechanics, Ane Books Pvt. Ltd.

Additional References

- David Tong- Cambridge Lectures on Classical Mechanics<http://www.damtp.cam.ac.uk/user/tong/dynamics.htm>
- Special topics in Classical Mechanics- NPTEL IIT Madrashttp://www.onlinevideolecture.com/physics/nptel-iit-madras/special-topics-in-classical-mechanics/?course_id=780

Semester I

Course Code: PHY-C-413

Course Title: ELECTRODYNAMICS

Credits: 4

Aim: To introduce the concepts of non-relativistic and relativistic electrodynamics.

Objectives: To provide basic understanding of the concepts of electricity magnetism electromagnetic waves. To analyse the theory of guided waves and radiation systems. To introduce the elements of relativistic electrodynamics.

Course Content

MODULE I

Electrostatics: Electrostatic boundary value problems-Formal solution with Green's function-method of images-Point charge near an infinite conducting plane-Point charge near a grounded conducting sphere- Point charge near charged insulated conducting sphere-Conducting sphere in a uniform electric field-Laplace's equation in spherical coordinates-Multipole expansion-Electrostatic multipole moments-energy of charge distribution in an external field-electrostatics of macroscopic media-electric polarization and displacement, dielectric constant-Boundary condition at dielectric interface.

MODULE II

Magnetostatics and Dynamics: BiotSavart's law and it's differential statement-Ampere's theorem-Magnetic vector potential- Magnetic charge- Faraday's law-Energy in magnetic field-Displacement current-Maxwell's equations-Scalar and vector potentials-Wave equation in terms of scalar and vector potentials-Gauge transformation -Gauge invariance-Coulomb Gauge-Lorentz Gauge- Boundary condition on fields at interfaces-Conservation of electromagnetic energy-Poynting theorem-Poynting vector.

MODULE III

Electromagnetic waves: Waves in vacuum-Monochromatic plane waves-Plane electromagnetic waves in non-conducting medium- linear and circular polarization-reflection and transmission at dielectric interface-Polarization by reflection- Total internal reflection-Electromagnetic waves in conductors-skin depth-Reflection at a conducting surface.

MODULE IV

Wave guides and Radiation systems: Rectangular and circular waveguides-TE and TM modes-Cavity resonators-Q factor-Concepts on transmission lines-transmission line parameters- Transmission line equations; Simple radiating systems: Green function for wave equation-fields and radiation of a localized oscillating source-Electric dipole field and radiation- Magnetic dipole and radiation-Retarded potentials.

MODULE V

Special theory of relativity: Postulates of relativity-Lorentz transformation-Four vector – Addition of velocities-Four velocity- Relativistic energy and momentum- Matrix representation of Lorentz transformation-Dynamics of relativistic particles; Motion of charged particle in uniform electric and magnetic field.

MODULE VI

Relativistic Electrodynamics: Magnetism as a relativistic problem-Transformation of the fields-Electric field of a uniformly moving point charge-Electromagnetic field tensor-Electrodynamics in tensor notation-Potential formulation of electrodynamics

References

- Cheng, D. K.(2015). Field and wave Electromagnetics, Pearson Education, 2nded.
- Griffiths, D. J. (2012). Introduction to Electrodynamics, Prentice-Hall of India, 3rded.
- Jackson, J. D. (2011). Classical Electrodynamics, Wiley Eastern Ltd., 3rded.
- Sadiku, M. N. O. &Kulkarni, S. V. (2015). Principles of Electromagnetics, Oxford University Press, 6thed.

Additional References

- Basic Plasma Physics<http://www.plasmas.org/plasma-physics.htm>
- Classical Electrodynamics<http://www.thp.uni-koeln.de/alexal/pdf/electrodynamics.pdf>
- Special Relativity and Electrodynamics<http://theoreticalminimum.com/courses/special-relativity-and-electrodynamics/2012/spring>

Semester I

Course Code: PHY-C-414

Course Title: ELECTRONIC DEVICES AND CIRCUITS

Credits: 4

Aim: To equip the students for designing basic electronic circuits.

Objectives: To teach the working BJT, FET, Op amp, Monolithic timers, Optoelectronic and microwave devices.

Course Content

MODULE I

Frequency response of amplifiers: Review of frequency response of CR circuits – Cut off frequencies – band width – Bode plots – single pole and two pole transfer functions – Dominant pole – gain round off- Frequency response of BJT amplifiers- Series capacitance and low frequency response – Shunt capacitance and high frequency response- high frequency characteristics of transistors.

MODULE II

Field Effect Transistor: Biasing of FET, small signal model, analysis of common source and common drain amplifiers, high frequency response – FET and VCR and its applications, CMOS logic and logic packages

Power Amplifiers: Types of power amplifiers, series fed class A amplifier- series fed transformer coupled Class B – Push-Pull circuits- harmonic distortion in amplifiers- Class C and D amplifiers- Design considerations.

MODULE III

Operational Amplifier Circuits: Differential amplifier, Ideal op-amp – inverting, non-inverting, voltage follower, differential configuration, real op-amp- inverting configuration, non-inverting configuration, op-amp parameters, effect of Offset, frequency response, op-amp applications, Buffer amplifier, Mathematical operations- summing, differentiator, integrator, log amplifier, antilog amplifier, active filters – low pass, high pass, band pass, band reject filters, analogue computations, comparators – zero crossing detector, Schmitt trigger, wave form generators- phase shift oscillator, twin-T oscillator, astable multi vibrator, mono-stable multi vibrator, bi-stable multi vibrator, triangular wave generator, sample and hold circuit, voltage regulators.

MODULE IV

Monolithic timers and their applications: RS flip flop, basic timing concept, 555 functional diagrams and pin configuration, astablemultivibrator, mono-stable multi vibrator, free running ramp.

MODULE V

Microwave and Optoelectronic Devices: Tunnel diode, Transfer electron device (Gunn diode) – optical fibre as a wave guide- mode theory of circular wave guides- wave guide equation – modes in step index fiber – graded index fiber – single mode fiber – mode characteristic and cut off frequencies.

MODULE VI

Optical sources – LEDs, Device configuration and efficiency – LED structures – Hetero-junction LED, surface emitting LED, edge emitting LED, Junction Laser,- Operating principle – Hetero-junction Laser. Photodetectors, photoconductors, Pin photo diode, heterojunction diodes, avalanche photodiodes, basic idea of photo transistors

References

- Boylestad, R. L & Nashelsky, L. (2009). Electronic devices and circuit theory, Dorling Kindersley (India) Pvt. Ltd., 10thed.
- Gayakwad, R.A. (2016). Op-Amps and Linear Integrated Circuits, Pearson Education, 4thed.
- Keiser, Gerd (2000). Optical Fiber Communications, McGraw-Hill book Co, Inc, 3rded.
- Millman, J. & Halkias, C. C. (2000) Integrated Electronics: analog and digital circuits and systems, Tata McGraw Hill Publishing Co. Ltd., 1sted.
- Pallab Bhattacharya (2000). Semiconductor Optoelectronic Devices, Prentice-Hall of India Pvt. Ltd., 1sted.
- Ryder, J. D. (2000). Electronic fundamentals and applications, Prentice-Hall of India Pvt. Ltd., 5thed.
- Senior, John M. (1994). Optical Fiber Communications: principles and practice, Prentice-Hall of India Pvt. Ltd., 2nded.

Additional References

- Introduction to the Amplifier and Amplifier Tutorial. http://www.electronics-tutorials.ws/amplifier/amp_1.html What is op-amp?
<http://www.engineersgarage.com/tutorials/op-amp-basics>
- Opto electronics devices - Slide Share
www.slideshare.net/SiddharthPanda1/opto-electronics-devices

Semester I

Course Code: PHY-C-415

Course Title: Lab: BASIC ELECTRONICS

Credits: 4

Aim: To equip the students to design, construct and analyse basic electronic circuits using diodes transistors and ICs.

Objectives: To familiarize the methods of designing practical electronic circuits as per the requirements using basic electronic devices.

List of Experiments

1. Full wave rectifier with Filter circuits
2. Clipper, clamper and voltage doubler
3. Zener voltage regulator
4. RC coupled common emitter transistor amplifier
5. Negative feedback amplifier
6. RC phase shift oscillator
7. Emitter follower
8. Astablemultivibrator using transistor
9. Inverting amplifier
10. Non inverting amplifier
11. Adder and scaler
12. Buffer amplifier
13. Astablemultivibrator using 555
14. Differentiator and integrator

References

- Navas, K. A. (2009). Electronics Lab Manual Vol.2, Rajath Publishers, 4thed
- Navas, K. A. (2013). Electronics Lab Manual Vol.1, Rajath Publishers, 5thed.
- Zbar, Paul B, et al. (1994), Basic Electronics: a text – lab manual, Tata McGraw-Hill Publishing Co.7thed.

Semester II

Course Code: PHY-C-421

Course Title: MATHEMATICAL PHYSICS II

Credits: 4

Aim: To equip the students with advanced mathematical tools to solve physical problems.

Objectives: To provide basic understanding of Complex variables, Tensors, Group Theory, and Probability.

Course Content

MODULE I

Complex Variables: Functions of a complex variable-derivatives-Cauchy-Riemann equations- Cauchy-Riemann equations in polar form-harmonic functions-trigonometric hyperbolic and logarithmic functions- line integrals of complex functions- Cauchy-Goursat theorem- Cauchy's integral formula- derivatives of analytic functions- Taylor series- Laurent series- singular points of an analytical function- poles –removable singularity- essential singularity- point at infinity- residues- calculation of residues- the residue theorem – evaluation of residues- evaluation of definite integrals – miscellaneous definite integrals.

MODULE II

Tensor Analysis: Transformation of co-ordinates in linear space- summation convention- contra-variant and covariant tensors- properties of Kronecker delta- addition, multiplication and contraction of tensors – metric tensor- conjugate metric tensor – associated tensor- tensor calculus- Christoffel's symbols – Christoffel's symbols in rectangular, cylindrical and spherical polar coordinates- covariant differentiation – tensor form of gradient, divergence, curl and Laplacian.

MODULE III

Green's Function: Green's function in one dimension – motion of a particle in a resistive medium- motion of a damped harmonic oscillator – Green's function in three dimensions – solution of Poisson's equation.

MODULE IV

Group Theory: Definition of a group – elementary properties of group-multiplication table-permutation groups-groups of transformations-conjugate elements and classes- sub groups – cyclic groups-cosets- and classes – cyclic group – direct product of groups – distinct groups of a given order-homomorphism and isomorphism.

MODULE V

Representation of Theory of Groups - Representation of finite groups – invariant subspace – properties of representations' – reducibility of a representation – irreducible representations – orthogonally theorem – characters of representations – orthogonally of characters – reduction of reducible representations – the groups C_{2v} and C_{3v} as examples – continuous groups – Lie groups – $SO(2)$ and $SO(3)$ groups – generators of $SO(2)$ – special unitary groups – $SU(2)$ and $SU(3)$ groups and their representations.

MODULE VI

Probability - Laws of probability – discrete probability distributions – theory of combinations and permutations – Stirling approximation for the factorial – continuous distributions – moments and standard deviations – Binomial distribution – Poisson distribution – normal distribution – distribution of a sum of normal variates – applications to experimental measurements.

References

- Arfken & Webber (2005). Mathematical Methods for Physicists, Academic Press, 6thed.
- Churchill, R. V. & Brown, J. W. (1996). Complex Variables and Applications, McGraw-Hill Book Co. Inc., 6thed.
- Joshi, A. W. (2000). Matrices and Tensors in Physics, New Age International Publishers (P) Ltd., 3rd ed.
- Joshi, A.W. (2015). Elements of group theory for physicists, New Age International Publishers (P) Ltd., 4thed.
- Pipes L.A. & Harvill L.R. (1982). Applied Mathematics for Engineers and Physicists, McGraw-Hill Book Company, 3rd ed.
- Spiegel, M. R. (1981). Schaum's Outline of Theory and Problems of Vector Analysis and an Introduction to Tensor Analysis, Schaum Publishing Co., 1sted.
- Tung, Wu-Ki (2014). Group Theory in Physics, World Scientific, 1sted.

Additional References

- *Complex Algebra* - University of Miami
www.physics.miami.edu/~nearing/mathmetho1.ds/complex_algebra.pdf
- TENSOR ANALYSIS - Princeton University
<https://web.math.princeton.edu/~nelson/books/ta.pdf>

Semester II

Course Code: PHY-C-422

Course Title: QUANTUM MECHANICS I

Credits: 4

Aim: To equip the student to think, formulate, analyse and interpret single particle nonrelativistic quantum mechanical problems.

Objective: To teach the fundamental aspects of quantum mechanics, introduce the methodology to formulate and solve quantum mechanical problems enabling a better understanding of atomic and molecular systems.

MODULE I

Origin of Quantum Physics: Inadequacy of Classical Physics: Particle aspect of radiation- Black body radiation- Max Planck's quantum hypothesis, Photoelectric effect- Einstein's explanation, Compton Effect, Pair production, Quantum theory of specific heat of solids. [*Experimental results and qualitative discussion only, Derivations not required*]. Frank-Hertz experiment- existence of atomic energy levels, Bohr's atom model, Wilson-Sommerfeld quantum conditions – Elliptical orbits of hydrogen atom, Particle in a box, Rigid rotator, Linear harmonic oscillator- Bohr's Correspondence principle, Limits of applicability of classical theory, Inadequacy of old quantum theory- Practical and Conceptual difficulties.

Wave aspect of Particles: De Broglie's hypothesis of matter waves, The Davisson-Germer experiment, G. P. Thomson's experiment, Matter waves for macroscopic objects. Particle versus Waves – Classical view of particles and waves, Quantum view of particles and waves, Wave-particle duality: Complementarity principle, Principle of linear superposition, Heisenberg's uncertainty principle, Position-momentum uncertainty, Uncertainty relation for other variables, Explanation of single slit diffraction experiment, double slit diffraction experiment and interference experiment (Michelson interferometer) using corpuscular picture and uncertainty principle.

MODULE II

Wave Mechanical Concepts: Time dependent Schrödinger equation – Development of time dependent Schrödinger equation, Physical significance of the wave function, ψ - Probability interpretation, orthogonal, normalized and orthonormal functions, Probability current density, Limitations on ψ , Expectation value of dynamical quantities, Ehrenfest's theorem. The general solution of time dependent Schrödinger equation for a free particle (one dimensional), Free particle propagator, Wave packet, Time dependent evolution of a wave packet, Group velocity and Phase velocity, Time independent Schrödinger equation, Stationary states.

MODULE III

Wave Mechanics - Operator Method in Quantum Mechanics: Definition of an operator, Operator algebra, Eigenvalues and Eigenfunctions, Properties of Eigenfunctions, Vector representation of Orthogonality relation, Expansion theorem, Vectors in a complex n-dimensional space, Hilbert space, Different types of operator- linear operator, Hermitian operator, Adjoint or Hermitian conjugate of an operator, Parity operator, Projection operator, Identity operator, Inverse operator, Unitary operator, Properties of Hermitian operator, Schwartz inequality, Quantum Mechanical operators and observables, - Fundamental postulates of wave mechanics – Schrödinger equation and Probability interpretation for an N-particle system, The Superposition principle, Exact proof and statement of uncertainty

principle, Classical Poisson Bracket, Quantum Poisson Bracket and equation of motion, Commutation rules for components of angular momentum.

Fourier techniques and momentum Representation: Momentum Eigenfunctions and their significance, The Kronecker delta and Dirac's delta functions, Coordinate and momentum representations, Schrödinger wave equation in momentum representation, Significance of momentum wave functions, Box normalization, Momentum wave function for a free particle.

MODULE IV

One-Dimensional Energy Eigenvalue Problems: (Exactly solvable) – Properties of one dimensional motion- Discrete spectrum (Bound state), Continuous spectrum (Unbound state), Mixed spectrum, Symmetry potentials and parity, Free particle: continuous state, The potential step, Boundary condition at the surface of an infinite potential, Square well potential with rigid walls, Square well potential with finite walls, Square potential barrier, Alpha emission, Bloch waves in a periodic potential, Attractive square well potential, Kronig-Penney square well periodic potential, Linear harmonic oscillator- Schrödinger method and Operator method.

MODULE V

Three Dimensional Energy Eigenvalue Problems: (Exactly solvable) Particle moving in a spherically symmetric potential, System of two interacting particles – Rigid rotator, Hydrogen atom, The free particle.

MODULE VI

Heisenberg Method – Matrix formulation of Quantum Mechanics: Matrix algebra, Special matrices, Eigenvalues and eigenvectors of matrices, Linear vector spaces, Hilbert space, Linear operators: Linear transformations, Matrix representation of wavefunction, Matrix representation of operators, Properties of matrix elements, Normalization and Orthogonality of wavefunctions in matrix form, Average value of a dynamical variable in matrix form, Product of two linear transformations, Dual space – Dirac's Bra and Ket notations, Change of basis, Unitary and similarity transformations, Schrödinger equation and the Eigenvalue problems in Matrix method, Quantum dynamics- Schrödinger picture, Heisenberg picture, Interaction picture, One dimensional linear harmonic oscillator solution using matrix mechanics.

Symmetry and Conservation Laws: Symmetry transformations, Translation in Space: Conservation of linear momentum, Translation in time: Conservation of energy, Rotation in Space: Conservation of angular momentum, Space inversion: Parity conservation, Time reversal.

References

- Ajoy Ghatak and Lokanatha S (2007) Quantum Mechanics Theory and Applications, Macmillan India Ltd, 5thed.
- Aruldas G (2011) Quantum Mechanics, Prentice - Hall of India, 2nded
- Mathews P M and Venkatesan K, (1976), A text Book of Quantum Mechanics, Tata McGraw-Hill Publishing Company Ltd.
- Schiff Leonard I (2010) Quantum Mechanics, McGraw-Hill Book Company, India 3rded
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- AjoyGhatak (1996) Introduction to Quantum Mechanics, Mcmillan India Ltd.
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- Merzbacher E (1997) Quantum Mechanics, John Wiley.
- onlinelibrary.wiley.com/doi/10.1002/prop.2190390304/pdf . On Solutions of Quantum Eigenvalue Problems
- [Quantum Physics I | Physics | MIT OpenCourseWareocw.mit.edu > Courses > PhysicsLecturewww.phy.iitb.ac.in/~dkg/qmech/Lecture5.pdf](http://www.phy.iitb.ac.in/~dkg/qmech/Lecture5.pdf)hyperphysics.phy-astr.gsu.edu/hbase/mod6.html
- Thankappan V K (1985) Quantum Mechanics, Wiley Eastern Ltd.
- Waghmare Y R (1997) Fundamentals of Quantum Mechanics, Wheeler Publishing.

Semester II

Course Code: PHY-C-423

Course Title: THERMAL AND STATISTICAL PHYSICS

Credits: 4

Aim: To teach fundamentals of statistical physics and make the students to understand the various statistical methods involved in explaining thermodynamics.

Objectives: To build a comprehensive understanding of microscopic description of systems and bridge these ideas to macroscopic description.

Course Content

MODULE I

Thermal Physics: Laws of thermodynamics- thermodynamic functions of an ideal gas – thermodynamic potentials- Maxwell's relations – Entropy of ideal gas- $T.dS$ equations – Entropy and disorder – Heat capacity of equations.

MODULE II

Classical Statistics: Phase space- density of distribution in phase space – Liouville's theorem- statistical equilibrium – micro-canonical ensemble – Maxwell Boltzmann distribution law- Evaluation of Maxwell Boltzmann constants- Maxwell's law of distribution of velocities – mean values – principles of equipartition of energy- grand canonical ensemble.

MODULE III

Quantum Statistics: Indistinguishability of similar particles – probability of Eigenstates-Bose Einstein statistics, Fermi-Dirac Statistics-Maxwell Boltzmann statistics – comparison of three statistics – Number of Eigen states in an energy range – Eigen states and the Maxwell-Boltzmann equation.

MODULE IV

Applications of Bose-Einstein Statistics: Bose-Einstein system- gas-degeneration-Bose-Einstein statistics and radiation-Bose-Einstein condensation.

Applications of Fermi-Dirac Statistics: Fermi-Dirac system– Extreme gas degeneration-electron gas in metals– thermionic emission of electrons from metals.

MODULE V

Statistical Thermodynamics: Entropy and probability-Entropy and number of Eigen states-thermodynamic functions of a monatomic gas – partition function – entropy and free energy-energy and heat capacity- effect of zero energy level – separation of partition function-translational partition function-translational thermodynamic functions-rotational partition function-nuclear spin effects-vibrational partition function.

MODULE VI

Phase transitions: Phase diagram of a simple substance- Clausius – Clapeyron's equation- phase diagram of Helium – Classification of phase transitions- superconducting phase transition.

References

- Pathria, R.K. (1999). Statistical Mechanics, Butterworth-Heinemann Books, 2nd ed.
- Pippard, A.B. (1966). Elements of classical thermodynamics for advanced students of physics, Cambridge University Press, 1st ed.
- Zemansky, M.W. (1997). Heat and Thermodynamics, McGraw-Hill International Book Co., 7th ed.

Additional References

- *Blackbody Radiation* - Hyper Physics hyperphysics.phy-astr.gsu.edu/hbase/mod6.html
- Handout 6. Thermodynamics - Stanford University micro.stanford.edu/~caiwei/me334/Chap6_Thermodynamics_v04.pdf
- *Phase Changes* - Hyper Physics hyperphysics.phy-astr.gsu.edu/hbase/thermo/phase.html
- *Probability theory* - hyperphysics.phy-astr.gsu.edu/hbase/math/probas.html
- *Statistical Mechanics* | Chemistry | MIT OpenCourseWare ocw.mit.edu › [Courses](#) › [Chemistry](#)

Semester II

Couse Code: PHY-C-424

Course Title: ATOMIC AND MOLECULAR PHYSICS

Credits: 4

Aim: To deliver ideas of matter- electromagnetic radiation interactions and thereby unravel atomic and molecular structures.

Objectives: To build a comprehensive understanding of matter - EM radiation interactions and study their effects with strong theoretical basis.

Course Content

MODULE I

Electronic structure of Atoms: Quantum state of an electron system in an atom, electronic wave functions– The shape of atomic orbitals- Hydrogen atom spectrum- Electronic angular momentum- orbital angular momentum- electron spin angular momentum- total electronic angular momentum- the fine structure of hydrogen atom. Stern-Gerlach experiment- Spin-orbit coupling- relativistic correction.

MODULE II

Electronic Spectra of Atoms: Spectroscopic terms– selection rules– exchange symmetry of wave functions- Pauli's exclusion principle. Many electron atoms- Building principle- the spectra of Li and hydrogen like elements, The L-S and j-j coupling schemes- total angular momentum – term symbols- The spectra of helium Zeeman effect – The magnetic moment of atom, Landé's g factor- The normal Zeeman effect- Emitted frequencies in anomalous Zeeman transitions- Nuclear spin and Hyperfine structure.

MODULE III

Rotation of Molecules: The rotation of molecules – Rotational spectra of diatomic molecules – Rigid Rotator- The intensities of spectral lines – The effect of isotopic substitution – The non-rigid rotator, The spectra of non-rigid rotator – rotational spectra of linear and symmetric top molecules- experimental techniques of MW spectroscopy- structure determination.

MODULE IV

Vibration of Molecules

Origin of infrared transitions- Experimental techniques of IR spectroscopy- the simple harmonic oscillator- the anharmonic oscillator- the diatomic vibration- rotation of diatomic molecules-selection rules- the vibration rotation spectrum of carbon monoxide- the interaction of rotations and vibration- the vibrations of the polyatomic molecules – the influence of rotation on the spectra of poly atomic molecules

Raman Spectroscopy

Classical theory of Raman effect- experimental techniques- Pure rotational Raman spectra- vibrational Raman spectra – Rule of mutual exclusion- Raman spectrometer, Structure determination from Raman and infrared spectroscopy- Basic ideas of surface enhanced Raman spectroscopy- Non-linear Raman spectroscopy- theory – hyper Raman effect.

MODULE V

Electronic Spectra of Diatomic molecules: The Born-Oppenheimer approximation- vibrational coarse structure- Frank Condon principle- Dissociation and pre-dissociation- rotational fine structure of electronic vibration transitions- Fortrat diagram-Electronic structure of diatomic molecules- Electronic angular momentum – Molecular hydrogen spectrum.

NMR spectroscopy: Nuclear magnetic resonance spectra- basic principle- experimental techniques – idea of chemical shift and spin orbit coupling – applications.

MODULE VI

ESR spectroscopy: Electrons spin resonance spectra – basic principle-experimental techniques – idea of hyperfine structure- hydrogen applications.

Mossbauer spectroscopy: Principle- Applications – Structural methods- Quadrupole effects – The effect of magnetic fields.

References

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- Colin N Banwell and Elaine M Mac Coah (2001) Fundamentals of Molecular Spectroscopy, 4th Edition Tata McGraw Hill New Delhi, 4th Edition.
- H E White (1934) Introduction to Atomic Spectroscopy McGraw-Hill Inc. 1st Edition.

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- [Electron spin - HyperPhysics](http://hyperphysics.phy-astr.gsu.edu/hbase/spin.html)hyperphysics.phy-astr.gsu.edu/hbase/spin.html
- **Fourier transform spectroscopy**https://www.princeton.edu/.../docs/Fourier_transform_spectroscopy.htm
- [Raman Scattering - HyperPhysics](http://hyperphysics.phy-astr.gsu.edu/hbase/atmos/raman.html)hyperphysics.phy-astr.gsu.edu/hbase/atmos/raman.html. [Mod-05 Lec-35 Introduction to Nuclear Magnetic ...](https://www.youtube.com/watch?v=Mod-05)[freevidelectures.com/Course/3029/Modern-Instrumental-Methods.../35](https://www.youtube.com/watch?v=Mod-05) [On Solutions of Quantum Eigenvalue Problems: A ...](https://www.youtube.com/watch?v=Mod-05)[onlinelibrary.wiley.com/doi/10.1002/prop.2190390304/pdf](https://www.youtube.com/watch?v=Mod-05)

Semester II

Course Code: PHY-C-425

Course Title: Lab: ADVANCED PHYSICS

Credits: 4

Aim: To equip the students to understand and realise fundamental as well as applied experimental techniques in Physics.

Objectives: To enhance fundamental and applied knowledge of the students through advanced Physics experiments.

List of Experiments

(Any 12 experiments from the list)

1. Determination of $\frac{e}{k}$ of Silicon.
2. Calibration of Scale Using He-Ne Laser.
3. Determination of Young's Modulus by Cornus Method.
4. Determination of Planck's constant (Photoelectric effect).
5. Measurement of Magnetic Susceptibility of a Solution by Quincke's Method.
6. Frank Hertz Experiment.
7. XRD Data Analysis I, II, III
8. Determination of Band Gap.
9. Faradays Rotation Apparatus.
10. Constant Deviation Spectrometer.- Arc Spectrum of Copper
11. Constant Deviation Spectrometer.- Arc Spectrum of Iron
12. Constant Deviation Spectrometer.- Arc Spectrum of Brass
13. Constant Deviation Spectrometer.- Absorption spectrum
14. Constant Deviation Spectrometer.- Hydrogen spectrum
15. Millikan's Oil Drop Experiment.
16. Particle Size Analyzer (Using Diode Laser).
17. Zeeman Effect
18. Michelson's Interferometer
19. e/m by Thomson method
20. UV-Visible spectrometer-Verification of BEER-Lambert's law
21. UV-Visible spectrometer- Band gap
22. Photo luminescent Spectrum

Semester III

Course Code: PHY-C-431

Course Title: QUANTUM MECHANICS II

Credits: 4

Aim: To equip the student to analyse and solve advanced problems in quantum mechanics by learning approximate techniques, handling many body problems, etc and to understand the preliminary ideas of relativistic quantum mechanics.

Objectives: To teach the different approximate methods of solving Schrodinger equations, handling many particle systems, etc., and to introduce relativistic quantum mechanics so that realistic problems could be analyzed and solved by the student.

Course Content

MODULE I

Theory of Angular momentum: The angular momentum operators– fundamental commutation relations of angular momentum. Eigen values and Eigen functions of L^2 and L_z . Spin – general angular momentum – Eigen values and Eigen vectors of J^2 and J_z , matrices for J_+ , J_- , J_x and J_y . Spin – (1/2) systems – Pauli's spin matrices, - Eigen vectors and Eigen values of spin – (1/2) systems. Addition of angular momenta , Eigen value of the total angular momenta – Clebsh - Gordan coefficients – recursion relations – construction procedure – some particular coefficients for cases ($j_1: \frac{1}{2}$, and $j_2: \frac{1}{2}$, only).

MODULE II

Time-Independent Perturbation Theory: Basic concepts, Non-degenerate case- first order and second order perturbations, Anharmonic oscillator – first order correction, Effect of electric field on the ground state of hydrogen. **Variation Method** – The principle of variation method- Rayleigh-Ritz method, Variational method for excited states- harmonic oscillator problem, ground state of Helium. **WKB Approximation** – The WKB method, Connection formula, validity of WKB method, Barrier penetration, Alpha emission.

MODULE III

Time-Dependent Perturbation Theory: Time – dependent perturbation theory – Harmonic perturbation – transition probability. Transition to continuum states – Transition probability per unit time – Fermi's golden rule. Interaction with classical radiation field – absorption and stimulated emission – electric dipole approximation, Einstein's A and B coefficients, selection rule for emission and absorption of light radiation, sudden and adiabatic approximation.

MODULE IV

Collision Theory: Elastic scattering– differential and total scattering cross-sections, the scattering amplitude. Method of partial waves – expansion of a plane wave in terms of partial waves – scattering by a central potential – phase shift – Optical theorem, scattering by a hard sphere, low energy scattering – s-wave scattering by a square well: Ramsauer-Townsend effect, scattering of neutrons by protons, resonance scattering – Briet-Wigner formula. Zero energy scattering – scattering length. Green's function technique of solving inhomogeneous differential equation – First Born approximation, validity of Born approximation.

Applications: Scattering amplitude in the case of spherically symmetric potential, Screened Coulomb potential leading to Rutherford scattering formula.

MODULE V

Identical particles: Indistinguishability and exchange symmetry – Fermion and Boson assemblies. Symmetric and anti-symmetric wave functions – construction from unsymmetrized functions, The exclusion principle – Slater determinant. Spin angular momentum – spin matrices and Eigen functions – spin functions for two electrons, The Helium atom, spin functions for three electrons, the He atom. Central field approximation – Hartree-Fock equation – direct term and exchange term.

MODULE VI

Relativistic wave equations: Klein-Jordan equations – interpretation and its failure, Dirac's relativistic equation – free-particle equation, Position probability density, expectation values, matrices for α and β , free-particle solutions and energy spectrum – existence of states with negative energy, spin of the Dirac particle, Significance of negative energy states.

References

- Ajoy Ghatak and Lokanatha S (2007) Quantum Mechanics Theory and Applications, Macmillan India Ltd, 5thed.
- Aruldas G (2011) Quantum Mechanics, Prentice - Hall of India, 2nded
- Mathews P M and Venkatesan K, (1976), A text Book of Quantum Mechanics, Tata McGraw-Hill Publishing Company Ltd.
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- Zettili Nouridine (2009) Quantum Mechanics, John Wiley and Sons Ltd Publishing.

Additional References

- Ajoy Ghatak (1996) Introduction to Quantum Mechanics, Mcmillan India Ltd.
- Greiner W (1994) Quantum Mechanics- An Introduction, Springer 3rded.
- <http://electron6.phys.utk.edu/qm1/Modules.htm>
- <http://physics.about.com/od/quantumphysics/p/quantumphysics.htm>
- <http://www.livescience.com/33816-quantum-mechanics-explanation.html>
- <http://www.physics.umd.edu/perg/qm/qmcourse/NewModel/qmtuts.htm>
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- Thankappan V K (1985) Quantum Mechanics, Wiley Eastern Ltd.
- Waghmare Y R (1997) Fundamentals of Quantum Mechanics, Wheeler Publishing.

Semester III

Course Code: PHY-C-432

Course Title: SOLID STATE PHYSICS

Credits: 4

Aim: To provide the student with an in-depth knowledge of crystals structure and introduce them to world of electrical and magnetic properties of solids.

Objectives: To teach elements of crystallography, bonding, lattice vibrations, semiconductors dielectric, magnetic and superconducting properties of solids.

Course Content

MODULE I

Crystal Physics: Periodicity in crystals - unit cell- Wigner Seitz cell - point group - space group - Number of lattice points per unit cell - symmetry elements - Bravais lattice in two dimensions- Bravais lattice in three dimensions- Miller indices-interplanar spacing- density of atoms in a crystal plane-structures of Diamond, ZnS, NaCl and CsCl. Bonding in solids - Cohesive energy-ionic bonding - evaluation of Madelung constant for NaCl - covalent bonding - Metallic bonding - Hydrogen bonding - Van der Waals bonding. Diffraction of X-rays by crystals - reciprocal lattice- structure determination by powder method, Laue method and rotating crystal method.

MODULE II

Lattice vibrations: Vibrations of Monatomic and diatomic linear lattices-acoustical and optical phonons - phonon momentum - lattice specific heat of Einstein and Debye model

Free electron theory:Electron motion in one dimensional potential well- three dimensional potential well - Density of energy states - Fermi Dirac distribution - electronic specific heat - electrical conductivity and Ohm's law - thermal conductivity - Brillouin zone in two and three dimensions - Fermi surface.

MODULE III

Band theory of solids: Nearly free electron model - origin of energy gap - Bloch theorem-Kronig-Penney model effective mass of an electron - reduced zone - Tight binding approximation.

MODULE IV

Semiconductors:- Intrinsic semiconductors - carrier concentration in intrinsic semiconductor - Fermi level - electrical conductivity of semiconductors - Band gap - Extrinsic semiconductor - carrier concentration - variation of carrier concentration with temperature - conductivity of extrinsic semiconductor carrier transport in semiconductors -Hall effect - Applications of Hall effect.

MODULE V

Dielectric Properties: Various polarization processes - Clausius - Mosottirelation - Dielectric loss - Applications of dielectric materials Ferro electricity - Pyroelectric material and their applications - Ferroelectric domain – Antiferroelectricity and Ferrielectricity.

MODULE VI

Magnetic properties: Classification of magnetic materials - Langevin's theory of diamagnetism - Quantum theory of paramagnetism - paramagnetism of free electrons - Ferromagnetism - Weiss molecular field theory - Curie-Weiss law - spin waves - magnons - Dispersion relation for magnons - magnon specific heat - Bloch wall - Ferromagnetic domains - Anti-ferromagnetism - two sub-lattice model - Ferromagnetism. Applications of different magnetic material

Superconductivity: Meissner effect - Type I and Type II superconductors - Thermal properties - Isotope effect - London equations - London penetration depth - coherence length - BCS theory - flux quantisation - Josephson effect - Applications of Superconductors.

References

- Azaroff, L.V. (2012). Introduction to Solids, TATA McGraw-Hill Publishing Co., 1sted.
- Blakemore, J. S. (1985). Solid State Physics, CBS Publishers & Distributors, 2nd ed.
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- <http://hyperphysics.phy-astr.gsu.edu/hbase/hframe.html>
- <http://web.mit.edu/redingtn/www/netadv/solidstate.html>
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Semester III

Course Code: PHY-C-433

Course Title: NUCLEAR AND PARTICLE PHYSICS

Credits: 4

Aim: To impart fundamentals of nuclear structure, decay and particle physics.

Objectives: To teach theoretical ideas of nuclear interactions, models, decay process and particle physics.

Course Content

MODULE I

Nuclear Interactions: Characteristics of inter-nucleon potential: charge independence, charge symmetry. Spin dependence, saturation, short range, attractive and exchange nature-the deuteron-tensor forces- Meson theory of nuclear force-Low energy n-p scattering and effective range theory.

MODULE II

Nuclear Reactions: Energetic of nuclear reactions - Weisskopf diagram for reaction mechanisms

Partial wave method of calculating cross section - Reciprocity theorem-Compound nucleus hypothesis - Scattering matrix - Breit-Weigner one-level formula - Resonance scattering-Energy production in stars.

MODULE III

Nuclear Models and Nuclear Decay: Doublet method of mass spectroscopy- Hofstadter experiment - Bethe-Weizsacker formula for nuclear binding energy - Segre chart - Bohr & Wheeler theory of nuclear fission -Shell model-Magic numbers, Spin-orbit coupling, Magnetic moments and Schmidt lines –Collective model of Bohr and Mottelson.

MODULE IV

Nuclear Decay: Fermi's theory of β -decay - Kurie plot - Selection rules the ^{60}Co experiment -Helicity of neutrino - Multipole transitions in nuclei - Angular momentum and parity selection rules - Internal conversion - Nuclear isomerism.

MODULE V

Particle Physics: Sub-nuclear particles - Intrinsic properties and conservation laws - Symmetries; unitary symmetry SU(2) and SU(3) groups - Gell- Mann Okubo mass formula - Mesons and baryons in quark model

MODULE VI

Quantum chromodynamics: -Fundamental interactions electromagnetic weak and strong couplings - Quark jets in $e^+ - e^-$ annihilation - CP violation in K^0 decay-Unification of weak and electromagnetic interactions - Neutral currents. Standard model

References

- Blin-Stoyle, R. J. (1992). Nuclear and Particle Physics, Chapman & Hall Ltd., 1sted.
- Burcham, W .E. &Jobes, A. (1998). Nuclear and Particle Physics, Addison-Wesley Publishing Co. Inc., 1st ed.
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- Ho-Kim, Quang& Pham, Xuan-Yem (1998). Elementary Particles and Their Interactions: concepts and phenomena, Springer-Verlag, 1sted.
- Hughes, I.S. (1991). Elementary Particles, Cambridge University Press, 3rded.
- Kachhava, C.M. (1997). Nuclear Physics and Applications, Raj Publications, 1sted.
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- http://www.analchem.ugent.be/radiochemie/funct_beeldvorming/Let's_Play_PET_stat ic/laxmi.nuc.ucla.edu_8000/lpp/nuclearphysics/imagerecon.html
- http://www.antonine-education.co.uk/Pages/Physics_5/Nuclear_Physics/NUC_01/Nuclear_1.htm
- <http://www2.lbl.gov/abc/Basic.html>

Semester III

Course Code: PHY-E-434

Course Title: COMPUTATIONAL METHODS

Credits: 4

Aim: To equip the students to use numerical techniques for solving physical problems.

Objectives: To teach numerical methods for solving different equations also to compare the efficiency of different methods

Course Content

MODULE I

Non Linear Algebraic and Transcendent Equations: Introduction-Bisection method (Method of equal interval)- Iteration method (The method of successive approximation)- Convergence criterion- acceleration of convergence-Aitken's $(\delta)^2$ process-The method of false position-Newton-Raphson method-Generalised Newton's method-Lin Bairstow method Solution of systems of Non-linear equations - The method of Iteration –Newton Raphson Method.

MODULE II

Eigen Values and Eigen Vectors of Matrices: Determinant of a Matrix - The eigen value problem- Power method to find the largest and smallest eigen values- House Holder's method- Eigen values of a symmetric tri-diagonal matrix - The QR method- Singular values of decomposition.

MODULE III

Interpolation: Introduction - Finite differences-Forward -Backward and Central Differences-Symbolic relations and separation of symbols- Differences of a polynomial-Newton's formula for Interpolation-Central Difference Interpolation Formulae-Gauss's Central difference formulae-Stirling's formula- Bessel's formula -Everette's formula- Interpolation of unevenly spaced points- Lagrange's Interpolation formula- Divided differences and Newton's General interpolation formula- Interpolation with Cubic splines.

MODULE IV

Curve Fitting: Least square curve fitting procedure- Fitting a straight line- Non-linear curve fitting- Curve fitting by sum of exponentials- Weighted least square approximation- Linear and non-linear - Methods of least squares for continuous functions.

MODULE V

Numerical Differentiation and Integration: Derivation of numerical differentiation formula from Newton's difference formulae - Cubic spline method Numerical Integration Trapezoidal rule- Simpson's 1/3 rule- Simpson 3/8 rule- Use of cubic splines- Newton - Cotes Integration formula- Numerical calculation of Fourier Integrals - Trapezoidal rule- Filon's formula. Monte Carlo Method Description of method- Applications- Numerical Integration- Monte Carlo Summation

MODULE VI

Numerical Solutions of ordinary Differential Equations: Introduction - Solution by Taylor's series- Picard's method of successive approximations- Euler's method- Modified Euler's method- Runge- Kutta method.

References

- Arumugam, S, et al. (2009). Numerical Methods, Scitech Publications (India) Pvt. Ltd., 2nded.
- Sastry, S. S. (2017). Introductory Methods of Numerical Analysis, Prentice-Hall of India Pvt. Ltd., 5thed.

Additional References

- <http://archives.math.utk.edu/visual.calculus/>
- <http://mathfaculty.fullerton.edu/mathews/numerical.html>
- <http://tutorial.math.lamar.edu/Classes/CalcI/CalcI.aspx>
- MIT open courseware: <http://ocw.mit.edu/courses/mathematics/18-03sc-differential-equations-fall-2011/Syllabus/>

Semester III

Course Code: PHY-E-435

Course Title: DIGITAL ELECTRONICS AND MICROPROCESSORS

Credits: 4

Aim: To introduce principles and applications of digital electronics, microprocessors and signal processing.

Objectives: To teach elements of digital circuits, microprocessors and signal processing.

Course Content

MODULE I

Basic Digital Electronics: Logic Gates- Boolean algebra- Decoder/Demultiplexer - Multiplexer-Encoder-Seven segment Decoder-Flip flops-RS, Clocked RS, D, T, JK, MSJK FF-Shift Registers-Counters-Synchronous and Asynchronous Counters-Cascade Counters.

MODULE II

Advanced Digital Electronics: Semiconductor Memories-RAM,ROM,PROM,EPROM-Digital to Analog Convertors-Ladder and Weighted Resistor type-Analog to digital converters-Counter type, Successive Approximation type, Dual slope convertors. Application of DAC and ADC converters.

MODULE III

Microprocessors: Microprocessor architecture and its operations- s-logic devices for interfacing- the 8085 microprocessor-Instruction and Data format - instruction classification- 8085 Instruction set-8085 assembly language.

MODULE IV

Programming 8085: illustrative programs-looping, counting and indexing-time delays-Stack and subroutines.Interfacing I/O ad memory devices: Memory interfacing-I/O interfacing-Data transfer schemes-programmed data transfer-asynchronous data transfer-synchronous data transfer-Interrupts.

MODULE V

Interfacing devices: the programmable peripheral interface: 8255A-Programming and applications-Programmable Interrupt Controller: 8259A-features and Programming-the 8237 DMA Controller-the USART 8251.

MODULE VI

Digital Signal processing: Signals and Systems-Classification of Signals-Discrete Time signals and systems-Z transform -Fourier series and Fourier Transform-Convolution and Correlation-Discrete Fourier Transform of DT signals-Fast Fourier Transform-Digital Filtering in Time Domain-FIR Filter-HR filter.

References

- Badri Ram (2012). Fundamentals of Microprocessors and Microcomputers, Dhanpat Rai & Sons, 7th ed.
- Gaonkar, R.S. (2016). Microprocessor Architecture, Programming, and Applications with the 8085, Penram International Publishing, 6th ed.
- Jain, R.P. (2011). Modern Digital Electronics, Tata McGraw Hill Publishing Co. Ltd., 4th ed.
- Leach, D.P. & Malvino, A.P. (1997). Digital Principles and Applications, TATA McGraw-Hill Publishing Co., 5th ed.
- Mathur, Aditya P. (1989). Introduction to Microprocessors, Tata McGraw Hill Publishing Co. Ltd., 3rd ed.
- Millman, J. & Halkias, C. (2000) Integrated Electronics: analog and digital circuits and systems, Tata McGraw Hill Publishing Co. Ltd., 1st ed.
- NagoorKani, A. (2017) Digital Signal Processing, McGraw Hill Publishing Co. Ltd., 2nd ed
- Proakis, J.G. & Manolakis, D.G. (2000). Digital Signal Processing: principles, algorithms and application, Prentice-Hall of India Pvt. Ltd., 3rd ed.
- Wang, Bu-Chin (2008). Digital Signal Processing Techniques and Applications in radar image processing, John Wiley & Sons Inc., 1st ed.

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- <http://computer.howstuffworks.com/microprocessor.htm>
- <http://logix4u.net/tutorials/20-dsp-tutorial>
- <http://www.cs.ucf.edu/~ahossam/teaching/microp/>
- <http://www.eastaughs.fsnet.co.uk/cpu/>
- <http://www.radio-electronics.com/info/rf-technology-design/digital-signal-processing/dsp-basics-tutorial.php>

Semester IV

Course Code: PHY-E-441

Course Title: COMMUNICATION ELECTRONICS AND INSTRUMENTATION

Credits: 4

Aim: To introduce the concepts of electronic communication systems and elements of instrumentation.

Objectives: To teach basics of communications systems such as

Course Content

MODULE I

Basic Communication: Need for modulation-Principle, generation and demodulation of SSB, VSB & FM - Frequency & time division multiplexing - Binary ASK, FSK, PSK modulation schemes - Information & channel capacity - Sampling theory - Quantizing of analog signals - PAM - PCM - Errors and codes.

MODULE II

Cellular Communications: Evolution of a cellular phone, concepts, frequency re use, Cell splitting, sectoring, segmentation and dualization, cellular phone systems analogue, and digital cellular phones CDMA and GSM networks.

MODULE III

Satellite Communications: Satellite orbit and orbital parameters - Geo stationary Sc. geo-synchronous satellites- Antenna look angles- Frequency allocation - Satellite system link models: up-link, \ transponder and down-link - Multiple accessing methods: frequency division, time- division and code-division multiple access.

MODULE: IV

Radar: Basic radar system - Radar range equation - Factors influencing maximum range: effects of noise, Target properties- Moving Target Indication (MTI) radar - Antenna Scanning – Antenna tracking - Display methods: A scope, Plan Position Indicator.

MODULE V

Measurement and Errors: Definitions, Accuracy and Precision, Significant figures. Types of errors, Statistical error analysis, Probability of errors, Limiting errors, Standards of Measurement.

Oscilloscope: block diagram, Cathode ray tube circuits. Vertical deflection system, Resistive divider attenuator, Compensated attenuator, Delay line - Function of the Delay line. Different kinds of Delay line - Lumped parameter Delay line. Distributed parameter Delay line, Multiple trace, Horizontal deflection system, Dual time base, Oscilloscope probes and Transducers, Oscilloscope techniques.

MODULE VI

Signal Generation: Sine wave generator, Inductor - Capacitor tuned oscillators, Frequency synthesized signal generators, Frequency divider generator, Pulse and Square wave generators, Pulse characteristics, Astablemultivibrator, Function generator, Audio frequency signal generation

References

- Gagliardi, R.M. (2002). Satellite Communication, CBS Pub.& Distributors, 1sted.
- Haykin, Simon (1994). Communication Systems, Wiley Eastern Limited, 3rded.
- Helfrick, A.D. & Cooper, W.D. (2014). Modern Electronic Instrumentation and Measurement Techniques, Prentice-Hall of India Pvt. Ltd., 1sted.
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- Document Part Number: GE000044
- Installation, Operation & Maintenance (IOM) Course Document Name: INST_IOMx_SATDATACOMOnline_060109.pdf
- *IOM Course Satellite and Data Communications Basics*
- Satellite Communications and Data Communications Basics-
- Signal Generator | [Tektronix](http://Tektronix.in.tek.com/signal-generator).tek.com/signal-generator
- *The analysis, design and implementation of uplink/downlink antennas for AMSAT AO-40- a thesis in department of electrical and computer engineering – Concordia university, Montreal, Quebec, Canada.* Cathode-Ray Oscilloscope boson.physics.sc.edu/~hoskins/Demos/CathodeRay.html

Semester IV

Course Code: PHY-E-442

Course Titles: SOLID STATE ELECTRONIC DEVICES

Credits: 3

Aim: To equip the students with basic ideas of solid-state electronics devices and its fabrication technology.

Objectives: To teach the physical process describing semiconductor theory and principles of transistor operations.

Course Content

MODULE I

Crystal growth of Semiconductors: Bulk Crystal Growth, Growth from melt, Zone refining and Floating Zone Growth, Epitaxial Growth, Liquid Phase Epitaxy, Vapour Phase epitaxy and molecular Beam Epitaxy.

Energy Bands and Diffusion of Carriers: Energy bands, direct and indirect semiconductors, Variations of energy bands with alloy composition, Charge Carriers in semiconductors, electrons and holes in quantum wells, conductivity and mobility effect of temperature and doping on mobility, diffusion process, diffusion and drift of carriers in built in fields, steady state carrier injection and diffusion length.

MODULE II

Junctions: Fabrication of p-n junctions, grown junctions, Alloyed Junctions, Diffused Junction, Ion implantation, space charge at a junction, capacitance of p-n junction, hetero junctions.

Transistors: Charge transport in Bipolar junction transistor, Fabrication of BJT, switching of BJT, Hetero-junction BJT, Field effect transistors, Pinch-off and saturation, Current Voltage Characteristics, MOSFET.

MODULE III

Integrated Circuits: Advantages of integration, types of integration circuits, Monolithic and hybrid circuits, masking selective doping, fine line lithography, monolithic device elements, bipolar transistors, merged transistors, MOS Transistors, integration of other elements, charge transfer devices, basics of CCD, very large scale integration.

References

- Ben G. Streetman and Banerjee S. K., (2010) Solid State Electronic Devices, Pearson, 6/e,
- Morgan, D.V. &Howes, M.J. (1972). Solid State Electronic Devices, Wykeham Publications, 1sted.

Semester IV

Course Code: PHY-C-443

Course Title: Lab: ADVANCED ELECTRONICS

Credits: 4

Aim: To equip the students to design, construct and analyse advanced electronic circuits using ICs.

Objectives: To familiarize the methods of designing practical electronic circuits as per the requirements using advanced electronic devices.

List Of Experiments

1. Monostablemultivibrator using 555 timer.
2. Voltage controlled Oscillator using 555 timer
3. Astablemultivibrator using IC 741
4. RC phase shift oscillator using IC 741
5. Wein Bridge Oscillator using IC 741
6. Triangular wave generator using IC 741
7. First order low pass Butterworth filter using IC 741
8. First order high pass Butterworth filter using IC 741
9. First order band pass Butterworth filter using IC 741
10. Second order low pass Butterworth filter using IC 741
11. Second order high pass Butterworth filter using IC 741
12. Execution of Programmes using Microprocessor- 8085

References

- Navas, K. A. (2013). Electronics Lab Manual Vol.1, Rajath Publishers, 5thed.
- Navas, K. A. (2009). Electronics Lab Manual Vol.2, Rajath Publishers, 4thed
- Gaonkar, R.S. (2016). Microprocessor Architecture, Programming, and Applications with the 8085, Penram International Publishing, 6thed.

Semester IV

Course Code: PHY-D-444

Course Title: PROJECT

Credits: 6

Aim: To cultivate and nurture proper research aptitude in the student and thereby equipping the young researcher with the ability to identify, define, formulate, execute, analyse and conclude a real world scientific problem of relevance within a stipulated time limit.

Objectives: The project will introduce the student to the scientific research methodology, literature survey, technical writing, assimilation and dissemination of results, etc. The project will also enable them to familiarize with the tools of a researcher such as sophisticated instrumental techniques or computational methods.

Extra Departmental Elective Courses

Semester: I

Course Code: PHY-X-411

Course Title: FOUNDATIONS OF ASTRONOMY

Credits: 2

Aim: To introduce the students to basics of Astronomy.

Objectives: To teach basic ideas as of earth-sun-moon system, observational techniques, solar system, our galaxy, stellar evolution and origin of life.

MODULE I

Exploring the Sky - Astronomy- Our position and time, relevance of astronomy. The sky-stars, sky and its motion, cycles of the sun, astronomical influences on the climate of earth. Cycles of the moon- the changeable moon, Lunar eclipse, solar eclipse, predicting eclipses. Origin of modern astronomy – Roots of astronomy, Copernician revolution, Planetary motion, Galileo's contribution, Modern Astronaomy. Gravity- Laws of motion due to Galileo and Newton, Orbital motion and tides, Einstein and relativity **Light and Telescopes**- Radiation- Information from space, Optical telescopes, special instruments, Radiotelescopes, Astronomy from space.

MODULE II

The Stars- Atoms and star light – Atoms, The interaction of light and matter, Stellar spectrum. The Sun – Solar atmosphere, nuclear fusion, solar activity. The family of stars, The interstellar medium, The formation and structure of stars, Stellar evolution, The death of stars, Newtron stars and black holes. **The Universe** – Milky way galaxy –Discovery , Structure , Spiral arms and star formation, the nucleus, Origin and history. Galaxies – The family of galaxies, measuring the properties of galaxies, evolution of galaxies. Active Galaxies and Supermassive Black Holes. Modern Cosmology – Big bang theory, Cosmic microwave background radiation.

MODULE III

The Solar System – The origin of solar system, Survey of solar system, Planet building. Earth – The standard of comparative planetology. Airless worlds – Moon and Mercury Venus and Mars, Moons of Mars. **Outer planets** - Jupiter and Saturn – Jupiter's family of moons, Saturn, Saturn's moons. Uranus, Neptune and Outer planets – Uranus, Neptune, The dwarf planets. Meteorites, Astroids and Comets., Impact of Asteroid and Comets.**Life**-Astrobilogy – Life on other worlds, The nature of life, life in the universe, intelligent life in the universe

References

- Abhayankar K D (2001), Astrophysics, University Press
- Michael A Seeds and Dana E Backman (2011), Foundations of Astronomy, Cengage learning, 11th International Students Edition.

Additional References

- Introduction to Cosmology- J. V. Narlikar (1993), Cambridge University Press.
- Space Physics and Space Astronomy – Michael D Pappagiannis (1972), Gordon and Breach Science Publishers Ltd.