MASTER OF SCIENCE
PHYSICS

SYLLABUS

Choice Based Credit System (CBCS)
2018-2020

**FAKIR MOHAN AUTONOMOUS COLLEGE,
BALASORE**

DISTRIBUTION OF MARK

Mid Semester Examination

Full Marks-20

1.	One Long Answer questions (LAQ) with One Alternative	12 marks
2.	Two Short Answer Question (SAQ) out of four options	2 x 4 =08 marks
		Total= 20 marks

Example

Q. No-1	LAQ Or LAQ	12 marks
Q. No-2	SAQ (Answer any two) a. b. c. d.	2 x 4= 08 marks
		Total = 80 marks

End Semester Examination
Full Marks-80

Section-A

10 Short Answer Questions (SAQ) out of 12 Questions covering the entire Syllabus	12 marks

Section-B

3 Long Answer Questions LAQ) each Question with one alternative set unit wise	3 x 20= 60 marks
	Total= 80 markls

Example

Section-A

Q. No-1 SAQ (Answer any ten)

a.
b.
c.
d. — 2 x 10= 20 marks
e.
f.
g.
h.
i.
j.
k.
l.

Section-B

Q. No-2 Unit-I	LAQ Or LAQ	20 marks
Q. No-2 Unit-II	LAQ Or LAQ	20 marks
Q. No-2 Unit-III	LAQ Or LAQ	20 marks
		Total= 80 marks

M.Sc PHYSICS SYLLABUS
CBCS Course Structure
Fakir Mohan Autonomous College, Balasore
2018-2020

Semeater	Paper	Paper Name	Credit	Marks in Each Semester		Total
				Mid Sem	End Sem	
IST SEMESTER	I	Classical Mechanics	06	20	80	100
	II	Mathematical Physics-I	06	20	80	100
	III	Mathematical Physics-II	06	20	80	100
	IV	Quantum Mechanics-I	06	20	80	100
	V(Pr)	Modern Physics and Optics/ Computational Methods in Physics	06	-	100	100
						500
2ND SEMESTER	VI	Quantum Mechanics-II (Application to Atomic & Molecular Physics)	06	20	80	100
	VII	Quantum Mechanics-III	06	20	80	100
	VIII	Statistical Mechanics	06	20	80	100
	IX	Basic Electronics-I	06	20	80	100
	X (Pr)	Modern Physics and Optics/ Computational Methods in Physics	06	-	100	100
						500
3RD SEMESTER	XI	Advanced Quantum Mechanics	06	20	80	100
	XII	Electronics-II	06	20	80	100
	XIII	Basic Condensed Matter Physics	06	20	80	100
	XIV	a/b (B:Core Elective paper-Theory)	06	20	80	100
	XV(Pr)	Electronics (Practical)	06	-	100	100
						500
4TH SEMESTER	XVI	Basic Nuclear & Particle Physics	06	20	80	100
	XVII	Classical Electrodynamics	06	20	80	100
	XVIII	a/b(B:Core Elective Papers-(Th.)	06	20	80	100
	XIX	a/b (B:Core Elective Papers (Pr.)	06	-	100	100
	XIX	Project/ Dissertation	06	-	100	100
						500

CONTENTS

FIRST YEAR
Semester- I

Credit-6 **F.M: 20+80=100**

PAPER-I
CLASSICAL MECHANICS

Unit- I

Mechanics of a System of Particles, Lagrangian Formulation, Velocity- Dependent Potentials and Dissipation function, Conservation Theorems and Symmetry Properties, Homogeneity and Isotrohy of Space and Conservation of Linear and Angular Momentum, Homogeheity of Time and Conservation of Energy.

HapmItonian Formulation

Calculus of Variations and Euler-Lagrange's Equation, Brachistochrone Problem, Hamilton's Principle, Extension of Hamilton's Principle to Nonholonomic Systems, Legendre Transformation and the Hamilton Equations of Motion, Physical Significance of Hamiltonian, Derivation of Hamilton's Equations of Motion from Variational Principle, Routh's Procedure, Δ - Variation, Principle of Least Action.

Unit- II

Canonical Transformations

Canonical Transformation, Types of Generating Function, Conditions for Canonical Transformation, Integral Invariance of Poincare, Poisson Bracket, Poisson's Theorem, Lagrange Bracket, Poisson and Lagrange Brackets as Canonical Invariant, Infinitesimal Canonical Transformation and Conservation Theorems, Liouville's Theorem.

Hamilton Jacobi Theory

Hamilton- Jacobi Equation for Hamilton's Principal Function, Harmonic Oscillator and Kepler problem by Hamilton- Jacobi Method, Action- Angle Variables for completely Separable System, Kepler Problem in Action- Angle Variables, Geometrical Optics and Wave Mechanism.

Unit- III

Small Oscillation

Problem of Small Oscillations, Example of Two coupled Oscillator, General Theory of Small Oscillations, Normal Coordinates and Normal Modes of Vibration, Free Vibrations of a Linear Triatomic Molecule.

Rigid Body Motion: The Independent Co-ordinates of a Rigid Body, Orthogonal Transformations, The Euler's angles, The Cayley- Klein parameters: Euler's Theorems on the Motion of a Rigid body. Infinitesimal Rotations, Rate of Change of a Vector, The Coriolis Force.

Rigid Body Dynamics: Angular Momentum and Kinetic Energy of Motion about a Point, The Inertia Tensor and Moment of Inertia, Eigenvalues of Inertia Tensor and the Principal Axis Transformation, The Euler Equations of Motion, Torque-free motion of a rigid body, The Heavy Symmertical Top with One Point Fixed, Elementary Idea about Nonlinearity and Chaos.

References

1. Classical Mechanics- H. Goldstein.
2. Mechanics- Landau and Liftshitz.
3. Analytical Mechanics- L. Hand and J. Finch.
4. Classical Mechanics- Corben & Stehle.
5. Classical Dynamics- Marion & Thornton.

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Semester- I

Credit-6 **F.M: 20+80=100**

PAPER-II

MATHEMATICAL PHYSICS-I

Unit- I: Matrices and Various transform

Orthogonal, Unitary, Hermitian and Lorentz matrices, Orthogonal, Similarity, Unitary and Transformation with examples having physical relevance, Matrix representation of vectors and groups. Eigenvalues and eigenfucntions of matrices. Digonalisation of matrices. Cayley- Homilton Theorem.

Unit- II: Calculus of variations

Functions and functionals. Fundamental concept of variation. Problem of extrimization of a functional. Euler- Lagrange's equation. Applications-1) The shortest distance between two points of a plane. 2) The shortest distance between two points on a curved surface. Principle of least action. Noether's theorem and symmetry.

Unit- III: Lorentz Transformation and Invariance

Lorentz Transformations, Concept of four vectors, Co-variant and contravarian vector in Minkowski space, Metric with signature (1, -1, -1, -1). 4- displacement, 4-velocity, 4-acceleration, 4- force, Covariant equations of motion. Lorentz invariance with few examples. Lagrangian of a charged relativistic particle.

References

1. Mathematical Methods of Physics- J. Mathews & R. L. Walker.
2. Mathematics for Physicists- Denner * Krzywicki.
3. Mathematical Methods for Physics- Arfken and Weber.
4. Group Theory- M. Hamermesh.
5. Methods of Theoretical Physics, Morse and Feshbach, Vol-I, Vol-II.

Semester- I

Credit-6 **F.M: 20+80=100**

PAPER-III

MATHEMATICAL PHYSICS-II

Unit- I: Variables

Cauchy's Integral Theorem, Cauchy's integral formula, Calculus of Residues, Cauchy's residue theorem, Evaluation of definite integrals. Tensor Analysis and Differential Geometry, Cartesian tensors in three-sapce, Curves in three space and Frenet formula, General Tensor Analysis, Covariant derivative and Christoffel symbol, Riemann and Ricci tensor.

Unit- II: Special Functions

Solutions of Bessel, Laguerre, Hypergeometric and Confluent Hypergeometric Equations by generating functions method and their properties. Solutions of inhomogeneous Partial Differential Equations by Green's function method.

Unit- III: Groups and Group Representations

Definition of groups, Finite groups, examples from Solid State Physics, Sub-groups and classes, Group Representations, Characters, Infinite groups and Lie groups, Irreducible representation of SU(2), SU(3) and O(3), SO(3).

References

1. Mathematical Methods of Physics- J. Mathews & R. L. Walker.
2. Mathematics for Physicsts- Denner & Krzywicki.
3. Mathematical Methods for Physics- Arfken and Weber.
4. Group Theory- M. Hamermesh.
5. Methods of Theoretical Physics, Morse and Feshbach Vol-I, Vol-II.

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Semester- I

Credit-6 **F.M: 100**

PAPER-IV

QUANTUM MECHANICS-I

Unit- I: General Principles of Q. M.

Linear Vector Space Formulation: Linear Vector Space (LVS) and its generality, Vectors- scalar product, metric space, basis vectors, Linear independence, Linear superposition of general quantum states, orthonornmality of basis vector, completeness, Schmidt's orthonormalisation procedure, Dual space, Bra and Ket Vectors, Operators- Linear, Adjoint, Hermitian, Unitary, Inverse, Nonlinear operators, Noncommutativity and uncertainty relation, complete set of compatible operators, Simultaneous Measurement, Projection operator, Eigenvalues and eigen vectors of linear. Hermitian, unitary operators, Matrix representation of vectors and operators, matrix elements, eigenvalue equation and expectation values, algebraic result on eigenvalues, transformation of basis vectors, similarity transformation of vector and operator representation, diagonalisation.

Vectors of LVS and wave function in coordinate, momentum and energy representations.

Unit- II: Quantum Dynamics

Time evolution of quantum states, Time evolution operator and its properties, Schrodinger picture, Heisenberg picture, Interaction picture, Equations of motion, Operator method solution of I D Harmonic Oscillator, Matrix representation and time evolution of creation and annihilation operators, Density Matrix.

Rotation and Orbital Angular Momentum

Rotation Matrix, Angular Momenum operators as the generators of rotation, L_x, L_y, L_z and L^2 and their commutator relations, Raising and lowering operators, (L_+ and L_-), L_x, L_y, L_z and L^2 in spherical polar coordinates, Eigen values and Eigen functions of L_2, L^2 (OP Method) spherical harmonics,Matrix representation of L_+, L_- and L^2.

Unit- III: Spin Angular Momentum

Spin 1/2 particles, pauli spin matrices and their properties, Eigenvalues and Eigen functions, Spinor transformation under rotation.

Addition of angular momentum

Total angular momentum J. Eigen value problem of J_z and J^2, Angular momentum matrices, Addition of angular momenta and C. G., co-efficients, Angular momentum states for composite systems in the angular momenta (1/2, 1/2) and (1, 1/2).

References

1. Quantum Physics- S. Gasiorowicz.
2. Quantum Mechanics- L I Schiff/ J. Sukurai/ E. Merzbacher/ A Messiah. Vol-1.
3. Advanced Quantum Mechanics- P. Roman.
4. Quantum Mechanics- R. Shankar.
5. Quantum Mechanics- A. Ghatak and S. Lokanathan.
6. Quantum Mechanics- S. N.Biswas.
7. Quantum Mechanics- A. Das.
8. Elementary Theory of Angular Momentum- M. E. Rose.
9. Principles of Quantum Mechanics- P. A. M. Dirac.
10. Quantum Mechanics (Non-relativistic theory)- L. D. Landua and E. M. Lifshitz.

Semester- I

Credit-6 **F.M: 100**

PAPER-V

COPMPUTATIONAL METHODS IN PHYSICS (PRACTICAL)

Introduction to computer hardware and software, introduction to storage in computer memory, stored programme concepts, storage media, computer operating system, compilers, LINUX commands.

Programming with FORTAN

Programme solving on computers- algorithm and flow charts in FORTAN data types, expression and statements, input/ output commands, sub programme.

Programming with C++

Structure of C++ programme, compilation, Data types, variable and constant, declaration of variables, initializing variables, arithmetic operators, Increment and Decrement operators, I/O statements, arithmetic expressions, functions, Control statements: decision making and looping statements, array.

Exercises for acquaintance

1. To find the largest or smallest of a given set of numbers.
2. To generate and print first hundred prime numbers.
3. Sum of an AP series, GP series, Sine series, Cosine series.
4. Factorial of a number.
5. Transpose a square matrix.
6. Matrix multiplication, addition.
7. Trace of a matrix.
8. Evaluation of log and exponentials.
9. Solution of quadratic equation.
10. Division of two complex numbers.
11. To find the sum of the digits of a number.

Numerical Analysis

1. Interpolation by Lagrange method.
2. Numerical solution of simple algebraic equation by Newton-Raphson method.
3. Least Square fit using rational functions.
4. Numerical integration: Trapezoidal method, Simpons method, Romberg integration, Gauss quadrature method.
5. Eigenvalues and eigenvectors of a matrix.
6. Solution of linear homogeneous equations.
7. Matrix inversion.
8. Solution of Ordinary differential equation by Runge- Kutta Method.
9. Solution of Radioactive decay, Simple harmonic oscillator, Schrodinger Equation.

References

1. Computer Programming in FORTRAN 90 and 95, V. Rajaraman.
2. V. Rajaraman- Fundamentals of Computers (Printice Hall, India)
3. Object Oriented Programming with C++, E Balagurusamy.
4. Programming with C++, J. R. Hubbard (McGraw Hill).
5. Computer Oriented Numerical Methods- R. S. Salaria.
6. An Introduction to computational Physics, T. Pang, Cambridge Unv. Press.
7. W. H. Press, S. A. Teukolsky, W. T. Vetterling and B. P. Flannery- Numerical Recipe (Cambridge University Press.)
8. V. Rajaraman, Elements of Parallel Processing (Printice Hall, 1990)
9. Fortrain 77 and Numerical Methods- C. Xavier.
10. P. S. Grover- Programming and Computing with FORTRAN 77/90 (Allied Publishers 1992)

MODERN PHYSICS AND OPTICS (PRACTICAL)

1. Michelson Interferometer
2. Fabry-perot Interferometers
3. Measurement of Rydberg constant
4. Babinet's compensator
5. Constant deviation spectroscope
6. e/m measurement by Braun tube
7. e/m measurement by Magnetron Valve Method
8. e/m measurement by Thomson Method
9. Magnetic field measurement by search coil
10. Ferroelectric transmission point by Dielectric Constant Measurement.
11. Rectification by junction Diode using various filters.
12. Characteristics of a Transistor.
13. Dielectric constant of solid (wax) by Lecher wire.
14. Verification of Richardson's $T^{3/2}$ low.
15. Determination of Planck's constant by total Radiation Method.
16. Determination of Planck's constant by Reverse Photoelectric effect method.
17. Hysteresis loop tracer.
18. Determination of 'e' by Millikan's oil drop experiment.
19. Measurement of attenuation and phase shift of A. C. in L. C. R. network RF characteristics of coil.
20. Study of power supply.
21. Calibration of an oscilloscope.
22. Stefan's constant measurement.
23. Existence of discrete energy level by Frank Hertz experiment.

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Semester- II

Credit-6 **F.M: 20+80=100**

PAPER-VI

QUANTUM MECHANICS-II

(Application to Atomic and Molecular Physics)

Unit- I: Approximation Methods for stationary States

Rayleigh Schrodinger Method for Time-Independent Non-Degenerate Perturbation Theory, First and Second Order Correction, Perturbed Harmonic Oscillator, Anharmonic Oscillator, The Stark Effect, Quadratic Stark Effect and Polarizability of Hydrogen Atom, Degenerate Perturbation Theory, Removal of Degeneracy, Parity Selection Rule, Linear Stark Effect of Hydrogen Atom, Spin-Orbit Coupling, Relativistic Correction, Fine Structure of Hydrogen like Atom, Normal and Anomalous Zeeman Effect, The Strong-Field Zeeman Effect, The Weak-Field Zeeman Effect and Lande's g-factor.

Unit- II: Variational Methods

Ground State, First Excited State and Second Excited State of One- Dimensional Harmonic Oscillator, Ground State of H-atom and He-atom, Hydrogen molecule, Hydrogen molecule ion, Rotational and Vibrational Degrees of Freedom.

Unit- III: Approximation Method

General Formalism, Validity of WKB Approximation Method, Connection Formulas, Bohr somerfield Quantization Rule, Application to Harmonic Oscillator, Bound State, for Potential Wells with One Rigid Wall and Two Rigid Walls, Tunneling Through a Potential Barrier, Cold Emission, Alpha Decay and Geiger-Nuttal relation.

References

1. Quantum Physics- S. Gasiorowicz.
2. Quantum Mechanics- N. Zettilli

3. Quantum Mechanics- B. H. Bransden, C. J. Joachain
4. Quantum Mechanics- R. Shankar.
5. Quantum Mechanics- A. Ghatak and S. Lokanathan.
6. Quantum Mechanics- A. Das.
7. Introductory Quantum Mechanics- R. Liboff
8. Quantum Mechanics- E. Merzbacher
9. Quantum Mechanics- S. N. Biswas
10. Quantum Mechanics- L. I. Schiff
11. Quantum Mechanics- A. Messiah
12. Principles of Quantum Mechanics- P. A. M. Dirac.
13. Quantum Mechanics (Non-relativistic theory)- L. D. Landua and E. M. Lifshitz.
14. Modern Quantum Mechanics- J. J. Sakurai
15. Advanced Quantum Mechanics- P. Roman
16. Elementary Theory of Angular Momentum- M. E. Rose

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Semester- II

Credit-6 **F.M: 20+80=100**

PAPER-VII

QUANTUM MECHANICS-III

Unit- I: Motion in Spherically Symmetric Field

Hydrogen atom, Reduction to equivalent one body problem, Radial equation, Energy eigen values and eigen functions, degeneracy, radial probability distribution, Free particle problem incoming and outgoing spherical waves, expansion of plane waves in terms of spherical waves, Bound states of a 3-D square well, particle in a sphere.

Unit- II: Time Dependant Perturbation Theory

Transition Probability, Constant and Harmonic Perturbation, Fermi Golden Rule, Interaction of one electron atoms with electromagnetic radiation, Basic Principles of Laser and Maser, Electric Dipole Radiation and Selection rules, Spontaneous Emission Einstein's A and B Co-efficients, Radiation, Quantum description of spontaneous emission.

Unit- III: Scattering Theory

Scattering amplitude and differential cross section, Relation between Lab and CM cross sections, Born Approximation, Application to Coulomb and Screened Coulomb Potential, Partial Wave Analysis for Elastic and Inelastic Scattering, Effective Range and Scattering Length, Optical Theorem, Black Disc- Scattering, Hard- Sphere Scattering, Resonance Scattering from a Square Well Potential, Scattering of identical particles.

References

1. Quantum Physics- S. Gasiorowicz.
2. Quantum Mechanics- N. Zettilli
3. Quantum Mechanics- B. H. Bransden, C. J. Joachain

4. Quantum Mechanics- R. Shankar.
5. Quantum Mechanics- A. Ghatak and S. Lokanathan.
6. Quantum Mechanics- A. Das.
7. Introductory Quantum Mechanics- R. Liboff
8. Quantum Mechanics- E. Merzbacher
9. Quantum Mechanics- S. N. Biswas
10. Quantum Mechanics- L. I. Schiff
11. Quantum Mechanics- A. Messiah
12. Principles of Quantum Mechanics- P. A. M. Dirac.
13. Quantum Mechanics (Non-relativistic theory)- L. D. Landua and E. M. Lifshitz.
14. Modern Quantum Mechanics- J. J. Sakurai
15. Advanced Quantum Mechanics- P. Roman
16. Elementary Theory of Angular Momentum- M. E. Rose

Semester- II

Credit-6 **F.M: 20+80=100**

PAPER-VIII

STATISTICAL PHYSICS

Unit- I: Classical Statistical Mechanics

Postulate of classical statistical mechanics, Liouville's theorem, micro canonical ensemble, Derivation of thermoodynamics, equipartition theorem, classical ideal gas, Gibb's la paradox,

Canonical ensemble and energy fluctuation, grand canonical ensemble and density fluctuation, Equivalence of canonical and grand canonical ensemble.

Unit- II: Quantum Statistical Mechanics

The density matrix, ensembles in quantum statistical mechanics, Ideal gas in micro-canonical and grand canonical ensembles; Equation of state for ideal Fermi gas. Theory of White dwarf stars. Ideal Bose Gas, Photons and Planck's Law, Phonons, Bose Einstein condensation.

Unit- III: Transition

Thermodynamic description of phase transitions, phase transitions of second kind, Discontinuity of specific heat, change in symmetry in a phase transition of second kind. Ising model: Definition of Ising Model. One Dimensional Ising Model.

References

1. Statistical Mechanics- K. Huang
2. Statistical Mechanics- R. K. Pathria
3. Elementary Statistical Physics- C. Kittel
4. Statistical Mechanics- F. Mohling
5. Statistical Mechanics- Landua and Lifsitz
6. Physics Transitions & Critical Phenomena- H. E. Stanly.
7. Thermal Physics- C. Kittel
8. Fundamentals of Statistical & Thermal Physics- F. Reif

Semester- II

Credit-6 **F.M: 20+80=100**

PAPER-IX

BASIC ELECTRONICS-I

Unit- I: Devices and Instrumentation

Semiconductor, Metal Semiconductor and metal Oxide Semiconductors.
BJT, FET, JFET, MESFET and MOSFET, SCR, TRIAC, DIAC, VTVM and CRO, Astable and Bistable multivibrator, 555 IC Timer, Boot strap sweep Generator.

Unit- II: Ampliifier and Oscillator

Feedback Criteria for Oscillation, phase shift, Wien bridge Oscillator, Crystal Controlled Oscillator, Klystron Oscillator.

Operation Amplifier: Basic Operational Amplifiers, Inverting and non inverting OPAMP, Rejection of common mode signals, Ideal operational amolifier- Input and Output impedance.

Application of OPAMP- Unitary gain buffer, Adder, Subtractor, Integrator, Differentiator, Logarithmic Amplifier.

Unit- III:

Radio Communication- Antenna, Basic Antenna Action, Current and Voltage distribution in linear Antenna, Dipole Antenna, Power Radiator, Different Types of antenna (only descriptive study), Horn Antenna, Yagi Antenna, TV Transmitter and Receiver Antenna.

Fiber Optic Communication:

Optical Fibers- Characteristic and fundamental parameters, Propagating modes, Low Loss Fibers, Transmission distance with Optical fibers, Example of Optical Transmission Techniques, Instrumentation and Control with Optical Fibers.

References

1. Electronic Fundamental and Application- J. D. Ryder.
2. Foundation of Electronics- Chattopadhyay, Rakshil.
3. Optical Fiber Communication- Gerd Keiser.
4. Semi Conductor and Opto Electronic Devices- P. Bhattacharaya (PHI).
5. Grob's Basic Electronics- Mitchel E. Schultz (McGrow Hill Publication).
6. Instruction to Fiber Optics- Ghatak, Thyagrajan.

Semester- II

Credit-6 **F.M: 100**

PAPER-X

MODERN PHYSICS AND OPTICS (PRACTICAL)

1. Michelson Interferometer
2. Fabry-perot Interferometers
3. Measurement of Rydberg constant
4. Babinet's compensator
5. Constant deviation spectroscope
6. e/m measurement by Braun tube
7. e/m measurement by Magnetron Valve Method
8. e/m measurement by Thomson Method
9. Magnetic field measurement by search coil
10. Ferroelectric transmission point by Dielectric Constant Measurement.
11. Rectification by junction Diode using various filters.
12. Characteristics of a Transistor.
13. Dielectric constant of solid (wax) by Lecher wire.
14. Verification of Riichardson's $T^{3/2}$ low.
15. Determination of Planck's constant by total Radiation Method.
16. Determination of Planck's constant by Reverse Photoelectric effect method.
17. Hysteresis loop tracer.
18. Determination of 'e' by Millikan's oil drop experiment.
19. Measurement of attenuation and phase shift of A. C. in L. C. R. network RF characteristics of coil.
20. Study of power supply.
21. Calibration of an oscilloscope.
22. Stefan's constant measurement.
23. Existence of discrete energy level by Frank Hertz experiment.

COPMPUTATIONAL METHODS IN PHYSICS (PRACTICAL)

Introduction to computer hardware and software, introduction to storage in computer memory, stored programme concepts, storage media, computer operating system, compilers, I. INUX commands.

Programming with FORTAN

Programme solving on computers- algorithm and flow charts in FORTAN data types, expression and statements, input/ output commands, sub programme.

Programming with C++

Structure of C++ programme, compilation, Data types, variable and constant, declaration of variables, initializing variables, arithmetic operators, Increment and Decrement operators, I/O statements, arithmetic expressions, functions, Control statements: decision making and looping statements, array.

Exercises for acquaintance

1. To find the largest or smallest of a given set of numbers.
2. To generate and print first hundred prime numbers.
3. Sum of an AP series, GP series, Sine series, Cosine series.
4. Factorial of a number.
5. Transpose a square matrix.
6. Matrix multiplication, addition.
7. Trace of a matrix.
8. Evaluation of log and exponentials.
9. Solution of quadratic equation.
10. Division of two complex numbers.
11. To find the sum of the digits of a number.

Numerical Analysis

1. Interpolation by Lagrange method.
2. Numerical solution of simple algebraic equation by Newton-Raphson method.
3. Least Square fit using rational functions.

4. Numerical integration: Trapezoidal method, Simpson method, Romberg integration, Gauss quadrature method.
5. Eigenvalues and eigenvectors of a matrix.
6. Solution of linear homogeneous equations.
7. Matrix inversion.
8. Solution of Ordinary differential equation by Runge- Kutta Method.
9. Solution of Radioactive decay, Simple harmonic oscillator, Schrodinger Equation.

References

1. Computer Programming in FORTRAN 90 and 95, V. Rajaraman.
2. V. Rajaraman- Fundamentals of Computers (Printice Hall, India)
3. Object Oriented Programming with C++, E Balagurusamy.
4. Programming with C++, J. R. Hubbard (McGraw Hill).
5. Computer Oriented Numerical Methods- R. S. Salaria.
6. An Introduction to computational Physics, T. Pang, Cambridge Unv. Press.
7. W. H. Press, S. A. Teukolsky, W. T. Vetterling and B. P. Flannery- Numerical Recipe (Cambridge University Press.)
8. V. Rajaraman, Elements of Parallel Processing (Printice Hall, 1990)
9. Fortrain 77 and Numerical Methods- C. Xavier.
10. P. S. Grover- Programming and Computing with FORTRAN 77/90 (Allied Publishers 1992)

SECOND YEAR

Semester- III

Credit-6 **F.M: 20+80=100**

PAPER-XI

ADVANCED QUANTUM MECHANICS

Unit- I: Relativistic Quantum Mechanics

Klein Gordon equation and its drawbacks, Dirac equation, Properties of Dirac matrices, Non- relativistic reduction of Dirac equation, magnetic moment, Drawins term, Spin-Orbit coupling, Poincare Transformation, Lorentz group, Covariant form of Dirac equation, Bilinear covariants, Gordon decomposition.

Unit- II:

Free particle solution of Dirac equation, Projection operators for energy and spin, Physical interpretation of free particle solution, Zitterbewegung, Hole theory, Charge conjugation, space reflection and time reversal symmetries of Dirac equation, Continuous systems and field, Transition from discrete to continuous systems, Lagrangian and Hamiltonians Formulations, Noether's theorem.

Unit- III: Quantization of free fields

Second quantization, Equal Time Commutators, Normal Ordering, Covariant quantization of electromagnetic field, Quantization of scalar, e.m. and Dirac Fields, Propagators for scalar, Spinor and Vector fields.

References

1. Advanced Quantum Mechanics- J. J. Sakuraj.
2. Relativistic Quantum Mechanics- J. D. Bjorken and S. D. Drell
3. Relativistic Quantum Fields- J. D. Bjorken and S. D. Drell.
4. Quantum Field Theory- F. Mandl and G. Shaw.
5. Quantum Field Theory- C. Itzykson and J. Zuber.
6. Quantum Field Theory- M. E. Peskin and D. V. Schroeder.
7. Quantum Field Theory- L. H. Ryder.
8. Quantum Field Theory- S. Weinberg.

Semester- III

Credit-6 **F.M: 20+80=100**

PAPER-XII

ELECTRONICS-II

Unit- I: Digital Electronics

Number system, Binary, Octal (Inter conversion), Grey Code, Binary Algebra (Addition, Subtraction, Multiplication, Division).
Boolean Theorem, OR gate, AND gate, NAND gate, Universal Building Block, Exclusive OR and NOR gate, De. Morgan's Theorem, Half Adder, Full Adder, Simplification of digital circuit using Karnaugh map, Do not care condition, Decoder, Encoder, BCD to 7 segment decoder, Digital Comparator, Multiplexer, De-Multiplexer, D/A converter with Ladder Network, Analog to Digital Conveter.

Unit- II:

Mesh and Node circuit Analysis, Reduction of complicated Network, Conversion between T & π Section, The Bridge Network, Lattice Network, Super position Theorem, Reciprocity Theorem, Thevenin and Norton's Theorem, Milliman's Theorem, Maximum Power Transform Theorem.

Unit- III:

Linear wave shaping- High pass, low pass R. C. Circuit, Their response for sinusoldal, step, pulse, square and ramp inputs, R. C. Network as differentiator and integrator, RL and RLC Circuit and their response for step input ringing Circuit, Non linear wave shaping- Diode clipper, Transistor Clipper, Transfer Characteristic of Clipper, Emitter coupled clipper, Comparator and their Application Clamping Operation.

References

1. Networks, Lines and Fields- J. D. Ryder, Pretice Hall of India, Pvt. Ltd.
2. Digital Electronics- W. H. Cothmann.
3. Digital Electronics using- R. P. Jain & M. M. S. Anand Integrated Cricuit.
4. Digital Electronics and Computer- M. M. Mano (PHI) Design.

Semester- III

Credit-6 **F.M: 20+80=100**

PAPER-XIII

BASIC CONDENSED MATTER PHYSICS

Unit- I:

Crystal Binding:

Crystal of inert gases, ionic crystals, covalent crystals, Metallic binding and hydrogen bounded crystals.

Phonons and lattice vibration

Vibrations of monatomic and diatomic lattices, dispersion, relation, optic and acoustic modes, Quantum of lattice vibration and phonon, phonon momentum, inelastic scattering of neutrons and photons by phonons.

Thermal Properties of Insulators

Lattice heat capacity, Debye & Einstein model, Anharmonic crystal interactions, thermal conductivity and thermal expansion.

Unit- II:

Free Electron Fermi Gas

Density of state in one dimension, effect of temperature on Fermi-Dirac distribution, Free electron gas in three dimensions, Heat capacity of electron gas, The Boltzmann equation, Electrical conductivity, General Transport coefficients, Thermal conductivity, Thermoelectric effect.

Band Theory

Electrons in periodic potential, Bloch's theorem, Kronig Penney model, Origin of band gap, Wave equation for an electron in a periodic potential, Bloch functions, Brillouin zones, E-k diagram under free electron approximation.

Unit- III:

Semiconductor

Intrinsic and impurity semiconductors, band gap, law of mass action, intrinsic carrier Concentration, mobility in the intrinsic region, p-n junction rectification.

Superconductivity

Experimental survey, Meissner effect, Type-I and Type-II superconductors, thermody namics of superconductors, London's theory, Electron-electron attractive interaction due to virtual phonon exchange, Cooper pairs and BCS Hamiltonian, Superconducting ground state and the gap equaiton at T= 0 K.

Josephson effect

Macroscopic quantum mechanical effect, DC Josephson effect, Effect of electric field- AC/ Inverse AC Josephson effect, Effect of magnetic field, SQUID.

High T_c Superconductors: Basic ideas and applications.

References

1. Introduction to Solid State Physics- C. Kittel.
2. Solid State Physics- Ashcroft and Mermin.
3. Principles of Condensed Matter Physics- P. M. Chaikin and T. C. Lubensky.
4. Solid State Physics- A. J. Dekker.
5. Quantum Theory Solid State- J. Callaway.
6. Solid State Physics- O. F. Animaler.

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Semester- III

Credit-6 **F.M: 20+80=100**

PAPER-XIV (A)

ADVANCED CONDENSED MATTER PHYSICS-I

Unit- I:

Lattice Vibration

Born Oppenheimer Approximation, Hamiltonian for lattice vibration in the harmonic approximation, Normal modes of the system and quantization of lattice vibration, phonons, Electron- phonon interaction, Second quantized form of Hamiltonian for electrons and phonons in interaction.

Energy Bands

Nearly free electron approximation- Diffraction of electrons by lattice planes and opening of gap in E-k diagram. Effective mass of electrons in crystals, Holes, Tight binding approximation, S and P state band, Wannier functions.
Density of States: Dynamical Mean field Theory

Unit- II:

Fermi Surface

Construction of Fermi surface, Experimental methods of study of Fermi surface, Cyclotron Resonance, de Hass van Alphen effect.

Electron Interaction

Perturbation formulation, Dielectric function of an interacting electron gas (Lindhardrs expression), Static screening, Screened impurity, Kohn effect, Friedel Oscillations and sum rule, Dielectric constant of semiconductor, Plasma Oscillations.

Unit- III:

Electronic and Lattice Defects

Lattice defects, Frenkel and Schottky defects, Line defects, edge and screw dislocations, Burger's Vector, Planner (stacking) faults- twin planes and grain boundaries color centers- mechanism of coloration of a solid, F-center, Other color centers.

Excitons: Loosely bound, tightly bound, Excitonic waves, electron hole droplets.

Hall Effect

Elementary ideas on Quantum Hall Effects, Magnetoresistance, Elementary ideas on Giant magneto- resistance and Colossal magneto resistance.

References

1. Principles of the Theory of Solids- J. M. Ziman.
2. Introduction to Solid State Physics- C. Kittel.
3. Advanced Solid State Physics- Philip Phillips, Overseas Press, India Pvt. Ltd.
4. Introduction to Modern Solid State Physics- Yuri M. Galperin.
5. Solid State Physics- Aschroft, Mermin.
6. Introduction to Solids- Azaroff.
7. Elementary to Solid State Physics- Omar.
8. Principles of Condensed Matter Physics- Chaikin and Lubensky.
9. Solid State Physics, Essential Concepts- David W. Snoke, Pearson Education, 2009.

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Semester- III

Credit-6 **F.M: 20+80=100**

PAPER-XIV (B)

ELECTRONICS AND INSTRUMENTATION

Unit- I:

Elemental and Compound Semiconductor Pseudomorphic

Elementary idea about lattice mismatched pscudomorphic materials epitary and epitexial growth, carrier effective mass and band structure, carrier scattering phenomena, conduction processes in semiconductors, Bulk and surface recombination, non-radiative and radiative recombinations, Shockley Read Hall Theory of recombination, P. N. Junction Theory, Schottky barriers and ohmic contact.

Varactor diode, PIN diode, Schottky barrier and backward diode.

Unit- II:

Gunn effect, Ridley-Watkin- Hilsam Mechanism device configuration, Tunnel diodes, Phenomen, theory and device configuration, IMPATT diodes.

LED, Electroluminescent process, LED materials, Device configuration and efficiency, LED structures Laser operating principles, semiconductor, structures and proper tics, Threshold current, Heterojunction Lasers, Photodectors, Photoconductors, Junction photo diodes, Avalanche photo diodes, solar cells, basic principles, spectral response, Heterojunction and cascaded solar cells, Schottky barrier cells, material and design consideration, Thin film solar cells.

Unit- III:

Digital Circuits

Simplification of digital circuits using Karnaugh maps, characteristics of logic families, Binary adder, Subtracting Flip-Flops-RS, JK, Master salve, Shift- registers, CMOS dynamic shift- registers, Asynchronous counters, Divide by N. counter, Decade ripple counter, Synchronous counter, Application of counters.

References

1. Physics of Semiconductor Device- S. M. Sze. Wiley Lastern Limited, 1987.
2. Electronic Fundamentals and Applications- J. D. Rider, Prentice Hall of India.
3. Integrated Electronics- J. Milliman and C. C. Halkies, McGraw Hill.
4. Instrumentation Devices and System- C. S. Rangon, G. R. Sarma dn V. S. V. Mani Tata McGraw Hill.
5. Physics of Semiconductor Devices- S. M. Sze. Wiley Lastern Limited, 1987.
6. Semiconductor Devices & Integrated Electronics- A. G. Mllnes, Van Nostrand Reinhold Company, 1980.
7. Microprocessor Fundamental- R. L. Tekhenin, McGraw Hill, 1986.
8. Electronic Instrumentation and Measurement Techniques- W. D. Cooper and A. D. Helfrick, Prentice Hall of India, 1989.
9. Microwave Propagation and Techniques- D. C. Sarkar, S. Chand & Co. Ltd. 1910.

Semester- III

Credit-6 **F.M: 100**

PAPER-XV

ELECTRONICS PRACTICAL

1. Setting of a transistor amplifier and determination of the amplification factor at various frequencies.
2. Frequency response of transistor amplifier with the without feedback.
3. Characteristics of Harteley Oscillator.
4. Determination of different parameters of transistor.
5. Study of multivibrator- Astable.
6. Study of multivibrator- Bistable.
7. Study of multivibrator- Monostable
8. VS WR' in a microwave transmission line
9. Study of squarewave response of R. C. Network
10. Modulation of detection
11. Lock-in-amplifier
12. Design of operational amplifier circuit
13. Design of a field-effect transistor crystal oscillator
14. Study of different gates
15. Study of digital voltmeter and frequency counter

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Semester- IV

Credit-6 **F.M: 20+80=100**

PAPER-XVI

BASIC NUCLEAR AND PARTICLE PHYSICS

Unit- I:

Two Nucleon Problem

Central and noncentral forces, deuteron and its magnetic moment and quardrupole moment, Force dependent on isospin, exchange force, charge independence and charge symmetry of nuclear force, mirror nuclei.

Nuclear models

Liquid drop model, fission, magic numbers, shell model, analysis of shell model predictions.

Unit- II:

Nuclear reaction

Energetics of nuclear reaction, compound nucleus theory, resonance scattering, Breit-Wigner formula, Alpha decay, Fermi's theory of beta decay, Selection rules for allowed transition, Parity violation.

Nuclear Structure

Form factor and charge distribution of the nucleus, Hoffstadder form factor.

Unit- III:

Particle Physics

The standard model of particle physics, particle classification, fermions and bosons, lepton flavours, quark flavors, electromagnetic, weak and strong processes, Spin and parity determination, Isospin, strangeness, hypercharge, and baryon number, lepton number, Gell-Mann-Nishijima Scheme, Quarks in hadrons: Meson and baryon octet, Elementary symmetry, charmonium, charmed mesons and B mesons, Quark spin and colour.

References

1. Introduction to Nuclear Theory- L. R. S. Elton.
2. Nuclear Physics- B. B. Roy and B. P. Nigam.
3. Nuclear Physics- K. S. Krane.
4. Subatomic Physics- Frauenfelder and Henley.
5. Concepts of Particle Physics- Gottfried and Weisskopf.
6. Elementary Particle Physics- D. J. Griffiths.
7. Introduction to Nuclear Physics- P. E. Hodgson & E. Gadioli.
8. Theoritical Nuclear Physics- Blatt and Weisokoff.
9. Introductory Nuclear Physics- S. S. Wong.
10. Particle Physics- R. Omnes.

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Semester- IV

Credit-6 **F.M: 20+80=100**

PAPER-XVII

CLASSICAL ELECTRODYNAMICS

Unit- I:

Maxwell's Equations

Maxwell's Equations in free sapce; Magnetic charge; Maxwell's Equations inside matter; Displacement current; Vector and scalars potentials; Wave equation for potentials; Lorentz and Coulomb guage conditions; Wave equation for Electric and Magnetic fields in absence of sources.

Covariant Formulation of Maxwell's Equation

Lorentz transformation; Scalars, Vectors and Tensors; Maxwell's equations and equations of continuity in terms of A, and J; Electromagnetic field tensor and its dual; Covariant form of electromagnetic field and Maxwell's equation as Euler-Lagrange equations.

Unit- II:

Plane Waves in Non- Conducting Media

Plane Waves in non-conducting media; velocity of wave propagation and energy flow; linear, circular and elliptic polarization; Reflection and Refraction on electromagnetic waves at a plane interface between dielectrics, normal and oblique incidence; total internal reflection and polarisation by reflection; Waves in dispersive media; Kramer- Kronig relation.

Plane Waves in Conduction Media

Plane waves in conduction media; Reflection and transmission at a conducting surface; Cylindrical cavities and wave gudies; Modes in rectangular wave guide and resonant cavities.

Unit- III:

Green's Function Solution for Retarded Potential

Green's function solution of potential form of Maxwell's equations. Retarded and advanced Green's functions.

Multipole Radiation

Potential, Field and radiation due to an oscillating electric dipole; radiation due to a centre fedlinear antenna; angular distribution of power radiated; Rayleigh Scattering. Magnetic dipole and Electric Quadrupole radiation.

Radiation by Point Charge

Lienard Weichert potential, Field due to a point charge, Angular distribution of radiation and total power radiated by an accelerated charge, Larmor's formula, Thomson's scattering.

References

1. Classical Electrodynamics- J. D. Jackson.
2. Classical Theory of Fields- L. Landau & Lifsitz.
3. Introduction to Electrodynamics- D. J. Griffiths.
4. Principles of Optics- M. Born and E. Wolf.
5. Introduction to Electrodynamics- Capri and Panat.

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Semester- IV

Credit-6 **F.M: 20+80=100**

PAPER-XVIII (A)

ADVANCED CONDENSED MATTER PHYSICS-II

(Magnetism and Nanoscience)

Unit- I:

Magnetism

Weiss theory of ferromagnetism, Curie-Wesis Law susceptibility, Heisenberg model- Conditions for ferro-and antiferro-magnetic order, Spin waves and magnons, Bloch's $T^{3/2}$ law, Antiferromagnetic order, Neel Temperature, Dilute Magnetic Semiconductors.

Ferroelectricity

Ferrelectric crystals, Classification of ferroelectric crystals, Polarization catastrophe, Soft optical phonons, Landau theory of phase transition- second and first order transition.

Multiferroics- Basic ideas, preparations and applications.

Unit- II:

Nanoscale Systems

Length scales in Physics, Nanostructures: ID, 2D and 3D nanostructures (nanodots, thin films, nanowires, nanorods), Band structure and density of states of materials at nanoscale, Size effects in nano systems, Qyuntum confinement: Applications of Schrodinger equation- Infinite potential well, potential step, potential box, quantum confinement of carries in 3D, 2D, 1D nanostructure and its consequences.

Synthesis of Nanostructure Materials

Top down and Bottom up approach, Photolithography, Ball milling, Gas phase condensation, Vacuum deposition, Physical vapor deposition (PVD); Thermal evaporation, E-beam evaporation, Pulsed Laser deposition, Chemical vapor deposition (CVD), Sol-Gel, Electro deposition, Spray pyrolysis, Hydrothermal synthesis, Preparation through colloidal methods, MBF growth of quantum dots.

Unit- III:

Characterisation of Nanostructure Materials

X-Ray Diffraction, Optical Microscopy, Scanning Electron Microscopy, Transmission Electron Microscopy, Atomic Force Microscopy, Scanning Tunneling Microscopy.

Applications of Nanostructure Materials

Applications of nanoparticles, quantum dots, nanowires and thin films for photonic devices (LED, Solar cells), Single electron devices (no derivation), CNT based transistors, Nanometerial Devices: Quantum dots heterostructure lasers, optical switching and optical data storage, Magnetic quantum well; magnetic dots-magnetic data storage, Micro Electromechanical Systems (MEMS), Nano Electromechanical Systems (NEMS).

References

1. Introduction to Solid State Physics- C. Kittel, John Willey & Sons, New York.
2. Quantum Theory of Solids- C. Kittel.
3. Text Book of Nanoscience and Nanotechnology- B. S. Murty, P. Shankar, B. Raj, B. B. Rath and J. Murday.
4. Introduction to Modern Solid State Physics by Yuri M. Galperin.
5. Introduction to Solids- Azroff.
6. Elementary Solid State Physics- Omar.
7. Solid State Physics- Aschroff & Mermin.
8. Science of Engineering Materials and Carbon Nanotubes- CM Srivastava & C. Crinivasan.
9. Solid State Physics- A. J. Dekkar Macmillan, London.
10. Solid State Physics- R. L. Singhal, Kedarnath and Ramnath Co. Meerut.
11. Low Dimensional Semiconductor Structures, K. Bamam and D. Vvedensky (Cambridge University Book), 2001.

12. Semiconductor Quantum Dots, L. Banyal and S. W. Koch (Wrold Scientific) 1993.
13. An Introduction to the Physics of Low Dimensional Semiconductor- J. H. Davies (Cambridge Press), 1998.
14. Introduction to Superconductors- Ketterson.
15. The Physics of Quasicrystals, Eds- Steinhardt and Ostulond.
16. Principles of Nanoscience and Nanotechnology- M. A. Shah and T. Ahmad.
17. Handbook of Nanostructured Materials and Nanotechnology (Vol. 1-4) ed. HS. Nalwa.
18. Solid State Physics- S. O. Pillai, New Age International Publishers, 2010.
19. Introduction to Solid State Physics- Arun Kumar
20. Solid State Physics- Wahab M. A.
21. Solid State Physics and Electronics- R. K. Puri, V. K. Babbar.
22. Solid State Physics- H. E. Hall.
23. Fundamentals of Solid State Physics- Saxena, Gupta, Saxena.

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Semester- IV

Credit-6 **F.M: 20+80=100**

PAPER-XVIII (B)

ELECTRONICS AND INSTRUMENTATION-II

Unit- I:

D/A and A/D Converters

Binary weighted resistance DAC, DAC using ladder network, BCD, counter ramp and successive approximation the ADC, single slope, dual slope ADC.

Unit- II:

Electric Test and Measuring Equipment

Cathod-ray Oscilloscope, Digital Voltmeters and Multimeters, Signal Generators, Regulated Power Supplies.

Data Acquisition and Processing

Introduction Transducer (Elementary ideas), Signal conditioning of the inputs, Single channel data acquisition system, Multichannel data acquisition system, Multiplexers and sample Hold circuits.

Unit- III:

Macroprocessors and Microcomputers

Microcomputers, 8085 Microprocessor architecture, stacks, Resource sharing, Memory access and transfer, interrupts, Microprocessor Softwares, RAM, ROM, EPROM, I/O devices, Operational sequences, Applications.

References

1. Physics of Semiconductor Devices- S. M. Sze, Wiley Eastern Limited, 1987.
2. Electronic Fundamentals & Applications- J. D. Ryder, Prentice Hall of India.

3. Integrated Electronics- J. Millman and C. C. Halkias, McGraw Hill.
4. Instrumentation device and system- C.Srangan, G. R. Sarma and V. S. Vmani, Tata McGraw Hill.
5. Digital Computer Electronics- A. P. Malvino, Tata McGraw Hill, 1989.
6. Physics of Semiconductor Devices- S. M. Sze, Wiley Eastern Limited, 1987.
7. Semiconductor Devices and Integrated Electronics- A. G. Milnes, Van Nostrand Reinhold Company, 1980.
8. Microprocessor Fundamental- R. L. Tokhein, McGraw Hill, 1986.
9. Electronic Instrumentation and Measurement Techniques- W. D. Cooper and A. D. Helfrick, Prentice Hall of India, 1989.
10. Microwave Propagation and Techniques- D. C. Sarkar, S. Chand and Co. Ltd.

Semester- IV

Credit-6 **F.M: 100**

PAPER-XIX (A)

CONDENSED MATTER PHYSICS (PRACTICAL)

1. Study of energy gap of Germanium by four-probe method.
2. Callibration of magnetic field using Hall apparatus.
3. Determination of Hall Voltage and Hall coefficients.
4. Measurement of Hall angle and mobility.
5. Determination of ferroelectric transition point (Curie temperature) of the goven sample.
6. Determination of magnetoresistance of bismuth.
7. Study of Laue's spot of mica sheet using X-ray diffraction technique.
8. Study of the dispersion relation for the monoatomic and lattices using the given electrical transmission line.
9. Find the Young's modulus for the given metal using composite piezoelectric oscillator technique.
10. Determination of magnetic susceptibility by Guoy-balance.
11. Velocity of ultrasonic waves in a given medium at different temperature.
12. Measurement of Lande's g factor of DPPII by ESR at Microwave frequency.
13. Study of thermoluminescence of F-centre in alkali halide crystals.
14. Study of phase transition using feed back amplifier circuit.

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Semester- IV

Credit-6 **F.M: 100**

PAPER-XIX (B)

ELECTRONICS AND INSTRUMENTATION (PRACTICAL)

1. Study of various stages of a regulated power supply and find its regulation and ripple factor.
2. Design and assemble of a single stage transistor amplifier and study of its frequency response.
3. Study of phase transition using feed-back amplifier circuit.
4. Study of multivibrator- Astable.
5. Study of multivibrator- Bistable.
6. Study of multivibrator- Monostable.
7. Design of operational amplifier circuit.
8. Use of operational amplifier for integration and differentation.
9. Use of operational amplifier for addition and subtraction.
10. Study of various stage of a digital voltmeter.
11. Study of various stages of digital voltmeter.
12. Study of various stages of a CRO and calibrate it for measurement of frequency and amplitude.
13. Determination of Hall voltage and Hall coefficient.
14. Study of different gates.
15. Programming using into 8085 microprocessor.

Semester- IV

Credit-6 **F.M: 50+50=100**

PAPER-XX

DISSERTATION PROJECT

Topic Include

General Theory of Relativity, Cosmology, Astroparticle Physics, High Energy Physics, Nano Science and Nano Technology, Materials Science, Nuclear Matter, Black Hole Physics, Accelerators Physics, Data Analysis and Computational Simulation.