Learning Outcome based Curriculum Framework (LOCF)

For

Choice Based Credit System (CBCS)

Syllabus

B.Sc.(Honours) in Physics

w.e.f. Academic Session 2020-21

Kazi Nazrul University

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West Bengal 713340

Preamble
B. Sc. (Honours) in Physics

Preferably, the B.Sc.(Honours) in Physics should aim and accomplish a sound establishing in understanding the essential Physics with adequate substance of themes from present day Physics and contemporary spaces of advancements in physical sciences. The curricula and syllabi are outlined and executed so that the essential association among theory and experiment and its significance in understanding Physics is obvious to the students. This fosters a logical disposition and inclination to develop, make and find in Physics. Supported drives are taken by increasing the expectations of accomplishments in learning outcomes. One of the huge changes in the undergraduate education is to present the Learning Outcomes-based Curriculum Framework (LOCF) which makes it student - centric, intuitive and outcome-oriented with well defined aims, targets and objectives to accomplish.

The Program of Honours in Physics has courses that cover both fundamental and advanced topics in Physics. It targets in preparing the students to be effectively able in working in academics, research and different boondocks in science and innovation. The syllabi incorporate both theoretical and experimental courses to satisfy the measures for the granting of the degree. Various elective specific courses are likewise presented to the students to fabricate a solid establishment in the space of their exploration interest.

We incorporate however much of fundamental physics as could be expected, while acquainting the student with the applied parts of physical science. At last, we need to recall that this is a period of interdisciplinary examinations. The physics student will benefit by the investigation of fields that cross-over with other domains of knowledge. The syllabi introduced here address an endeavour to adjust this load of prerequisites.

This includes theoretical principles and experimental findings in Physics and its different subfields like Classical Physics, Mathematical Physics, Classical Electrodynamics, Relativistic Mechanics, Thermodynamics, Electronics, Optics, Computational Physics, Quantum Physics, Nuclear and Particle Physics, Statistical Physics, Condensed Matter Physics, Atomic and Molecular Physics, Classical Dynamics, Nanotechnology, Astrophysics and Cosmology and other related fields of study.

Semester – I

Course Name: Mathematical Methods of Physics –I

Code: BSCHPHSC101

Course Type: **Core(Theoretical)**	Course Details:CC-1			L-T-P: **5-1-0**	
Credit: **6**	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		……	**10**	……	**40**

Course Learning Outcomes:

After the completion of course, the students will have ability to:

1. *Enrich themselves with analytical tools needed for further studies in physics, like basic linear algebra, vector algebra and calculus, solutions of ordinary and partial differential equations, probability distributions, determinant and non-singular matrices.*

2. *Apply the techniques for solving different problems related to probability, differential equations, integral transform and linear algebra.*

Course Content:

Theory:

1. Calculus : Infinite sequences and series; Conditional and Absolute Convergence; Tests for Convergence (proofs not required, only applications), Functions of several real variables - partial differentiation, Taylor's series, multiple integrals.

(5L)

2. Vector Analysis : Definition, Transformation properties, Differentiation and integration of vectors; Line integral, volume integral and surface integral involving vector fields; Gradient, divergence and curl of a vector field; Gauss' divergence theorem, Stokes' theorem, Green's theorem - application to simple problems; Orthogonal curvilinear co-ordinate systems, unit vectors in such systems, illustration by plane, spherical and cylindrical co-ordinate systems only. **(15 L)**

3. Statistics : Random variables and probabilities - statistical expectation value, variance; Analysis of random errors: Probability distribution functions (Binomial, Gaussian, and Poisson). **(6L)**

4. Determinant and Matrices:

Basic operations on Determinant, Algebra of matrices – Equality, Addition, Multiplication; Transpose and conjugate transpose of a matrix, Singular and non-singular matrices; Adjoint and Inverse of a Matrix; rank of a matrix; Normal Forms; Solution of simultaneous equation of matrices by Cramer's rule; Solution of systems of linear homogenous and inhomogeneous equations by matrix method; Cayley-Hamilton theorem; Characteristics equation of a square matrix and diagonalization; Properties of Eigenvalues and eigenvectors of matrices; Types of matrices - Symmetric, Skew- symmetric, Hermitian, Orthogonal and unitary matrices and their properties.

(17L)

5. Ordinary Differential Equations : Singular Points of Second Order Linear Differential Equations and their importance; Solution of second order linear differential equations with constant coefficients and variable coefficients by Frobenius' method; Solution of Legendre and Hermite equations about x=0; Legendre and Hermite polynomials – orthonormality properties.

(7L)

6. Partial Differential Equations:

Functions of several variables; Partial Derivatives; Partial Differential Equations; Partial Differential Equations in Physics; Solutions by the method of separation of variables; Simple examples, Laplace's equation and its solution in Cartesian, spherical polar (axially symmetric problems), and cylindrical polar (`infinite cylinder' problems) coordinate systems; Diffusion equation, Wave equation. (10L)

References/ Suggested Readings:

1. Mathematical Methods in the Physical Sciences, Mary L. Boas
2. Essential Mathematical Methods for Physicists by Hans J. Weber and George B. Arfken
3. Introduction to Mathematical Physics - C. Harper (Prentice-Hall of India).
4. Mathematical Physics by Binoy Bhattacharya
5. Mathematical Physics by D. Biswas
6. Mathematical Physics by B S Grewal
7. Vector Analysis - M. R. Spiegel, (Schaum's Outline Series) (Tata McGraw-Hill).
8. Mathematical Physics – P.K. Chattopadhyay (Wiley Eastern)

Course Name: Mechanics

Course Code: BSCHPHSC102

Course Type: **Core(Theory and Practical)**	Course Details: **CC-2**		L-T-P: **4-0-4**	
Credit: **6**	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**10**	20	**40**

Course Learning Outcomes:

After the completion of course, the students will have ability to:

1. Understand classical mechanics of single as well as system of particles within the scope Newtonian formulation.

2. Explain general properties of bulk matter and different types of simple harmonic linear oscillations.

Course Content:

Theory

1. Mechanics of a Single Particle:

Velocity and acceleration of a particle in (i) plane polar coordinates - radial and cross-radial components (ii) spherical polar and (iii) cylindrical polar co-ordinate system; Time and path integral of force; work and energy; Conservative force and concept of potential; Conservation of energy; Dissipative forces; resistive motion and friction. Conservation of linear and angular momentum. **(10 L)**

2. **Mechanics of a System of Particles:**

Linear momentum, angular momentum and energy - centre of mass decomposition; Equations of motion, conservation of linear and angular momenta. **(6L)**

3. Elasticity: Elastic Moduli and their relations; Bending of a beam; Torsional Oscillation **(4L)**

4. Surface Tension*:* Surface energy and surface tension, angle of contact, excess pressure on curved surface, capillary rise, equilibrium vapour pressure over curved surface**.** **(6L)**

5. Mechanics of Ideal Fluids and Viscosity:

Definition of Newtonian and non-Newtonian fluids, Streamlines and turbulent flow. Stokes' law-terminal velocity. Equation of continuity; Euler's equation of motion; Streamline motion -Bernoulli's equation and its applications.

(7L)

6. Oscillations:

SHM: Simple Harmonic Oscillations. Differential equation of SHM and its solution. Kinetic energy, potential energy, total energy and their time-average values. Damped oscillation. Forced oscillations: Transient and steady states; Resonance, sharpness of resonance; power dissipation and Quality Factor. Concept of different types of waves (plane, spherical, cylindrical), Group and phase velocity, Growth and decay of sound waves in hall, Sabine's formula reverberation.

(12L)

Practical

1. Measurements of length (or diameter) using vernier caliper, screw gauge and travelling microscope.
2. To study the random error in observation
3. To study the Motion of Spring and calculate (a) Spring constant, (b) **g** and (c) Modulus of rigidity.
4. To determine the Moment of Inertia of a Flywheel/regular shaped body.
5. To determine Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method).
6. To determine the Young's Modulus of a Wire by Optical Lever Method.
7. To determine the elastic Constants of a wire by Searle's method.
8. To determine the value of g using Bar/Kater Pendulum.
9. Determination of surface tension of a liquid by Jaeger's method.
10. Determination of Young's modulus by flexure method.
11. Determination of the rigidity modulus of a wire by statical /dynamical method

References/ Suggested Readings

1. Classical Mechanics – J. Goldstein (Narosa Publ. House).
2. Principles Of Mechanics - John. L Synge and Byron. A Griffith,
3. Theoretical Mechanics - M. R. Spiegel, (Schaum's Outline Series) (McGraw-Hill).
4. Mechanics - K. R. Symon (Addison-Wesley).
5. Introduction to Classical Mechanics - R. G. Takwale and P. S. Puranik (Tata McGraw-Hill).
6. Classical Mechanics – N. C. Rana and P. S. Joag (Tata McGraw-Hill).
7. The Feynman Lectures on Physics – Vol I (Addison-Wesley).
8. Mechanics – H. S. Hans and S. P. Puri (Tata McGraw-Hill).
9. Berkeley Physics Course, Vol – I (Mechanics) (Mc Graw Hill).
10. Mechanics – D. S. Mathur (S. Chand and Company).
11. Waves and Oscillations by N K Bajaj
12. Waves and Oscillations by R. N. Chowdhury

Semester – II

Course Name: Mathematical Methods of Physics-II

Course Code: BSCHPHSC201

<table>
<tr><td>Course Type:
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<tr><td>30</td><td>10</td><td>20</td><td>40</td></tr>
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Course Learning Outcomes:

After the completion of course, the students will have ability to:

1. *Work with (i) different properties of special functions, useful in other branches of physics; (ii) Fourier expansion of analytic functions; (iii) properties of complex variables and their integrals; (iv) standard integrals.*
2. *Do computer programming using C /C++, aiming for basic mathematical problems as well as on problems based on standard numerical analysis.*

Course Content:

Theory

1. Fourier Series: Periodic functions. Orthogonality of sine and cosine functions, Dirichlet Conditions (Statement only). Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients. Complex representation of Fourier series. Expansion of functions with arbitrary period. Expansion of non-periodic functions over an interval. Even and odd functions and their Fourier expansions. Application. Summing of Infinite Series. Term-by-Term differentiation and integration of Fourier Series. Parseval Identity. **(12 L)**

2. Frobenius Method and Special Functions: Legendre, Bessel, Hermite and Laguerre Differential Equations. Properties of Legendre Polynomials: Rodrigues Formula, Generating Function. Simple recurrence relations. Expansion of function in a series of Legendre Polynomials. Bessel Functions of the First Kind: Generating Function, simple recurrence relations. Zeros of Bessel Functions and Orthogonality. **(14 L)**

3. Some Special Integrals: Beta and Gamma Functions and Relation between them. Expression of Integrals in terms of Gamma Functions. Error Function (Probability Integral) **(5L)**

4. Theory of Errors: Systematic and Random Errors. Propagation of Errors. Normal Law of Errors. Standard and Probable Error. **(4 L)**

5. Functions of a complex variable: Limit, continuity and complex differentiation, analytical functions, the Cauchy Riemann equations, multivalued functions, complex, integration, Cauchy's theorem, Taylor's series, Laurent series, singularities of complex functions, Cauchy residue theorem, Principle value of integral, evaluation of certain definite integrals by contour integration. **(10 L)**

Practical

1. Introduction and Overview: Computer architecture and organization, memory and Input/output devices.

2. **Basics of scientific computing:** Binary and decimal arithmetic, Floating point numbers, algorithms, Sequence, Selection and Repetition, single and double precision arithmetic, underflow &overflow emphasize the importance of making equations in terms of dimensionless variables, Iterative methods.

3. Errors and error Analysis: Truncation and round off errors, Absolute and relative errors, Floating point computations.

4. C & C++ Programming fundamentals: Introduction to Programming, constants, variables and data types, operators and Expressions, I/O statements, scanf and printf, c in and c out, Manipulators for data formatting, Control statements (decision making and looping statements) (*If-statement. If-else Statement.Nested if Structure. Else-if Statement. Ternary Operator.Goto Statement. Switch Statement. Unconditional and Conditional Looping. While Loop. Do-While Loop. FOR Loop. Break and Continue Statements. Nested Loops*), Arrays (*1D & 2D*) and strings, user defined functions, Structures and Unions, Idea of classes and objects.

5. Programs: Sum & average of a list of numbers, largest of a given list of numbers and its location in the list, sorting of numbers in ascending descending order, Binary search.

6. Random number generation: Area of circle, area of square, volume of sphere, value of pi (**π**).

Solution of Algebraic and Transcendental equations by Bisection, Newton Raphson and Secant methods: Solution of linear and quadratic equation.

7.Curve fitting, Least square fit, Goodness of fit, standard deviation : Ohms law to calculate R, Hooke's law to calculate spring constant.

8. Solution of Linear system of equations: Gauss elimination method and Gauss Seidal method.

9. Diagonalization of matrices, Inverse of a matrix, Eigen vectors, eigen values problems : Solution of mesh equations of electric circuits (3 meshes), Solution of coupled spring mass systems (3 masses).

References/ Suggested Readings

1. Mathematical Methods for Physicists: Arfken, Weber, 2005, Harris, Elsevier.
2. Fourier Analysis by M.R. Spiegel, 2004, Tata McGraw-Hill.
3. Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole.
4. Differential Equations, George F. Simmons, 2006, Tata McGraw-Hill.
5. Partial Differential Equations for Scientists & Engineers, S.J. Farlow, 1993, Dover Pub.
6. Mathematical methods for Scientists & Engineers, D.A. McQuarrie, 2003, Viva Books Mathematical Physics by Binoy Bhattacharya
7. Mathematical Physics by D. Biswas
8. Mathematical Physics by B S Grewal
9. Introduction to Numerical Analysis, S.S. Sastry, 5th Edn. , 2012, PHI Learning Pvt. Ltd.
10. Schaum's Outline of Programming with C++. J. Hubbard, 2000, McGraw-Hill Pub.
11. Numerical Recipes in C: The Art of Scientific Computing, W.H. Pressetal, 3rd Edn., 2007, Cambridge University Press.
12. A first course in Numerical Methods, U.M. Ascher & C. Greif, 2012, PHI Learning.
13. Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press.
14. Complex Variables, A.S. Fokas & M.J. Ablowitz, 8th Ed., 2011, Cambridge Univ. Press.
15. First course in complex analysis with applications, D.G. Zill and P.D. Shanahan, 1940, Jones & Bartlett.
16. Computational Physics, D.Walker, 1st Edn., 2015, Scientific International Pvt. Ltd.
17. A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3rd Edn., Cambridge University Press

Course Name: Electricity and Magnetism

Course Code: BSCHPHSC202

<table>
<tr><td>Course Type:
Core (Theory & Practical)</td><td colspan="3">Course Details: **CC-4**</td><td colspan="2">L-T-P: **4-0-4**</td></tr>
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<tr><td>30</td><td>**10**</td><td>20</td><td>**40**</td></tr>
</table>

Course Learning Outcomes:

After the completion of course, the students will have ability to:

1. *Discuss the properties of (i) the produced electric field due to charges at rest; (ii) the produced magnetic field due to steady, both in free-space and inside matter.*
2. *Explain the idea of electromagnetism, through Maxwell's equation.*
3. *Analysis of electrical networks and bridges in presence of alternating currents.*

Course Content:

Theory

1. Electric Field and Electric Potential:

Electric field: Electric field lines. Electric flux. Gauss' Law with applications to charge distributions with spherical, cylindrical and planar symmetry. Conservative nature of Electrostatic Field. Electrostatic Potential. Laplace's and Poisson equations. Conductors in an electrostatic Field. Surface charge and force on a conductor. The Uniqueness Theorem. . Method of Images and its application to: (1) Plane Infinite Sheet and (2) Sphere. Potential and Electric Field of a dipole. Force and Torque on a dipole. mutual potential energy of two dipoles, force and torque between two dipoles, linear and planner quadruples – their potentials and fields. **(15 L)**

2. Electrostatic Energy:

Electrostatic energy of system of charges. Electrostatic energy of a charged sphere. Capacitance of a system of charged conductors. Parallel-plate, Cylindrical and Spherical capacitor. Capacitance of an isolated conductor **(3 L)**

3. Dielectric Properties of Matter: Electric Field in matter. Polarization, Polarization Charges. Electrical Susceptibility and Dielectric Constant. Capacitor (parallel plate, spherical, cylindrical) filled with dielectric.

Displacement vector **D**. Relations between **E**, **P** and **D**. Gauss' Law in dielectrics. **(3 L)**

4. Magnetic Field: Magnetic force between current elements and definition of Magnetic Field **B**. Biot-Savart's Law and its simple applications: straight wire and circular loop. Current Loop as a Magnetic Dipole and its Dipole Moment (Analogy with Electric Dipole). Ampere's Circuital Law and its application to (1) Solenoid and (2) Toroid. Properties of **B**: curl and divergence. Vector Potential. Magnetic Force on (1) point charge (2) current carrying wire (3) between current elements. Torque on a current loop in a uniform Magnetic Field. **(6 L)**

5. Magnetic Properties of Matter: Magnetization vector (**M**). Magnetic Intensity (**H**). Magnetic Susceptibility and permeability. Relation between **B, H, M**. Ferromagnetism, B-H curve and hysteresis. **(3 L)**

6. Electromagnetic Induction: Faraday's Law. Lenz's Law. Self Inductance and Mutual Inductance. Reciprocity Theorem. Energy stored in a Magnetic Field. Introduction to Maxwell's Equations. Charge Conservation and Displacement current. **(4 L)**

7. Ballistic Galvanometer: Torque on a current Loop. Ballistic Galvanometer: Current and Charge Sensitivity. Electromagnetic damping. Logarithmic damping. CDR. **(2 L)**

8. Network theorems: Ideal Constant-voltage and Constant-current Sources. Network Theorems: Thevenin theorem, Norton theorem, Superposition theorem, Reciprocity theorem, Maximum Power Transfer theorem. Applications to dc circuits, **(4 L)**

9. Electrical Circuits: AC Circuits: Kirchhoff's laws for AC circuits. Complex Reactance and Impedance. Series LCR Circuit: (1) Resonance, (2) Power Dissipation and (3) Quality Factor, and (4) Band Width. Parallel LCR Circuit. AC bridges-Anderson bridge,Wien bridge, De'Sauty's bridge. **(5 L)**

Practical

1. Use a multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, (d) Capacitances, and (e) Checking electrical fuses.
2. To study the characteristics of a series RC Circuit.
3. To determine an unknown low resistance using Potentiometer.
4. To determine an unknown low resistance using Carey Foster's Bridge.
5. To compare capacitances using De'Sauty's bridge.
6. Measurement of field strength B and its variation in a solenoid (determine dB/dx)

7. To verify the Thevenin and Norton theorems.

8. To verify the superposition, and maximum power transfer theorems.

9. To determine self inductance of a coil by Anderson's bridge.

10. To study response curve of a Series LCR circuit and determine its (a) Resonant frequency, (b) Impedance at resonance, (c) Quality factor Q, and (d) Band width.

11. To study the response curve of a parallel LCR circuit and determine its (a) anti-resonant frequency and (b) Quality factor Q.

12. Measurement of charge and current sensitivity and CDR of Ballistic Galvanometer

13. Determine a high resistance by leakage method using Ballistic Galvanometer.

14. To determine self-inductance of a coil by Rayleigh's method.

15. To determine temperature co-efficient of resistance by meter-bridge.

References/ Suggested Readings

1. Introduction to Electrodynamics, D.J. Griffiths, 3rd Edn., 1998, Benjamin Cummings.
2. Electricity and Magnetism, By Rakshit and Chatterjee
3. Electricity and Magnetism, Edward M. Purcell, 1986 McGraw-Hill Education
4. Electricity and Magnetism, J. H. Fewkes & J. Yarwood. Vol. I, 1991, Oxford Univ. Press.
5. Feynman Lectures Vol.2, R. P. Feynman, R. B. Leighton, M. Sands, 2008, Pearson Education
6. Electricity, Magnetism & Electromagnetic Theory, S. Mahajan and Choudhury, 2012, Tata McGraw-Hill Education

Semester-III

Course Name: Classical Mechanics and Special Theory of Relativity

Course Code: BSCHPHSC301

Course Type: **Core (Theory)**	Course Details:**CC-5**		L-T-P: **5-1-0**	
Credit: **6**	Full Marks: **50**	CA Marks	ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		……	**10**	……	**40**

Course Learning Outcomes:

After the completion of course, the students will have ability to:

1. *Explain the classical mechanics of rotating systems and particle under central force.*
2. *Understand the Lagrangian and Hamiltonian formulations of classical mechanics.*
3. *Explain the necessity of replacing Newtonian relativity through Einstein's special relativity, and elaborate on the classical mechanics of fast particles under the special relativity.*

Course Content:

Theory

1. Kinematics and Dynamics of Rigid Body Motion

a) ***Rotational Motion:***

Moment of inertia, radius of gyration; Energy and angular momentum of rotating systems of particles; Parallel and perpendicular axes theorems of moment of inertia; Calculation of moment of inertia for simple symmetric systems; Ellipsoid of inertia and inertia tensor; Setting up of principal axes in simple symmetric cases. Euler's equation, Rotating frames of reference - Coriolis and centrifugal forces, simple examples. Force free motion of rigid bodies - free spherical top and free symmetric top. **(12L)**

b) ***Central force Motion***:

Motion of a particle under a central force field. Two-body problem and its reduction to one-body problem and its solution. The energy equation and energy diagram. Kepler's Laws. Satellite in circular orbit and applications. Geosynchronous orbits. Weightlessness. Physiological effects on astronauts. Gravitational potential, Basic idea of global positioning system (GPS). **(12L)**

2. Lagrangian and Hamiltonian formulation of Classical Mechanics

a) ***Lagrangian Formulation***: Generalized coordinates, constraints and degrees of freedom; D'Alembart's principle; Lagrange's equation for conservative systems and its application to simple cases; Generalized momentum; Idea of cyclic coordinates, its relation with conservation principles. **(8L)**

b) ***Hamiltonian Formulation***: Definition of Hamiltonian, Hamilton's equation (derivation by Legendre transformation) and its application to simple cases. Poisson's bracket and equation of motion, Jacobi identity, canonical transformation. **(8 L)**

3. **Special Theory of Relativity : a)** Michelson Moreley experiment : implication of this experiments; non -invariance of Maxwell's equations under Galilean transformation. **(6L)**

b) Postulates of Special Theory of Relativity; Lorentz transformation; length contraction; time dilatation; simultaneity; velocity addition theorem; explanation of stellar aberration, Fizeau's experiment and Michelson Morley experiment; Doppler effect (non- relativistic and relativistic); variation of mass with velocity; force and kinetic energy; transformation relations for momentum, energy and force :invariance of Maxwell's wave equation under Lorentz transformation. **(14 L)**

References/ Suggested Readings

1. Classical mechanics-Goldstein
2. Mechanics- Landau and Liftshitz.
3. Classical Mechanics- Rana and Jog
4. Strogatz, Nonlinear Dynamics and Chaos
5. R. Resnick – Introduction to Special Theory of Relativity.
6. S. Banerji and A. Banerjee – The Special Theory of Relativity (Prentice Hall of India, 2002)
7. Stephen Wiggins, "Introduction to Applied Nonlinear Dynamical Systems and Chaos", Springer-Verlag, Second Edition.
8. Dominic Jordan, Peter Smith, "Nonlinear Ordinary Differential Equations: An Introduction for Scientists and Engineers" (Oxford Texts in Applied and Engineering Mathematics).
9. Classical Mechanics by Gupta Kumar
10. Classical Mechanics by A. Roy Chowdhury

Course Name: Thermal Physics – I

Course Code: BSCHPHSC302

<table>
<tr><td>Course Type:
Core(Theory & Practical)</td><td colspan="2">Course Details: CC-6</td><td colspan="3">L-T-P: 4-0-4</td></tr>
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<tr><td>30</td><td>10</td><td>20</td><td>40</td></tr>
</table>

Course Learning Outcomes:

After the completion of course, the students will have ability to:

1. *Demonstrate molecular motion (kinetics) inside an ideal and a real classical gas.*
2. *Explain how the processes of heat transfer through solid, viz., conduction and radiation*

Course Content:

Theory

1. ***Kinetic Theory of Gases***: Basic assumptions of kinetic theory, Ideal gas approximation, deduction of pressure and perfect gas laws. Maxwell’s distribution law, root mean square and most probable speeds. Effect of finite size of molecules. Collision probability, Deduction of free paths and mean free path from elementary, Clausius and Maxwell’s distribution. Degrees of freedom, Equipartition of energy (derivation not required). **(14L)**
2. ***Transportation Phenomenon:*** Viscosity, thermal conduction and diffusion in gases. **(4L)**
3. **Brownian Motion and its application*:*** Einstein theory, Perrin’s work, determination of Avogadro number **(5L)**

4. Real Gases : Nature of intermolecular interaction : isotherms of real gases. van der-Waals equation of state, Other equations of state, critical constants of a gas, law of corresponding states; Virial Coefficients, Boyle temperature. **(8L)**

5. Conduction of Heat: Thermal conductivity, diffusivity. Fourier’s equation for heat conduction – its solution for rectilinear and radial (spherical and cylindrical) flow of heat. **(5L)**

6. Radiation: Prevost’s theory of exchanges; emissive and absorptive powers; Kirchhoff’s law, black body radiation; energy density; radiation pressure; Wien's displacement law; Stefan Boltzmann law; Wien's law and Rayleigh Jean's law; Planck's law and deductions of Wien's law, Stefan Boltzmann law and Rayleigh Jean's law from Planck's law, Radiation pyrometer, Solar temperature. **(9L)**

Practical:

1. To determine mechanical equivalent of Heat, J, by Callender and Barne's constant flow method.
2. To determine the coefficient of thermal conductivity of Cu by Searle's Apparatus.
3. To determine the coefficient of thermal conductivity of a bad conductor by Lee and Charlton's disc method.
4. To determine the temperature coefficient of resistance/boiling point by platinum resistance thermometer
5. To study the variation of thermo-emf of a thermocouple with difference of temperature of its two Junctions.
6. To determine temperature co-efficient of resistance of metal/semiconductor by meter-bridge.
7. Determination of the boiling point of a liquid by Platinum resistance thermometer.
8. Determination of coefficient of linear expansion by optical lever/travelling microscope.
9. Determination of pressure coefficient of air by Jolly's apparatus.

References/ Suggested Readings

1. Heat and Thermodynamics, M.W. Zemansky, Richard Dittman, 1981, McGraw-Hill.
2. A Treatise on Heat, Meghnad Saha, and B.N.Srivastava, 1958, Indian Press.
3. Thermal Physics, S. Garg, R. Bansal and Ghosh, 2nd Edition, 1993, Tata McGraw-Hill.
4. Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer.
5. Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Sears & Salinger, 1988, Narosa.
6. Concepts in Thermal Physics, S.J. Blundell and K.M. Blundell, 2nd Ed., 2012, Oxford University Press.
7. Thermal Physics by Roy Gupta

Course Name: Analog Systems and Applications
Course Code: BSCHPHSC303

<table>
<tr><td>Course Type: Core
(Theory & Practical)</td><td colspan="2">Course Details: CC-7</td><td colspan="3">L-T-P: 4-0-4</td></tr>
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<tr><td>30</td><td>10</td><td>20</td><td>40</td></tr>
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Course Learning Outcomes:

After the completion of course, the students will have ability to:

1. *Explain the electronic transport mechanisms through intrinsic and extrinsic semiconductors.*
2. *Understand the theory of the transport through doped semiconductor junctions in diodes, transistors.*
3. *Use diode as rectifier and junction transistors as amplifiers.*

Course Content:

Theory

1. Semiconductor Diodes

P and N type semiconductors. Energy Level Diagram. Conductivity and Mobility, Concept of Drift velocity. PN Junction Fabrication (Simple Idea). Barrier Formation in PN Junction Diode. Static and Dynamic Resistance. Current Flow Mechanism in Forward and Reverse Biased Diode. Drift Velocity. Derivation for Barrier Potential, Barrier Width and Current for Step Junction. Current Flow Mechanism in Forward and Reverse Biased Diode. **(5L)**

2. Two-terminal Devices and their Applications

Rectifier Diode: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers, Calculation of Ripple Factor and Rectification Efficiency, C-filter

Zener Diode and Voltage Regulation. Principle and structure of (1) LEDs, (2) Photodiode and (3) Solar Cell. **(7L)**

3. Bipolar Junction transistors

n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. Current gains α and β Relations between α and β. Load Line analysis of Transistors. DC Load line and Q-point. Physical Mechanism of Current Flow. Active, Cutoff and Saturation Regions. **(4L)**

4. Field Effect transistors

Basic principle of operations of JFET and MOSFET only. **(3 L)**

5. Amplifiers

Amplifiers: Transistor Biasing and Stabilization Circuits. Fixed Bias and Voltage Divider Bias. Transistor as 2-port Network. h-parameter Equivalent Circuit. Analysis of a single-stage CE amplifier using Hybrid Model. Input and Output Impedance. Current, Voltage and Power Gains. Classification of Class A, B & C Amplifiers. Frequency response of a CE amplifier. **(6L)**

6. Coupled Amplifier: Two stage RC-coupled amplifier . **(2L)**

Feedback in Amplifiers: Effects of Positive and Negative Feedback on Input Impedance, Output Impedance, Gain, Stability, Distortion and Noise. (**3 L**)

Sinusoidal Oscillators: Barkhausen's Criterion for self-sustained oscillations. RC Phase shift oscillator, determination of Frequency. Hartley & Colpitts oscillators. (**4L**)

Operational Amplifiers (Black Box approach): Characteristics of an Ideal and Practical Op-Amp. (IC 741) Open-loop and Closed-loop Gain. Frequency Response. CMRR. Slew Rate and concept of Virtual ground. Applications of Op-Amps: Linear - (1) Inverting and non-inverting amplifiers, (2) Adder, (3) Subtractor, (4) Differentiator, (5) Integrator, (6) Log amplifier, (7) Zero crossing detector (8) Wein bridge oscillator. Non-linear – (1) inverting and non-inverting comparators, (2) Schmidt triggers. (**8L**)

Conversion: Resistive network (Weighted and R-2R Ladder). Accuracy and Resolution. A/D Conversion (successive approximation) (**3L**)

Practical

1. To study V-I characteristics of PN junction diode, and Light emitting diode.
2. To study the V-I characteristics of a Zener diode and its use as voltage regulator.
3. To study the characteristics of a Bipolar Junction Transistor in CE configuration.
4. To design a CE transistor amplifier of a given gain (mid-gain) using voltage divider bias.
5. To study the frequency response of voltage gain of a RC-coupled transistor amplifier.
6. To design a digital to analog converter (DAC) of given specifications.
7. To design an inverting amplifier using Op-amp (741,351) for dc voltage of given gain
8. To design inverting amplifier using Op-amp (741,351) and study its frequency response
9. To design non-inverting amplifier using Op-amp (741,351) & study its frequency response
10. To add two dc voltages using Op-amp in inverting and non-inverting mode
11. To investigate the use of an op-amp as an Integrator and as a differentiator.

References/ Suggested Readings

1. Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill.
2. Electronics: Fundamentals and Applications, J.D. Ryder, 2004, Prentice Hall.
3. Solid State Electronic Devices, B.G.Streetman & S.K.Banerjee, 6th Edn.,2009, PHI Learning
4. Electronic Devices & circuits, S.Salivahanan & N.S.Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill
5. OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall
6. Microelectronic circuits, A. S.Sedra, K.C. Smith, A.N. Chandorkar, 2014, 6th Edn., Oxford University Press.
7. Electronic circuits: Handbook of design & applications, U.Tietze, C.Schenk,2008, Springer
8. Semiconductor Devices: Physics and Technology, S.M. Sze, 2nd Ed., 2002, Wiley India
9. Microelectronic Circuits, M.H. Rashid, 2nd Edition, Cengage Learning
10. Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson India
11. Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-Graw Hill.
12. OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall.
13. Electronic Principle, Albert Malvino, 2008, Tata Mc-Graw Hill.
14. Electronic Devices & circuit Theory, R.L. Boylestad & L.D. Nashelsky, 2009, Pearson.

SKILL ENHANCEMENT COURSE (SEC-I)

(Evaluation is to be done internally)

Course Name: Electrical Circuit Network Skills

Course Code: BSCHPHSSEC 301

<table>
<tr><td>Course Type: SEC (Practical)</td><td colspan="2">Course Details: SEC-1</td><td colspan="2">L-T-P: 0-0-8</td></tr>
<tr><td rowspan="3">Credit: 4</td><td rowspan="3">Full Marks: 50</td><td colspan="2">CA Marks</td><td colspan="2">ESE Marks</td></tr>
<tr><td>Practical</td><td>Theoretical</td><td>Practical</td><td>Theoretical</td></tr>
<tr><td>30</td><td>…….</td><td>20</td><td>……</td></tr>
</table>

Course Learning Outcomes:

After the completion of course, the students will have ability to:

1. *Design and trouble shoots the electrical circuits, networks and appliances through hands-on mode.*
2. *Choose proper devices depending upon application considering economic and technology up-gradation.*

Course Content:

Practical

1. Basic Electricity Principles: Voltage, Current, Resistance, and Power. Ohm's law, Series, parallel, and series-parallel combinations. AC Electricity and DC Electricity, Familiarization with multimeter, voltmeter and ammeter. **(8L)**

2. Understanding Electrical Circuits: Main electric circuit elements and their combination. Rules to analyze DC sourced electrical circuits. Current and voltage drop across the DC circuit elements. Single-phase and three-phase alternating current sources. Rules to analyze AC sourced electrical circuits. Real, imaginary and complex power components of AC source. Power factor. Saving energy and money. **(8L)**

3. Electrical Drawing and Symbols: Drawing symbols. Blueprints. Reading Schematics. Ladder diagrams. Electrical Schematics. Power circuits. Control circuits. Reading of circuit schematics. Tracking the connections of elements and identify current flow and voltage drop. **(8L)**

4. Generators and Transformers: DC Power sources. AC/DC generators. Inductance, capacitance, and impedance. Operation of transformers. **(8L)**

5. Electric Motors: Single-phase, three-phase & DC motors. Basic design. Interfacing DC or AC sources to control heaters & motors. Speed & power of ac motor. **(8L)**

6. Solid-State Devices: Resistors, inductors and capacitors. Diode and rectifiers. Components in Series or in shunt. Response of inductors and capacitors with DC or AC sources. **(8L)**

7.Electrical Protection: Relays. Fuses and disconnect switches. Circuit breakers. Overload devices. Ground-fault protection. Grounding and isolating. Phase reversal. Surge protection. Interfacing DC or AC sources to control elements (relay protection device). **(6L)**

8. Electrical Wiring: Different types of conductors and cables. Basics of wiring-Star and delta connection. Voltage drop and losses across cables and conductors. Instruments to measure current, voltage, power in

DC and AC circuits. Insulation. Solid and stranded cable. Conduit. Cable trays. Splices: wirenuts, crimps, terminal blocks, split bolts, and solder. Preparation of extension board. **(6L)**

References/ Suggested Readings:

1. A text book in Electrical Technology - B L Theraja - S Chand & Co.
2. A text book of Electrical Technology - A K Theraja
3. Performance and design of AC machines - M G Say ELBS Edn.

Course Name: Technical Drawing Skills

Course Code: BSCHPHSSEC302

<table>
<tr><td>Course Type: SEC (Practical)</td><td colspan="3">Course Details: SEC-1</td><td colspan="2">L-T-P: 0-0-8</td></tr>
<tr><td rowspan="3">Credit: 4</td><td rowspan="3">Full Marks: 50</td><td colspan="2">CA Marks</td><td colspan="2">ESE Marks</td></tr>
<tr><td>Practical</td><td>Theoretical</td><td>Practical</td><td>Theoretical</td></tr>
<tr><td>30</td><td>…….</td><td>20</td><td>……</td></tr>
</table>

Course Learning Outcomes:

After the completion of course, the students will have ability to:

1. *Know and understand the conventions and the method of engineering drawing.*
2. *Interpret engineering drawings using fundamental technical mathematics.*
3. *Construct basic and intermediate geometry.*
4. *Improve their visualization skills so that they can apply the skill in developing new products.*
5. *Improve their technical communication skill in the form of communicative drawings.*
6. *Comprehend the theory of projection.*

Course Content:

Practical

1. Introduction: Drafting Instruments and their uses. lettering: construction and uses of various scales: dimensioning as per I.S.I. 696-1972. Engineering Curves: Parabola: hyperbola: ellipse: cycloids, involute: spiral: helix and loci of points of simple moving mechanism. 2D geometrical construction. Representation of 3D objects. Principles of projections.

2. Projections: Straight lines, planes and solids. Development of surfaces of right and oblique solids. Section of solids.

3. Object Projections: Orthographic projection. Interpenetration and intersection of solids. Isometric and oblique parallel projection of solids.

4. CAD Drawing: Introduction to CAD and Auto CAD, precision drawing and drawing aids, Geometric shapes, Demonstrating CAD- specific skills (graphical user interface. Create, retrieve, edit, and use symbol libraries. Use inquiry commands to extract drawing data). Control entity properties. Demonstrating basic skills to produce 2-D and 3-Ddrawings. 3D modeling with Auto CAD (surfaces and solids), 3D modeling with sketch up, annotating in Auto CAD with text and hatching, layers, templates & design centre, advanced plotting (layouts, viewports), office standards, dimensioning, internet and collaboration, Blocks, Drafting symbols, attributes, extracting data. basic printing, editing tools, Plot/Print drawing to appropriate scale.

References/ Suggested Readings:

1. K. Venugopal, and V. Raja Prabhu. Engineering Graphic, New Age International
2. AutoCAD 2014 & AutoCAD 2014/Donnie Gladfelter/Sybex/ISBN:978-1-118-57510-9
3. Architectural Design with Sketchup/Alexander Schreyer/John Wiley & Sons/ISBN:978-1-118- 12309-6

Semester-IV

Course Name: Electromagnetic Theory

Course Code: BSCHPHSC401

Course Type: **Core (Theory)**	Course Details:**CC-8**			L-T-P: **5-1-0**	
Credit: **6**	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		……	**10**	……	**40**

Course Learning Outcomes:

After the completion of course, the students will have ability to:

1. *Demonstrates the theory behind the generation of the electromagnetic (transverse) progressive wave in combination of oscillating electric and magnetic fields.*
2. *Understand the basics of electromagnetic wave and its propagation through conducting and non-conducting medium and their application in modern day communication system.*
3. *Understand he theories of the manifestations by EM wave (viz., dispersion, scattering, polarisation).*

Course Content:

Theory

1. Electromagnetic Theory :

a) Displacement current; continuity equation; Maxwell's equations; scalar and vector potentials, gauge invariance and Lorentz and Coulomb gauge. Wave equation for the electromagnetic wave and its solution – plane wave and spherical wave solutions; relation between E and B; field energy; Poynting vector and Poynting's theorem; boundary conditions. **(14L)**

b) Wave equation in Isotropic Dielectrics; reflection and refraction at plane surfaces; reflection and transmission coefficients; Fresnel's formulae and applications; change of phase on reflection; Brewster's law; total internal reflection. **(9L)**

c) Wave equation in Anisotropic Dielectrics; crystal optics – equation of the wave surface: electromagnetic theory of optical activity. **(7L)**

d) Waves in a Conducting Medium; reflection and transmission at metallic surface – skin effect. Propagation of electromagnetic waves between parallel conducting plates – wave guides with rectangular cross -sections; TE and TM modes. Optical fibres – total internal reflection; optical fibre as wave -guide; step index and graded index fibres. **(11L)**

2. Dispersion: Normal and Anomalous Dispersions; Sellmeier's and Cauchy's formulae from electromagnetic theory. **(6L)**

3. Scattering: Radiation from an Oscillating Dipole (qualitative only) scattering of radiation by a bound charge. Rayleigh scattering; depolarization factor; blue of the sky; absorption; Raman scattering (qualitative). **(8L)**

4. Electro-and Magneto-optic Effects : Kerr and Faraday effects. (Brief introduction) **(5L)**

References/ Suggested Readings:

1. Born and Wolf : Principles of Optics – Pergamon.
2. Sommerfeld : Optics – Academic Press.
3. Jackson : Classical Electrodynamics – John Wiley.
4. Ditchburn : Light – Pergamon.
5. B B Laud : Electromagnetics
6. Griffiths : Electromagnetic theory.
7. Ajay Ghatak : Optics (6^{th} Edition)
8. Marion and Heald : Classical Electromagnetic Radiation – Academic Press.
9. Reitz, Milford and Christy : Electromagnetic Theory – Addison Wesley.
10. Kittel, Knight and Ruderman : Mechanics, Berkeley Physics, Vol.I – McGraw Hill.
11. French : Special Theory of Relativity – ELBS.
12. Sriranjan Bandopadhyay :ApekshikataTatwa (in Bengali) – W.B. State Book Board.
13. A.K. Raychaudhuri : Uchatara Gatividya (in Bengal) – W.B. State Book Board.

Course Name: Waves and Optics

Course Code: BSCHPHSC402

Course Type: Core(Theory & Practical)	Course Details: **CC-9**			L-T-P: **4-0-4**	
Credit: **6**	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**10**	20	**40**

Course Learning Outcomes:

After the completion of course, the students will have ability to:

1. *Explain linear superposition of several collinear and mutually perpendicular SHMs.*
2. *Grow understanding due to manifestations by the optical (light) waves (viz., interference, diffraction and polarisation) can be made.*
3. *Apply knowledge of sound waves, and light waves to explain natural physical processes and related technological advances.*

Course Content:

Theory

1. Superposition of Collinear Harmonic oscillations: Linearity and Superposition Principle. Superposition of two collinear oscillations having (1) equal frequencies and (2) different frequencies (Beats). Superposition of N collinear Harmonic Oscillations with (1) equal phase differences and (2) equal frequency differences. **(5 L)**

2. Superposition of two perpendicular Harmonic Oscillations: Graphical and Analytical Methods. Lissajous Figures (1:1 and 1:2) and their uses. **(2 L)**

3. Wave Motion: Plane and Spherical Waves. Longitudinal and Transverse Waves. Plane Progressive (Travelling) Waves. Wave Equation. Particle and Wave Velocities. Differential Equation. Pressure of a Longitudinal Wave. Energy Transport. Intensity of Wave. Water Waves: Ripple and Gravity Waves. **(4 L)**

4. Interference of light waves

Young's experiment; spatial and temporal coherence; intensity distribution; Fresnel's biprism, interference in thin film; fringes of equal inclination and equal thickness; Newton's ring. Michelson's interferometer, Multiple beam interference – reflected and transmitted pattern. Fabry-Perot interferometer.

(9 L)

5. Diffraction of light waves

Fresnel and Fraunhofer class, Fresnel's half period zones; explanation of rectilinear propagation of light; zone plate. Fraunhofer diffraction due to a single slit, double slit and circular aperture (qualitative). Plane diffraction grating (transmission). Rayleigh criterion of resolution; resolving power of prism, telescope, microscope and transmission grating. **(10 L)**

6. Polarisation

Different states of polarisation; double refraction, Malus law, Huygen's construction for uniaxial crystals; polaroids and their uses. Production and analysis of plane, circularly and elliptically polarised light by retardation plates and Babinet compensator; Rotatory polarisation and optical activity; Fresnel's explanation of optical activity; Biquartz and half shade polarimeter. **(6 L)**

Practical

1. To verify the law of Malus for plane polarized light.
2. To determine the specific rotation of sugar solution using polarimeter.
3. To analyze elliptically polarized light by using a Babinet's compensator.
4. Determination of angle of prism and to determine refractive index of the material of a prism using sodium source.
5. To determine the dispersive power and Cauchy constants of the material of a prism using mercury/helium source.
6. To determine wavelength of sodium light using Fresnel biprism.
7. To determine wavelength of sodium light using Newton's rings.
8. To determine wavelength of (1) sodium source and (2) spectral lines of mercury/helium source using plane diffraction grating.

References/ Suggested Readings:

1. Waves: Berkeley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGraw-Hill.
2. Fundamentals of Optics, F.A. Jenkins and H.E. White, 1981, McGraw-Hill

3. Principles of Optics, Max Born and Emil Wolf, 7th Edn., 1999, Pergamon Press.
4. Optics, Ajoy Ghatak, 2008, Tata McGraw Hill
5. The Physics of Vibrations and Waves, H. J. Pain, 2013, John Wiley and Sons.
6. The Physics of Waves and Oscillations, N.K. Bajaj, 1998, Tata McGraw Hill.
7. Optics (Classical & Quantum) -R.K. Kar (Books and Allied)
8. Waves and Oscillations by N K Bajaj
9. Waves and Oscillations by R N Chowdhury
10. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House
11. A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal
12. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
13. A Laboratory Manual of Physics for undergraduate classes, D. P. Khandelwal, 1985, Vani Pub.

Course Name: Digital Systems and Applications
Course Code: BSCHPHSC 403

<table>
<tr><td>Course Type:
Core(Theory & Practical)</td><td colspan="3">Course Details: CC-10</td><td colspan="2">L-T-P: 4-0-4</td></tr>
<tr><td rowspan="3">Credit: 6</td><td rowspan="3">Full Marks: 100</td><td colspan="2">CA Marks</td><td colspan="2">ESE Marks</td></tr>
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<tr><td>30</td><td>10</td><td>20</td><td>40</td></tr>
</table>

Course Learning Outcomes:

After the completion of course, the students will have ability to:

1. Work with binary logic, and thus know how different kinds of logic gates work.

2. Develop a digital logic and apply it to solve real life problems.

3. Understand the difference between combinational and sequential logic circuits.

4. Analyze, design and implement combinational and sequential logic circuits.

5. Gain knowledge how modern day computer works.

Course Content:

Theory

1. Integrated Circuits : Active & Passive components. Discrete components. Wafer. Chip. Advantages and drawbacks of ICs. Scale of integration: SSI, MSI, LSI and VLSI (basic idea and definitions only). Classification of ICs. Examples of Linear and Digital lCs. **(3L)**

2. Digital Circuits: Difference between Analog and Digital Circuits. Binary Numbers. Decimal to Binary and Binary to Decimal Conversion. BCD, Octal and Hexadecimal numbers. AND, OR and NOT Gates (realization using Diodes and Transistor). NAND and NOR Gates as Universal Gates. XOR and XNOR Gates and application as Parity Checkers. **(5L)**

3. Boolean algebra: De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra. Fundamental Products. Idea of Minterms and Maxterms. Conversion of a Truth table into Equivalent Logic Circuit by (1) Sum of Products Method and (2) Karnaugh Map. **(6L)**

4. Data processing circuits: Basic idea of Multiplexers, De-multiplexers, Decoders, Encoders. **(4L)**

5. Circuits: Arithmetic Circuits: Binary Addition. Binary Subtraction using 2's Complement. Half and Full Adders. Half & Full Subtractors, 4-bit binary Adder/Subtractor. Sequential Circuits: SR, D, and JK Flip-Flops. Clocked (Level and Edge Triggered) Flip-Flops. Preset and Clear operations. Race-around conditions in JK Flip-Flop. M/S JK Flip-Flop; Shift register and counter. **(16L)**

6. Computer Organization : Input/Output Devices. Data storage (idea of RAM and ROM). Computer memory. Memory organization & addressing. Memory Interfacing. Memory Map. **(4L)**

Practical

1. To measure (a) Voltage, and (b) Time period of a periodic waveform using CRO.
2. To test a Diode and Transistor using a Multimeter.
3. To design a switch (NOT gate) using a transistor.
4. To verify and design AND, OR, NOT and XOR gates using NAND gates.
5. To design a combinational logic system for a specified Truth Table.
6. To convert a Boolean expression into logic circuit and design it using logic gate ICs.
7. To minimize a given logic circuit.
8. Half Adder, Full Adder and 4-bit binary Adder.
9. Half Subtractor, Full Subtractor, Adder-Subtractor using Full Adder I.C.
10. To build Flip-Flop (RS, Clocked RS, D-type and JK) circuits using NAND gates.
11. To build JK Master-slave flip-flop using Flip-Flop ICs
12. To build a 4-bit Counter using D-type/JK Flip-Flop ICs and study timing diagram.

13. To make a 4-bit Shift Register (serial and parallel) using D-type/JK Flip-Flop ICs.
14. To design an astable multivibrator of given specifications using 555 Timer.
15. To design a monostable multivibrator of given specifications using 555 Timer.

References/ Suggested Readings:

1. Digital Principles and Applications, A.P. Malvino, D. P. Leach and Saha, 7th Ed., 2011, Tata McGraw
2. Fundamentals of Digital Circuits, Anand Kumar, 2nd Edn, 2009, PHI Learning Pvt. Ltd.
3. Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.
4. Digital Electronics G K Kharate ,2010, Oxford University Press
5. Digital Systems: Principles & Applications, R.J.Tocci, N.S.Widmer, 2001, PHI Learning
6. Logic circuit design, Shimon P. Vingron, 2012, Springer.
7. Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning.
8. Digital Electronics, S.K. Mandal, 2010, 1st edition, McGraw Hill
9. Microprocessor Architecture Programming & applications with 8085, 2002, R.S. Goankar, Prentice Hall.
10. Digital Electronics by R P jain
11. Electronics By Rakshit & Chatterjee
12. Modern Digital Electronics, R.P. Jain, 4th Edition, 2010, Tata McGraw Hill.
13. Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-Graw Hill.

SKILL ENHANCEMENT COURSE

(Evaluation is to be done internally)

Course Name: Basic Instrumentation Skills

Course Code: BSCHPHSSEC401

<table>
<tr><td>Course Type: SEC (Practical)</td><td colspan="3">Course Details: SEC-2</td><td colspan="2">L-T-P: 0-0-8</td></tr>
<tr><td rowspan="3">Credit: 4</td><td rowspan="3">Full Marks: 50</td><td colspan="2">CA Marks</td><td colspan="2">ESE Marks</td></tr>
<tr><td>Practical</td><td>Theoretical</td><td>Practical</td><td>Theoretical</td></tr>
<tr><td>30</td><td>…….</td><td>20</td><td>……</td></tr>
</table>

Course Learning Outcomes:

After the completion of course, the students will have ability to:

1. *Get exposure with various aspects of instruments and their usage through hands-on mode.*
2. *Do experiments listed below in continuation of the topics*

Course Content:

Practical

1.Basic of Measurement: Instruments accuracy, precision, sensitivity, resolution range etc. Errors in measurements and loading effects.

2. Multimeter: Principles of measurement of dc voltage and dc current, ac voltage, ac current and resistance. Specifications of a multimeter and their significance.

2.Electronic Voltmeter: Advantage over conventional multimeter for voltage measurement with respect to input impedance and sensitivity. Principles of voltage, measurement (block diagram only). Specifications of an electronic Voltmeter/Multimeter and their significance.

3. AC millivoltmeter: Type of AC millivoltmeters: Amplifier- rectifier, and rectifier- amplifier. Block diagram ac millivoltmeter**,** specifications and their significance.

4. Cathode Ray **Oscilloscope:** Block diagram of basic CRO. Construction of CRT, Electron gun, electrostatic focusing and acceleration (Explanation only– no mathematical treatment), brief discussion on screen phosphor, visual persistence & chemical composition. Time base operation, synchronization. Front panel controls. Specifications of a CRO and their significance.

Use of CRO for the measurement of voltage (dc and ac frequency, time period. Special features of dual trace, introduction to digital oscilloscope, probes. Digital storage Oscilloscope: Block diagram and principle of working.

6. Signal Generators and Analysis Instruments: Block diagram, explanation and specifications of low frequency signal generators. pulse generator, and function generator. Brief idea for testing, specifications. Distortion factor meter, wave analysis.

7. Impedance Bridges & Q-Meters: Block diagram of bridge. working principles of basic (balancing type) RLC bridge. Specifications of RLC bridge. Block diagram & working principles of a Q- Meter. Digital LCR bridges.

8. Digital Instruments: Principle and working of digital meters. Comparison of analog & digital instruments. Characteristics of a digital meter. Working principles of digital voltmeter.

9. Digital Multimeter: Block diagram and working of a digital multimeter. Working principle of time interval, frequency and period measurement using universal counter/frequency counter, time- base stability, accuracy and resolution.

The test of lab skills will be of the following test items:

1. Use of an oscilloscope.
2. CRO as a versatile measuring device.
3. Circuit tracing of Laboratory electronic equipment.
4. Use of Digital multimeter/VTVM for measuring voltages.
5. Circuit tracing of Laboratory electronic equipment.
6. Winding a coil / transformer.
7. Study the layout of receiver circuit.
8. Trouble shooting a circuit.
9. Balancing of bridges.

Laboratory Exercises:

1. To observe the loading effect of a multimeter while measuring voltage across a low resistance and high resistance.
2. To observe the limitations of a multimeter for measuring high frequency voltage and currents.
3. To measure Q of a coil and its dependence on frequency, using a Q- meter.
4. Measurement of voltage, frequency, time period and phase angle using CRO.
5. Measurement of time period, frequency, average period using universal counter/frequency counter.

6. Measurement of rise, fall and delay times using a CRO.

7. Measurement of distortion of a RF signal generator using distortion factor meter.

8. Measurement of R, L and C using a LCR bridge/ universal bridge.

Open Ended Experiments:

1. Using a Dual Trace Oscilloscope.

2. Converting the range of a given measuring instrument (voltmeter, ammeter).

References/ Suggested Readings:

3. A text book in Electrical Technology - B L Theraja - S Chand and Co.
4. Performance and design of AC machines - M G Say ELBS Edn.
5. Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.
6. Logic circuit design, Shimon P. Vingron, 2012, Springer.
7. Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning.
8. Electronic Devices and circuits, S. Salivahanan & N. S.Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill.
9. Electronic circuits: Handbook of design and applications, U.Tietze, Ch.Schenk, 2008, Springer.
10. Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson India.

Course Name: Computational Physics

Course Code: BSCHPHSSEC402

Course Type: **SEC (Practical)**	Course Details: **SEC-2**		L-T-P: **0-0-8**		
Credit: **4**	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	…….	20	……

Course Learning Outcomes:

After the completion of course, the students will have ability to:

1. *Use computer programming language FORTRAN for solving the problems in physics through*

programming.

2. *Prepare manuscript for scientific publication using Latex .*
3. *Visualize numerical data using Gnuplot software.*

Course Content:

Practical

1. Introduction: Importance of computers in Physics, paradigm for solving physics problems for solution**.** Usage of linux as an Editor.

2. Algorithms and Flowcharts: Algorithm: Definition, properties and development. Flowchart: Concept of flowchart, symbols, guidelines, types. Examples: Cartesian to Spherical Polar Coordinates, Roots of Quadratic Equation, Sum of two matrices, Sum and Product of a finite series, calculation of sin(x) as a series, algorithm for plotting (1) lissajous figures and (2) trajectory of a projectile thrown at an angle with the horizontal.

3. Scientific Programming: Some fundamental Linux Commands (Internal and External commands). Development of FORTRAN, Basic elements of FORTRAN: Character Set, Constants and their types, Variables and their types, Keywords, Variable Declaration and concept of instruction and program. Operators: Arithmetic, Relational, Logical and Assignment Operators. Expressions: Arithmetic, Relational, Logical, Character and Assignment Expressions. Fortran Statements: I/O Statements (unformatted/formatted), Executable and Non-Executable Statements, Layout of Fortran Program, Format of writing Program and concept of coding, Initialization and Replacement Logic. Examples from physics problems.

4. Control Statements: Types of Logic (Sequential, Selection, Repetition), Branching Statements (Logical **IF**, Arithmetic IF, Block IF, Nested Block IF, SELECT CASE and ELSE IF Ladder statements), Looping Statements (DO-CONTINUE, DO-ENDDO, DOWHILE, Implied and Nested DO Loops), Jumping Statements (Unconditional GOTO, Computed GOTO, Assigned GOTO) Subscripted Variables (Arrays: Types of Arrays, DIMENSION Statement, Reading and Writing Arrays), Functions and Subroutines (Arithmetic Statement Function, Function Subprogram and Subroutine), RETURN, CALL, COMMON and EQUIVALENCE Statements), Structure, Disk I/O Statements, open a file, writing in a file, reading from a file. Examples from physics problems.

5. Programming:

1. Exercises on syntax on usage of FORTRAN.
2. Usage of GUI Windows, Linux Commands, familiarity with DOS commands and working in an editor to write sources codes in FORTRAN.
3. To print out all natural even/ odd numbers between given limits.

4. To find maximum, minimum and range of a given set of numbers.
5. Calculating Euler number using exp(x) series evaluated at x = 1.

6. Scientific word processing: Introduction to LaTeX: TeX/LaTeX word processor, preparing a basic LaTeX file, Document classes, Preparing an input file for LaTeX, Compiling LaTeX File, LaTeX tags for creating different environments, Defining LaTeX commands and environments, Changing the type style, Symbols from otherlanguages. **Equation representation:** Formulae and equations, Figures and other

floating bodies, Lining in columns- Tabbing and tabular environment, Generating table of contents, bibliography and citation, Making an index and glossary, List making environments, Fonts, Picture environment and colors, errors.

7. Visualization: Introduction to graphical analysis and its limitations. Introduction to Gnuplot. importance of visualization of computational and computational data, basic Gnuplot commands: simple plots, plotting data from a file, saving and exporting, multiple data sets per file, physics with Gnuplot (equations, building functions, user defined variables and functions), Understanding data with Gnuplot

Hands on exercises:

1. To compile a frequency distribution and evaluate mean, standard deviation etc.
2. To evaluate sum of finite series and the area under a curve.
3. To find the product of two matrices
4. To find a set of prime numbers and Fibonacci series.
5. To write program to open a file and generate data for plotting using Gnuplot.
6. Plotting trajectory of a projectile projected horizontally.
7. Plotting trajectory of a projectile projected making an angle with the horizontally.
8. Creating an input Gnuplot file for plotting a data and saving the output for seeing on the screen. Saving it as an eps file and as a pdf file.
9. To find the roots of a quadratic equation.
10. Motion of a projectile using simulation and plot the output for visualization.
11. Numerical solution of equation of motion of simple harmonic oscillator and plot the outputs for visualization.
12. Motion of particle in a central force field and plot the output for visualization.

References/ Suggested Readings:

1. Introduction to Numerical Analysis, S.S. Sastry, 5th Edn., 2012, PHI Learning Pvt. Ltd.
2. Computer Programming in Fortran 77". V. Rajaraman (Publisher: PHI).
3. LaTeX–A Document Preparation System", Leslie Lamport (Second Edition, Addison-Wesley, 1994).
4. Gnuplot in action: understanding data with graphs, Philip K Janert, (Manning 2010)
5. Schaum's Outline of Theory and Problems of Programming with Fortran, S Lipsdutz and A Poe, 1986Mc-Graw Hill Book Co.
6. Computational Physics: An Introduction, R. C. Verma, et al. New Age International Publishers, New Delhi (1999)
7. A first course in Numerical Methods, U.M. Ascher and C. Greif, 2012, PHI Learning
8. Elementary Numerical Analysis, K.E. Atkinson, 3 rd Edn. , 2007, Wiley India

Semester – V

Course Name: Quantum Mechanics

Course Code:BSCHPHSC501

<table>
<tr><td>Course Type:
Core (Theory & Practical)</td><td colspan="2">Course Details: CC-11</td><td colspan="2">L-T-P: 4-0-4</td></tr>
<tr><td rowspan="3">Credit: 6</td><td rowspan="3">Full Marks: 100</td><td colspan="2">CA Marks</td><td colspan="2">ESE Marks</td></tr>
<tr><td>Practical</td><td>Theoretical</td><td>Practical</td><td>Theoretical</td></tr>
<tr><td>30</td><td>10</td><td>20</td><td>40</td></tr>
</table>

Course Learning Outcomes:

After the completion of course, the students will have ability to:

1. Explain the failures of classical theory in explaining different experiments of early twentieth century are discussed.
2. Understand ideas of wave-particle duality, matter-wave.
3. Explain how the importance of Schrodinger equation (time-dependent and time-independent) to demonstrate solutions of some systems for different proto-type potentials (1d and 3d) .
4. Understand the concepts of quantum (hermitian) operators and basis vectors.

Course Content:

Theory

1. Old quantum theory

Planck's formula of black-body radiation, Photoelectric effect, Bohr atom and quantization of energy levels.

(5L)

2. Basic quantum mechanics

de Broglie hypothesis, Electron double-slit experiment, Compton effect, Davisson-Germer experiment, Heisenberg's uncertainty principle (statement) with illustrations. Concept of wave function as describing the dynamical state of a single particle. Group and phase velocities, classical velocity of a particle and the group velocity of the wave representing the particle. Principle of superposition. Schrodinger equation. Probabilistic interpretation; equation of continuity, probability current density. Boundary conditions on the wave function. **(10L)**

3. Basic postulates of quantum mechanics

Dynamical variables as linear hermitian operators and eigenvalue equations, Momentum, energy and angular momentum operators. Measurement of observables, expectation values. Commutation relations between operators. Compatible observables and simultaneous measurements, Ehrenfest theorem.

(10L)

4. Time dependent and time independent Schrodinger equation

Eigenstates, normalization and orthonormality. **(4L)**

5. Simple applications of Quantum Mechanics

One dimensional potential well and barrier, boundary conditions, bound and unbound states.
Reflection and transmission coefficients for a rectangular barrier in one dimension – explanation of alpha decay. Free particle in one dimensional box, box normalization, momentum eigenfunctions of a free particle. Linear harmonic oscillator, energy eigenvalues from Hermite differential equation, wave function for ground state, parity of wave function.

(11L)

6. Schrodinger equation in spherical polar coordinates

Angular momentum operators and their commutation relations; eigenvalues and eigenfunctions of L^2 and L_z; theorem of addition of angular momenta [statement with examples]. The hydrogen atom problem – stationary state wavefunctions as simultaneous eigenfunctions of H, L^2, and L_z; radial Schrodinger equation and energy eigenvalues [Laguerre polynomial solutions to be assumed]; degeneracy of the energy eigenvalues. **(10L)**

Practical

1. Measurement of Planck's constant using black body radiation and photo-detector.
2. Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light.
3. To determine work function of material of filament of directly heated vacuum diode.
4. To determine the Planck's constant using LEDs of at least 4 different colours.
5. To determine the ionization potential of mercury.
6. To determine the absorption lines in the rotational spectrum of Iodine vapour.
7. To determine the value of e/m by (a) Magnetic focusing or (b) Bar magnet.
8. Determination of separation of D_1 and D_2 lines of sodium by using plane transmission grating.

9. Draw the calibration curve between μ and λ using mercury discharge tube and find out the unknown wavelength of a particular light.
10. Frank-Hertz experiment.
11. Determination of grating element of a diffraction grating using a semiconductor laser.
12. Determination of wavelength of light using laser and single slit/wire.

References/ Suggested Readings:

1. Introduction to Quantum Mechanics (2nd Edition) by David J. Griffiths
2. Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles, 2ed by Robert Eisberg, Robert Resnick
3. A Textbook Of Quantum Mechanics 2/E by P M Mathews and K Venkatesan
4. Quantum Mechanics: Theory and Applications by Ajoy Ghatak and S. Lokanathan
5. Introductory Quantum Mechanics by S. N. Ghoshal
6. Modern Physics by A. Beiser

Course Name: Thermal Physics II

Course Code: BSCHPHSSC502

Course Type: **Core(Theory)**	Course Details:**CC-12**			L-T-P: **5-1-0**	
Credit: **6**	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		……	**10**	……	**40**

Course Learning Outcomes:

After the completion of course, the students will have ability to:

1. *Demonstrate a mastery of the core knowledge in the areas of Thermal Physics.*
2. *Explain the concept of thermodynamic as an emperical description for the thermal properties of a macroscopic system.*
3. *Understand the* applications *of thermodynamics and the theory of the phase-transitions are discussed.*

Course Content:

Theory

1. First Law of Thermodynamics: Basic concepts: microscopic and macroscopic points of view; thermodynamic variables of a system; exact and inexact differentials; thermal equilibrium and the zeroth law; concept of temperature: internal energy; external work; thermodynamic equilibrium; quasi –static processes; first law of thermodynamics and applications; magnetic systems; specific heats and their ratio; isothermal and adiabatic changes in perfect and real gases.

(6L)

2. Second Law of Thermodynamics : Reversible and irreversible processes :Carnot's cycle and Carnot's theorem – efficiency of heat engines; entropy; second law of thermodynamics –different formulations and their equivalence; Clausius theorem: entropy changes in simple processes : T -S diagrams for simple processes; isothermal and adiabatic elasticities; increase of entropy in natural processes; entropy and disorder; probabilistic interpretation of entropy. Kelvin's scale of temperature – relation to perfect gas scale. **(10L)**

3. Thermodynamic Functions: Enthalpy, Helmholtz and Gibbs Free energies: Legendre transformations; Maxwell's relations and simple deductions using these; thermodynamic equilibrium and free energies.

(5L)

4. Heat Engines : External Combustion engine – steam engine and the Rankinecycle; internal combustion engines – Otto and Diesel cycles.

5. Refrigerators : Compression and absorption types of machines. **(5L)**

6. Thermodynamics of Reversible cells – Gibbs Helmholtz equation **(2L)**

7. Change of State : Equilibrium between phases and triple point : Gibbs phase rule and simple applications; first and higher order phase transitions – Ehrenfest's classification; Clausius Clapeyron's equation; Joule Thomson effect; inversion temperature, regenerative cooling, liquefaction of air, hydrogen and helium; cooling by adiabatic expansion and adiabatic demagnetization.

(6L)

8. Multicomponent Systems : Thermodynamic functions for a mixture of gases; change of entropy in diffusion; law of mass action; heat of reaction; effect of temperature and pressure on reaction constant; chemical potential; conditions of chemical equilibrium; principle of Le -Chatelier. Nernst heat theorem; third law of thermodynamics. **(5L)**

References/ Suggested Readings:

1. Saha and Srivastava : A Treatise on Heat – Indian Press, Allahabad.

2. Zemansky and Ditman; Heat and Thermodynamics – McGraw Hill Kogakusha.

3. Sears and Salinger : Thermodynamics, Statistical Mechanics and Kinetic Theory – Narosa.

4. Kittel and Kroemer : Thermal Physics – Freeman.

5. Loeb : Kinetic Theory - Radha

6. Jeans : Dynamical theory of Gases - Cambridge

7. Fermi : Thermodynamics – Chicago University Press

8. Callen : Thermodynamics – Wiley International

9. Pratip Chaudhuri :Gaser Anabiktatwa (in Bengali) = W.B. state Book Board.

10. Ashoke Ghosh :Tapgatitatwa (in Bengali) – W.B. state Book Board.

11. Thermal Physics by Roy & Gupta

Discipline Specific Elective (DSE I & II)

Course Name: Nuclear and Particle Physics

Course Code: BSCHPHSDSE501

Course Type: **DSEC(Theory)**	Course Details: **DSEC1&2**			L-T-P: **5-1-0**	
Credit: **6**	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		……	**10**	……	**40**

Course Learning Outcomes:

After the completion of course, the students will have ability to:

1. *Explain structure and properties of nuclei, the mechanism of different radioactive decays and their applications in peaceful use of nuclear energy.*
2. *Understand what are the elementary particles that constitute this known universe.*
3. *Gather capability of elementary problem solving in nuclear and particle physics.*

Course Content:

Theory

1. General Properties of Nuclei : Constituents of nucleus and their Intrinsic properties, quantitative facts about mass, radii, charge density (matter density), binding energy, average binding energy and its variation with mass number, main features of binding energy versus mass number curve, N/A plot, angular momentum, parity, magnetic moment, electric moments, nuclear excites states.

(10L)

2. Nuclear Models : Liquid drop model approach, semi empirical mass formula and significance of its various terms, condition of nuclear stability, two nucleon separation energies, Fermi gas model (degenerate fermion gas, nuclear symmetry potential in Fermi gas), evidence for nuclear shell structure, nuclear magic numbers, basic assumption of shell model, concept of mean field, residual interaction, concept of nuclear force. **(12L)**

3. Radioactivity decay (a) Alpha decay: basics of α-decay processes, theory of α- emission, Gamow factor, Geiger Nuttall law, α-decay spectroscopy. (b) β-decay: energy kinematics for β-decay, positron emission, electron capture, neutrino hypothesis, Reines and Cowan experiment. (c) Gamma decay: Gamma rays emission & kinematics, internal conversion, Gamma ray interaction through matter, photoelectric effect, Compton scattering, pair production, neutron interaction with matter.

(12L)

4. Nuclear Reactions Types of Reactions, Conservation Laws, kinematics of reactions, Q-value, reaction rate, reaction cross section, Concept of compound and direct Reaction, resonance reaction, Coulomb scattering (Rutherford scattering). **(8L)**

5. Particle Accelerators Accelerator facility available in India: Van-de Graaff generator (Tandem accelerator), Linear accelerator, Cyclotron, Betatron, Synchrotrons. **(5L)**

6. Particle physics Discovery of elementary particles, Particle interactions; basic features, types of particles and its families. Symmetries and Conservation Laws: energy and momentum, angular momentum, parity, baryon number, Lepton number, Isospin, Strangeness and charm, concept of quark.

(13L)

References/ Suggested Readings:

1. Introductory nuclear Physics by Kenneth S. Krane (Wiley India Pvt. Ltd., 2008).
2. Concepts of nuclear physics by Bernard L. Cohen. (Tata Mcgraw Hill, 1998).
3. Introduction to the physics of nuclei & particles, R.A. Dunlap. (Thomson Asia, 2004).
4. Introduction to High Energy Physics, D.H. Perkins, Cambridge Univ. Press.
5. Introduction to Elementary Particles, D. Griffith, John Wiley & Sons.
6. Quarks and Leptons, F. Halzen and A.D. Martin, Wiley India, New Delhi.
7. Basic ideas and concepts in Nuclear Physics - An Introductory Approach by K. Heyde (IOP-Institute of Physics Publishing, 2004).
8. Radiation detection and measurement, G.F. Knoll (John Wiley & Sons, 2000).
9. Physics and Engineering of Radiation Detection, Syed Naeem Ahmed (Academic Press, Elsevier, 2007).
10. Theoretical Nuclear Physics, J.M. Blatt & V. F. Weisskopf (Dover Pub.Inc., 1991).
11. Nuclear Physics by D C Tayal
12. Nuclear Physics by S B Pattel

Course Name: Communication Electronics

Course Code: BSCHPHSDSE502

Course Type: **DSEC (Theory)**	Course Details: **DSEC1&2**		L-T-P: **5-1-0**	
Credit: **6**	Full Marks: **50**	CA Marks		ESE Marks
		Practical	Theoretical	Practical	Theoretical
		……	**10**	……	**40**

Course Learning Outcomes:

After the completion of course, the students will have ability to:

1. *Get familiar with different types of communication systems used in electronics.*
2. *Understand information theory and coding techniques. They will get knowledge about principle of Radar, satellite and mobile communication system.*

Course Content:

Theory

1. Electronic communication

Introduction to communication – means and modes. Need for modulation. Block diagram of an electronic communication system. Brief idea of frequency allocation for radio communication system in India (TRAI). Electromagnetic communication spectrum, band designations and usage. Channels and base-band signals. Concept of Noise, signal-to-noise (S/N) ratio. **(15L)**

2. Analog Modulation: Amplitude Modulation, modulation index and frequency spectrum. Generation of AM (Emitter Modulation), Amplitude Demodulation (diode detector), Concept of Single side band generation and detection. Frequency Modulation (FM) and Phase Modulation (PM), modulation index and frequency spectrum, equivalence between FM and PM, Generation of FM using VCO, FM detector (slope detector), Qualitative idea of Super heterodyne receiver. **(30 L)**

3.Analog Pulse Modulation: Channel capacity, Sampling theorem, Basic Principles- PAM, PWM, PPM, modulation and detection technique for PAM only, Multiplexing (CDMA, TDMA, FDMA).

(15L)

References/ Suggested Readings:

1. Electronic Communications, D. Roddy and J. Coolen, Pearson Education India.

2. Advanced Electronics Communication Systems- Tomasi, 6th edition, Prentice Hall.
3. Electronic Communication systems, G. Kennedy, 3rd Edn, 1999, Tata McGraw Hill.
4. Principles of Electronic communication systems – Frenzel, 3rd edition, McGraw Hill
5. Communication Systems, S. Haykin, 2006, Wiley India.
6. Electronic Communication system, Blake, Cengage, 5th edition.
7. Wireless communications, Andrea Goldsmith, 2015, Cambridge University Press.
8. Electronics by Rakshit and Chatterjee
9. Electronics Fundamentals by Ryder

Course Name: Atomic Physics & Spectroscopy

Course Code: BSCHPHSDSE503

Course Type: **DSEC(Theory)**	Course Details: **DSEC1&2**			L-T-P: **5-1-0**	
Credit: **6**	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		……	**10**	……	**40**

Course Learning Outcomes:

After the completion of course, the students will have ability to:

1. *Understand the concepts of atomic spectra and its origin using the old quantum theory whose consistency can be later verified by the direct application of the quantum mechanics.*
2. *Account for theoretical models, terminology & working methods used in atomic and molecular physics*.
3. *Carry out experimental and theoretical studies on atomic and molecular physics with focus on structure and dynamics of atoms and molecules.*

Course Content:

Theory

1. Atomic Spectrum

Good quantum numbers, and selection rules. Stern-Gerlach experiment and spin as an intrinsic quantum number. Incompatibility of spin with classical ideas. Bohr-Sommerfeld model. Fine structure. Study of fine structure by Michelson interferometer. **(14L)**

2. Vector atom model

Magnetic moment of the electron, Lande g factor. Vector model – space quantization. Zeeman effect. Explanation from vector atom model. **(14L)**

3. Many electron model

Pauli exclusion principle, shell structure. Hund's rule, spectroscopic terms of many electron atoms in the ground state. **(10L)**

4. Molecular spectroscopy

Diatomic molecules – rotational and vibrational energy levels. Basic ideas about molecular spectra. Raman effect and its application to molecular spectroscopy (qualitative discussion only). **(12L)**

5. Laser Spectroscopy

Population inversion, Einstein's A and B coefficients; feedback of energy on a resonator; 3-level and 4-level systems, Ruby Laser and He-Ne Laser. **(10L)**

References/ Suggested Readings:

1. Atomic Physics (Modern Physics) by Ghoshal S. N.
2. Concepts of Modern Physics by Arthur Beiser and Shobhit Mahajan.
3. Introduction to Atomic Spectra by Harvey Elliott White
4. Atomic & Molecular Spectra: Laser" by Raj Kumar
5. Elements of Spectroscopy Atomic, Molecular and Laser Physics" by Gupta
6. Modern Atomic Physics by Vasant Natarajan
7. Quantum Mechanics by S N Ghosal
8. Modern Physics by Mani & Mehta

Course Name: Astronomy & Astrophysics

Course Code: BSCHPHSDSE504

<table>
<tr><td>Course Type: DSEC(Theory)</td><td colspan="3">Course Details: DSEC1&2</td><td colspan="2">L-T-P: 5-1-0</td></tr>
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<tr><td>Practical</td><td>Theoretical</td><td>Practical</td><td>Theoretical</td></tr>
<tr><td>……</td><td>10</td><td>……</td><td>40</td></tr>
</table>

Course Learning Outcomes:

After the completion of course, the students will have ability to:

1. *Learn how to unravel the secrets of the Universe applying basic physical principles from a broad range of topics in physics to astronomical circumstances.*
2. *Understand the astrophysical processes and systems, ranging from our own sun to stars, galaxies and the whole universe.*
3. *Use proficiency in physics, mathematics, computer science, and statistics to get a broader understanding of the universe*

Course Content:

Theory

1. **Astronomical Scales:** Astronomical Distance, Mass and Time, Scales, Brightness, Radiant Flux and Luminosity, Measurement of Astronomical Quantities Astronomical Distances, Stellar Radii, Masses of Stars, Stellar Temperature. Basic concepts of positional astronomy: Celestial Sphere, Geometry of a Sphere, Spherical Triangle, Astronomical Coordinate Systems, Geographical Coordinate Systems, Horizon System, Equatorial System, Diurnal Motion of the Stars, Conversion of Coordinates. Measurement of Time, Sidereal Time, Apparent Solar Time, Mean Solar Time, Equation of Time, Calendar. Basic Parameters of Stars: Determination of Distance by Parallax Method; Brightness, Radiant Flux and Luminosity, Apparent and Absolute magnitude scale, Distance Modulus; Determination of Temperature and Radius of a star; Determination of Masses from Binary orbits; Stellar Spectral Classification, Hertzsprung-Russell Diagram.

(24 L)

2. **Astronomical techniques:** Basic Optical Definitions for Astronomy (Magnification Light Gathering Power, Resolving Power and Diffraction Limit, Atmospheric Windows), Optical Telescopes (Types of Reflecting Telescopes, Telescope Mountings, Space Telescopes), Detectors and Their Use with Telescopes

(Types of Detectors, detection Limits with Telescopes). Physical principles: Gravitation in Astrophysics (Virial Theorem, Newton versus Einstein), Systems in Thermodynamic Equilibrium.

(9 L)

3. **The sun** (Solar Parameters, Solar Photosphere, Solar Atmosphere, Chromosphere. Corona, Solar Activity, Basics of Solar Magneto-hydrodynamics. Helioseismology). The solar family (Solar System: Facts and Figures, Origin of the Solar System: The Nebular Model, Tidal Forces and Planetary Rings, Extra-Solar Planets. Stellar spectra and classification Structure (Atomic Spectra Revisited, Stellar Spectra, Spectral Types and Their Temperature Dependence, Black Body Approximation, H R Diagram, Luminosity Classification) **(11 L)**

4. **The milky way:** Basic Structure and Properties of the Milky Way, Nature of Rotation of the Milky Way (Differential Rotation of the Galaxy and Oort Constant, Rotation Curve of the Galaxy and the Dark Matter, Nature of the Spiral Arms), Stars and Star Clusters of the Milky Way, Properties of and around the Galactic Nucleus. **(14 L)**

5. **Galaxies:** Galaxy Morphology, Hubble's Classification of Galaxies, Elliptical Galaxies (The Intrinsic Shapes of Elliptical, de Vaucouleurs Law, Stars and Gas). Spiral and Lenticular Galaxies (Bulges, Disks, Galactic Halo) The Milky Way Galaxy, Gas and Dust in the Galaxy, Spiral Arms.

(7 L)

6. **Large scale structure & expanding universe:** Cosmic Distance Ladder (An Example from Terrestrial Physics, Distance Measurement using Cepheid Variables), Hubble's Law (Distance- Velocity Relation), Clusters of Galaxies (Virial theorem and Dark Matter). **(10L)**

References/ Suggested Readings:

1. Modern Astrophysics, B.W. Carroll & D.A. Ostlie, Addison-Wesley Publishing Co.
2. Introductory Astronomy and Astrophysics, M. Zeilik and S.A. Gregory, 4th Edition, Saunders College Publishing.
3. The physical universe: An introduction to astronomy, F. Shu, Mill Valley: University Science Books.
4. Fundamental of Astronomy (Fourth Edition), H. Karttunen et al. Springer.
5. K.S. Krishnasamy, 'Astrophysics: A modern perspective' Reprint, New Age International (p) Ltd, New Delhi,2002.
6. Baidyanath Basu, 'An introduction to Astrophysics', Second printing, Prentice - 58 Hall of India Private limited, New Delhi, 2001.
7. Textbook of Astronomy and Astrophysics with elements of cosmology, V.B. Bhatia, Narosa Publication.

Semester -VI

Course Name: Statistical Mechanics

Course Code: BSCHPHSC601

<table>
<tr><td>Course Type: Core(Theory)</td><td colspan="3">Course Details:CC-13</td><td colspan="2">L-T-P: 5-1-0</td></tr>
<tr><td rowspan="3">Credit: 6</td><td rowspan="3">Full Marks: 50</td><td colspan="2">CA Marks</td><td colspan="2">ESE Marks</td></tr>
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<tr><td>……</td><td>10</td><td>……</td><td>40</td></tr>
</table>

Course Learning Outcomes:

After the completion of course, the students will have ability to:

1. *Understand how probability theory can be used to derive relations between the microscopic and macroscopic properties of matter.*
2. *Understand classical and quantum statistics and their application in different systems enable students to develop knowledge about how Bosonic and Fermionic systems behave.*
3. *Realize how electrons behave in metals and semiconductors, and photons in blackbody radiations or phonons in solids.*

Course Content:

Theory

1. Microstates and macro states

Classical description in terms of phase space and quantum description in terms of wave functions. Hypothesis of equal *a priori* probability for microstates of an isolated system in equilibrium. Concept of ensemble, Interactions between two systems – thermal, mechanical and diffusive. Statistical definition of temperature, pressure, entropy and chemical potential. Partition function of a system in thermal equilibrium with a heat bath (canonical ensemble).

(15L)

2. Classical statistical mechanics

Maxwell-Boltzmann distribution law. Calculation of thermodynamic quantities for ideal monatomic gases.

(5 L)

3. Motivations for quantum statistics

Gibbs' paradox. Identical particle and symmetry requirement. Derivation of MB, FD and BE statistics as the most probable distributions (micro-canonical ensemble). Classical limit of quantum statistics. **(10L)**

4. Quantum statistical mechanics

Bose-Einstein statistics: B-E Condensation, Phonon Specific Heat, Specific Heat, Comparison with Einstein modification with Debye's theory, properties of liquid He (qualitative description). (**15L**)

Fermi-Dirac statistics: Fermi distribution at zero and non-zero temperatures. Fermi energy and its expression in terms of particle density. Degenerate and non-degenerate Fermi gas. Electron specific heat of metals at low temperature. Saha's equation for thermal ionization.

(15L)

References/ Suggested Readings:

1. R. K. Pathria, Statistical Mechanics
2. K. Huang, Statistical Mechanics, John Wiley.
3. L. D. Landau, and E. M. Lifshitz, Statistical Physics (Pt.-I)
4. R. P. Feynaman, Statistical Mechanics, A set of lectures
5. S. K. Ma, Statistical Physics
6. A. Ishihara, Statistical Physics
7. F. Reif – Fundamentals of Statistical and Thermal Physics : McGraw Hill
8. Stephen J. Blundell and Katherine M. Blundell - Concepts in Thermal Physics
9. Statistical Mechanics by Agarwal &Eisner
10. Statistical Mechanics by D. Bhattacharya
11. Thermal Physics by Roy & Gupta

Course Name: Condensed Matter Physics

Course Code: BSCHPHSC602

<table>
<tr><td>Course Type: Core(Theory)</td><td colspan="3">Course Details:CC-14</td><td colspan="2">L-T-P: 5-1-0</td></tr>
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<tr><td>Practical</td><td>Theoretical</td><td>Practical</td><td>Theoretical</td></tr>
<tr><td>……</td><td>10</td><td>……</td><td>40</td></tr>
</table>

Course Learning Outcomes:

After the completion of course, the students will have ability to:

1. *Understand the lattice structure in crystalline solids and their different properties (viz., dielectric, magnetic, electrical transport).*
2. *Explain elementary idea on superconductivity.*

Course Content:

Theory

1.Crystal Structure Solids: Amorphous and Crystalline Materials. Lattice Translation Vectors. Lattice with a Basis – Central and Non-Central Elements. Unit Cell. Miller Indices. Reciprocal Lattice. Types of Lattices. Brillouin Zones. Diffraction of X-rays by Crystals. Bragg's Law. Atomic and Geometrical Factor. **(12L)**

2. Elementary Lattice Dynamics: Lattice Vibrations and Phonons: Linear Monoatomic and Diatomic Chains. Acoustical and Optical Phonons. Qualitative Description of the Phonon Spectrum in Solids. Dulong and Petit's Law, Einstein and Debye theories of specific heat of solids. T^3 law **(10L)**

3. Magnetic Properties of Matter: Dia-, Para-, Ferri- and Ferromagnetic Materials. Classical Langevin Theory of dia– and Paramagnetic Domains. Quantum Mechanical Treatment of Paramagnetism. Curie's law, Weiss's Theory of Ferromagnetism and Ferromagnetic Domains. Discussion of B-H Curve. Hysteresis and Energy Loss. **(12L)**

4. Dielectric Properties of Materials: Polarization. Local Electric Field at an Atom. Depolarization Field. Electric Susceptibility. Polarizability. Clausius Mosotti Equation. Classical Theory of Electric Polarizability. Normal and Anomalous Dispersion. Cauchy and Sellmeir relations. Langevin-Debye

equation. Complex Dielectric Constant. Optical Phenomena. Application: Plasma Oscillations, Plasma

Frequency, Plasmons, TO modes. **(10L)**

5. Elementary band theory: Kronig Penny model. Band Gap. Conductor, Semiconductor (P and N type) and insulator. Conductivity of Semiconductor, mobility, Hall Effect. Measurement of conductivity (four probe method) & Hall coefficient. **(10L)**

6. Superconductivity: Meissner effect, critical temperature and critical field, Type-I and Type-II superconductor, London equation and penetration depth. (6L)

References/ Suggested Readings:

1. Introduction to Solid State Physics, Charles Kittel, 8th Edition, 2004, Wiley India Pvt. Ltd.
2. Elements of Solid State Physics, J. P. Srivastava, 4th Edition, 2015, Prentice-Hall of India.
3. Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw Hill.
4. Solid State Physics, N.W. Ashcroft and N.D. Mermin, 1976, Cengage Learning.
5. Solid-state Physics, H. Ibach and H. Luth, 2009, Springer.
6. Solid State Physics, Rita John, 2014, McGraw Hill.
7. Elementary Solid State Physics, 1/e M. Ali Omar, 1999, Pearson India.
8. Solid State Physics, M.A. Wahab, 2011, Narosa Publications.
9. Solid state Physics by Puri & Babbar
10. Modern Physics by A. Beiser

Discipline Specific Elective (DSE III & IV)

Course Name: Applied Optics
Course Code: BSCHPHSDSE601

Course Type: DSEC	Course Details: DSEC3&4		L-T-P: **5-1-0**	
Credit: **6**	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		……	**10**	……	**40**

Course Learning Outcomes:

After the completion of course, the students will have ability to:

1. *Understand the geometrical / ray optics through transfer matrix-formalism*
2. *Acquire basic knowledge on different types of optical phenomena*
3. *Realize the technological applications of optical phenomena as a background of the fiber optics, holography, LASER and photo-detectors.*
4. *Analyze different laser systems and its applications in various fields.*
5. *Conceptualize optical fiber, its construction and importance in communication physics.*

Course Content:

Theory

1. **Fermat's Principle:** Principle of least path and extremum paths-example of extremum path. Aplanatic surface, Application to laws of reflection and refraction for a) plane surface and b) spherical surface. Application to determine lens formula. **(6L)**
2. **Matrix Method:** Introduction. Translation, refraction and reflection matrix. System matrix for thick and thin lenses. Cardinal points of optical system. Application to image formation by combination two lenses. Vergence – entrance and exit. Vergence matrix. **(12L)**
3. **Aberration:** Seidal aberration and its different types. Its removal-Abbes Sine condition. Aplanatism and Aplanatic Surface. Its application to high power microscope objective. Chromatic aberration – longitudinal and transverse. Achromatism- achromatic doublet and separated doublet. **(10L)**

4. **Eye piece:** Vignitting. Construction of eyepiece. Positive and negative eye piece. Huygens eye piece and Ramsden eye piece-construction working and application. **(6L)**
5. **Sources and Detectors**. Basic principle of LED, Characteristics and application of various kinds of LED. Laser, spontaneous and stimulated emissions, theory of laser action, Einstein coefficient. Characterization of of laser beam. He-Ne Laser, semiconductor laser. Characteristics of various kinds of photo detectors. (10L)
6. **Holography:** Basic principle and theory. Coherence, resolution types of hologram, white light reflection hologram. Application of holography in microscopy and interferometry. (8L)
7. **Fibre optics:** Optical fibre and their properties. Principle of light propagation through optical fibre. Numerical aperture. Attenuation in fibre and its limit. Power loss. Application, fiberscope – communication system. (8L)

References/ Suggested Readings:

1. Fundamental of optics, F. A. Jenkins & H. E. White, 1981, Tata McGraw hill. 78
2. LASERS: Fundamentals & applications, K.Thyagrajan & A.K.Ghatak, 2010, Tata McGraw Hill
3. Fibre optics through experiments, M.R.Shenoy, S.K.Khijwania, et.al. 2009, Viva Books
4. Nonlinear Optics, Robert W. Boyd, (Chapter-I), 2008, Elsevier.
5. Optics, Karl Dieter Moller, Learning by computing with model examples, 2007, Springer.
6. Optical Systems and Processes, Joseph Shamir, 2009, PHI Learning Pvt. Ltd.
7. Optoelectronic Devices and Systems, S.C. Gupta, 2005, PHI Learning Pvt. Ltd.
8. Optical Physics, A.Lipson, S.G.Lipson, H.Lipson, 4th Edn., 1996, Cambridge Univ. Press
9. Modern Optics- Meyer And Arrend
10. Introduction To Optics- A.K. Ghatak
11. Optics- Hetch And Zajack
12. A Textbook On Optics- B. Ghosh And K.G. Mazumdar

Course Name: Physics of Devices and Instruments

Course Code: BSCHPHSDSE602

<table>
<tr><td>Course Type: DSEC(Theory)</td><td colspan="3">Course Details: DSEC3&4</td><td colspan="2">L-T-P: 5-1-0</td></tr>
<tr><td rowspan="3">Credit: 6</td><td rowspan="3">Full Marks: 50</td><td colspan="2">CA Marks</td><td colspan="2">ESE Marks</td></tr>
<tr><td>Practical</td><td>Theoretical</td><td>Practical</td><td>Theoretical</td></tr>
<tr><td>……</td><td>10</td><td>……</td><td>40</td></tr>
</table>

Course Learning Outcomes:

After the completion of course, the students will have ability to:

1. *Get exposure with various aspects of instruments and their usage through hands-on mode.*
2. *Analyze the performance characteristics of different electronic devices.*
3. *Understand the concepts of Communication Systems effectively.*

Course Content:

Theory

1. Devices: Characteristic and small signal equivalent circuits of UJT and JFET. Metal-semiconductor Junction. Metal oxide semiconductor (MOS) device. Ideal MOS and Flat Band voltage. SiO2-Si based MOS. MOSFET– their frequency limits. Enhancement and Depletion Mode MOSFETS, CMOS. Charge coupled devices. Tunnel diode. **(13 L)**

2. Power supply and Filters: Block Diagram of a Power Supply, Qualitative idea of C and L Filters. IC Regulators, Line and load regulation, Short circuit protection.
Active and Passive Filters, Low Pass, High Pass, Band Pass and band Reject Filters. **(10 L)**

3. Multivibrators: Astable and Monostable Multivibrators using transistors. **(5 L)**

4. Phase Locked Loop (PLL): Basic Principles, Phase detector (XOR & edge triggered), Voltage Controlled Oscillator (Basics, varactor). Loop Filter– Function, Loop Filter Circuits, transient response, lock and capture. Basic idea of PLL IC (565 or 4046). **(5 L)**

5. Processing of Devices: Basic process flow for IC fabrication, Electronic grade silicon. Crystal plane and orientation. Defects in the lattice. Oxide layer. Oxidation Technique for Si. Metallization technique. Positive and Negative Masks. Optical lithography. Electron lithography. Feature size control and wet anisotropic etching. Lift off Technique. Diffusion and implantation. **(12 L)**

6. Introduction to communication systems: Block diagram of electronic communication system, Need for modulation. Amplitude modulation. Modulation Index. Analysis of Amplitude Modulated wave. Sideband frequencies in AM wave. CE Amplitude Modulator. Demodulation of AM wave using Diode Detector. basic idea of Frequency, Phase, Pulse and Digital Modulation including ASK, PSK, FSK.

(15 L)

References/ Suggested Readings:

1. Physics of Semiconductor Devices, S.M. Sze & K.K. Ng, 3rd Ed.2008, John Wiley & Sons
2. Electronic devices and integrated circuits, A.K. Singh, 2011, PHI Learning Pvt. Ltd.
3. Op-Amps & Linear Integrated Circuits, R.A.Gayakwad,4 Ed. 2000,PHI Learning Pvt. Ltd
4. Electronic Devices and Circuits, A. Mottershead, 1998, PHI Learning Pvt. Ltd.
5. Electronic Communication systems, G. Kennedy, 1999, Tata McGraw Hill.
6. Introduction to Measurements & Instrumentation, A.K. Ghosh, 3rd Ed., 2009, PHI Learning Pvt. Ltd
7. Semiconductor Physics and Devices, D.A. Neamen, 2011, 4th Edition, McGraw Hill
8. PC based instrumentation; Concepts & Practice, N. Mathivanan, 2007, Prentice-Hall of India

Course Name: Classical Dynamics

Course Code: BSCHPHSDSE603

Course Type: **DSEC(Theory)**	Course Details: **DSEC3&4**		L-T-P: **5-1-0**	
Credit: **6**	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		……	**10**	……	**40**

Course Learning Outcomes:

After the completion of course, the students will have ability to:

1. *Understand how the formulation of the Lagrangian and Hamiltonian mechanics comes through the calculus of variation.*
2. *Get idea how small oscillations of isolated and coupled systems are studied through normal modes.*
3. *Understand how the formulation of (special) relativistic mechanics comes through four-vectors and Minkowski cone.*

Course Content:

Theory

1. Calculus of variation : Variational principle; Euler-Lagrange equations and Hamilton's principle from variational principle, Brachistrochrone problem, minimum surface of revolution, motion under gravity, Solution of Hamilton's equation for a particle in a central force field; homogeneity of time and conservation of energy; isotropy of space and conservation of angular momentum (24L)

2. Small Amplitude Oscillations: Minima of potential energy and points of stable equilibrium, expansion of the potential energy around a minimum, small amplitude oscillations about the minimum, normal modes of oscillations example of N identical masses connected in a linear fashion to (N -1) - identical springs. (16L)

3. Special Theory of Relativity: Postulates of Special Theory of Relativity. Lorentz Transformations. Minkowski space. The invariant interval, light cone and world lines. Space-time diagrams. Time-dilation, length contraction and twin paradox. Four-vectors: space-like, time-like and light-like. Four-velocity and acceleration. Four-momentum and energy-momentum relation. Concept of four-force. (20L)

References/ Suggested Readings:

13. Classical Mechanics, H. Goldstein, C.P. Poole, J.L. Safko, 3rd Edn. 2002, Pearson Education.
14. Mechanics, L. D. Landau and E. M. Lifshitz, 1976, Pergamon.
15. Classical Electrodynamics, J.D. Jackson, 3rd Edn., 1998, Wiley.
16. The Classical Theory of Fields, L.D Landau, E.M Lifshitz, 4th Edn., 2003, Elsevier.
17. Introduction to Electrodynamics, D.J. Griffiths, 2012, Pearson Education.
18. Classical Mechanics, P.S. Joag, N.C. Rana, 1st Edn., McGraw Hall.
19. Classical Mechanics, R. Douglas Gregory, 2015, Cambridge University Press.
20. Classical Mechanics: An introduction, Dieter Strauch, 2009, Springer.

21. Solved Problems in classical Mechanics, O.L. Delange and J. Pierrus, 2010, Oxford Press
22. Special Theory of Relativity, Banerjee and Banerjee
23. Relativity, J. V. Narlikar, Cambridge University press.

Course Name: Nanomaterials and Applications

Course Code: BSCHPHSDSE604

Course Type: **DSEC (Theory)**	Course Details: **DSEC3&4**			L-T-P: **5-1-0**	
Credit: **6**	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		……	**10**	……	**40**

Course Learning Outcomes:

After the completion of course, the students will have ability to:

1. *Gain experience in applying unique properties of nanomaterials to solve problems and challenges in our life.*
2. *Demonstrate the ability to develop case studies of nanomaterials with a focus on fundamentals, fabrication, characterization, and applications.*
3. *Gather knowledge about synthesis, characterization and applications of nanomaterials.*
4. *Collect information about optical, electrical and mechanical properties of the nanomaterials.*

Course Content:

Theory

1. Nanoscale Systems: Length scales in physics, Nanostructures: 1D, 2D and 3D nanostructures (nanodots, thin films, nanowires, nanorods), Band structure and density of states of materials at nanoscale, Size Effects in nano systems, Quantum confinement: Applications of Schrodinger equation- Infinite potential well, potential step, potential box, quantum confinement of carriers in 3D, 2D, 1D nanostructures and its consequences. **(10 L)**

2. 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. MBE growth of quantum dots. **(8 L)**

3. Characterization: X-Ray Diffraction. Optical Microscopy. Scanning Electron Microscopy. Transmission Electron Microscopy. Atomic Force Microscopy. Scanning Tunneling Microscopy. **(8 L)**

4. Optical Properties: Coulomb interaction in nanostructures. Concept of dielectric constant for nanostructures and charging of nanostructure. Quasi-particles and excitons. Excitons in direct and indirect band gap semiconductor nanocrystals. Quantitative treatment of quasi-particles and excitons, charging effects. Radiative processes: General formalization-absorption, emission and luminescence. Optical properties of heterostrctures and nanostructures. **(14 L)**

5. Electron transport: Carrier transport in nanostrcutures. Coulomb blockade effect, thermionic emission, tunneling and hoping conductivity. Defects and impurities: Deep level and surface defects.

(6 L)

6. Applications: Applications of nanoparticles, quantum dots, nanowires and thin films for photonic devices (LED, solar cells). Single electron transfer devices (no derivation). CNT based transistors. Nanomaterial 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). **(14 L)**

References/ Suggested Readings:

1. C.P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology (Wiley India Pvt. Ltd.).
2. S.K. Kulkarni, Nanotechnology: Principles & Practices (Capital Publishing Company)
3. K.K. Chattopadhyay and A. N. Banerjee, Introduction to Nanoscience and Technology (PHI Learning Private Limited).
4. Richard Booker, Earl Boysen, Nanotechnology (John Wiley and Sons).
5. M. Hosokawa, K. Nogi, M. Naita, T. Yokoyama, Nanoparticle Technology Handbook (Elsevier, 2007).

6. Introduction to Nanoelectronics, V.V. Mitin, V.A. Kochelap and M.A. Stroscio, 2011, Cambridge University Press.
7. Bharat Bhushan, Springer Handbook of Nanotechnology (Springer-Verlag, Berlin, 2004).
8. Physics of Semiconductor Devices by S.M. Sze, Kwok K. Ng, Wiley.