ASSAM UNIVERSITY, SILCHAR

SYLLABUS UNDER

CHOICE BASED CREDIT SYSTEM

PHYSICS

(HONOURS)

Course Structure
Details of courses for B.Sc. (Honours) Physics

Course	*Credits	
	Theory+ Practical	Theory+ Tutorial
I. Core Course		
Core Course Theory **(14 Papers)**	14X4= 56	14X5=70
Core Course Practical / Tutorial* **(14 Papers)**	14X2=28	14X1=14
II. Elective Course		
A.1. Discipline Specific Elective **(4 Papers)**	4X4=16	4X5=20
A.2. Discipline Specific Elective Practical/Tutorial* **(4 Papers)**	4 X 2=8	4X1=4
B.1. Generic Elective **(4 Papers)** to be chosen from other discipline	4X4=16	4X5=20
B.2. Generic Elective Practical/ Tutorial* **(4Papers)**	4 X 2=8	4X1=4
III. Ability Enhancement Courses		
A.1. Ability Enhancement Compulsory **(2 Papers)**		
Environmental Science	1 X 4=4	1 X 4=4
English/MIL Communication	1 X 4=4	1 X 4=4
A.2. Ability Enhancement Elective (Skill Based) **(2 Papers)**	2 X 4=8	2 X 4=8
Total credit	148	148

- Each credit is equivalent to 1 hour of activity per week

SCHEME FOR CHOICE BASED CREDIT SYSTEM IN

B. Sc. Honours (Physics)

	CORE COURSE (14)	Ability Enhancement Compulsory Course (AECC) (2)	Skill Enhancement Course (SEC) (2) (Skill Based)	Elective: Discipline Specific DSE (4)	Elective: Generic (GE) 4 To be taken from other discipline
I	PHYSICS-C-101	English/MIL Communication			GE-1
	PHYSICS-C-102				
II	PHYSICS-C-201	Environmental Science			GE-2
	PHYSICS-C-202				
III	PHYSCS-C-301		PHYSICS-SEC-301		GE-3
	PHYSICS-C-302				
	PHYSICS-C-303				
IV	PHYSICS-C-401		PHYSICS-SEC-401		GE-4
	PHYSICS-C-402				
	PHYSICS-C-403				
V	PHYSICS-C-501			PHYSICS-DSE-501	
	PHYSICS-C-502			PHYSICS-DSE -502	
VI	PHYSICS-C-601			PHYSICS-DSE -601	
	PHYSICS-C-602			PHYSICS-DSE -602	

Semester wise list of Physics papers to be studied by a Physics (Hons.) student

SEMESTER	COURSE OPTED	COURSE NAME	CREDITS
I	PHSHCC101T	Mathematical Physics-I	4
	PHSHCC101P	Mathematical Physics-I Lab	2
	PHSHCC102T	Mechanics	4
	PHSHCC102P	Mechanics Lab	2
II	PHSHCC201T	Electricity and Magnetism	4
	PHSHCC201P	Electricity and Magnetism Lab	2
	PHSHCC202T	Waves and Optics	4
	PHSHCC202P	Waves and Optics Lab	2
III	PHSHCC301T	Mathematical Physics-II	4
	PHSHCC301P	Mathematical Physics-II Lab	2
	PHSHCC302T	Thermal Physics	4
	PHSHCC302P	Thermal Physics Lab	2
	PHSHCC303T	Digital Systems and Applications	4
	PHSHCC303P	Digital Systems & Applications Lab	2
	PHSSEC301T	Workshop skill	4
IV	PHSHCC401T	Mathematical Physics III	4
	PHSHCC401P	Mathematical Physics-III Lab	2
	PHSHCC402T	Elements of Modern Physics	4
	PHSHCC402P	Elements of Modern Physics Lab	2
	PHSHCC403T	Analog Systems and Applications	4
	PHSHCC403P	Analog Systems & Applications Lab	2
	PHSSEC401T	Electrical Circuit and Network	4
V	PHSHCC501T	Quantum Mechanics & Applications	4
	PHSHCC501P	Quantum Mechanics Lab	2
	PHSHCC502T	Solid State Physics	4
	PHSHCC502P	Solid State Physics Lab	2
	PHSDSE501T	A. Classical Dynamics	6
		B. Biological Physics	
	PHSDSE502	A. Nuclear and Particle Physics	6
		B. Advanced Mathematical Physics	
VI	PHSHCC601T	Electro-magnetic Theory	4
	PHSHCC601P	Electro-magnetic Theory Lab	2
	PHSHCC602T	Statistical Mechanics	4
	PHSHCC602P	Statistical Mechanics Lab	2
	PHSDSE601T	A. Astronomy and Astrophysics	6
		B. Nano-materials and applications	
	PHSDSE602T	A. Dissertation	6
		B. Physics of Devices and Communication	

PHSHCC101T: MATHEMATICAL PHYSICS-I

Contact Hours: 60

Full Marks = 70 [ESE (50) CCA(20)]

Pass Marks = 28 [ESE (20) CCA (8)]

(Two questions of 10 marks will be set from each unit, one needs to be answered from each unit)

Unit 1: Matrices and Ordinary differential equations

Matrices: Addition law of matrices, matrix multiplication, properties of matrices, special square matrices, inverse of matrices, Elementary transformation of matrices – similarity, orthogonal and unitary transformation. Eigen value, Eigen vector. Solution of simultaneous linear equations. Diagonalisation of matrix. **(8 Lectures)**

First Order and Second Order Differential equations: First Order Differential Equations and Integrating Factor. Homogeneous Equations with constant coefficients. Wronskian and general solution. Statement of existence and Uniqueness Theorem for Initial Value Problems. Particular Integral. **(7 Lectures)**

Unit 2: Vector Calculus I

Recapitulation of vectors: Properties of vectors under rotations. Scalar product and its invariance under rotations. Vector product, Scalar triple product and their interpretation in terms of area and volume respectively, Vector triple product. Scalar and Vector fields. **(5 Lectures)**

Vector Differentiation: Directional derivatives and normal derivative. Gradient of a scalar field and its geometrical interpretation. Divergence and curl of a vector field. Del and Laplacian operators. Vector identities. **(7 Lectures)**

Unit 3: Vector Calculus II:

Vector Integration: Ordinary Integrals of Vectors. Multiple integrals, Jacobian. Notion of infinitesimal line, surface and volume elements. Line, surface and volume integrals of Vector fields. Flux of a vector field. Gauss' divergence theorem, Green's and Stokes Theorems and their applications (no rigorous proofs). **(14 Lectures)**

Unit 4: Orthogonal Curvilinear Coordinates and Introduction to Numerical Techniques:

Orthogonal Curvilinear Coordinates. Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems. **(8 Lectures)**

Solution of Algebraic and Transcendental equations by Bisection, Newton Raphson, Simpson Rule. Interpolation by Newton Gregory Forward and Backward difference formula. **(8 Lectures)**

Unit 5: Introduction to probability and Theory of errors

Independent random variables: Probability distribution functions; binomial, Gaussian, and Poisson, with examples. Mean and variance.

Dependent events: Conditional Probability. Bayes' Theorem and the idea of hypothesis testing.

Theory of errors: Systematic and Random Errors, Propagation of Errors, Normal Law of Errors, Standard and Probable Error, Least-squares fit. **(6 Lectures)**

Reference Books:

i. Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, F.E. Harris, 2013, 7th Edn., Elsevier.
ii. An introduction to ordinary differential equations, E.A. Coddington, 2009, PHI learning
iii. Differential Equations, George F. Simmons, 2007, McGraw Hill.
iv. Mathematical Tools for Physics, James Nearing, 2010, Dover Publications.
v. Mathematical methods for Scientists and Engineers, D.A. McQuarrie, 2003, Viva Book
vi. Advanced Engineering Mathematics, D.G. Zill and W.S. Wright, 5 Ed., 2012, Jones and Bartlett Learning
vii. Mathematical Physics, Goswami, 1st edition, Cengage Learning
viii. Engineering Mathematics, S.Pal and S.C. Bhunia, 2015, Oxford University Press
ix. Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India.
x. Essential Mathematical Methods, K.F.Riley & M.P.Hobson, 2011, Cambridge Univ. Press

PHSHCC101P

Contact Hours: 60

Full Marks = 30 Pass Mark = 12 ESE Time = 3 hours

Two experiments to be performed from two groups out of given five groups at the time of ESE.

Use C/C++/FORTRAN/ Scilab/ Python/Matlab/Mathematica/others to solve the following problems:

1. To Find i. Area of circle ii. Area of square iii. Volume of sphere.

2. To
   i. Find sum & average of a list of numbers.
   ii. Find largest of a given list of numbers and its location in the list.
   iii. Sort a list of numbers in ascending or descending order.
   iv. Find maximum, minimum and range of numbers.
   v. Find values of sine, cosine and exponential function using their series expansion up to definite number of terms.

3. To
   i. Generate a list of random integers.
   ii. Find value of pi by random numbers.
   iii. Find factorial of a number.
   iv. Generate Fibonacci series.

4. To solve algebraic equations:
   i. by Bisection method.
   ii. by Newton-Raphson method.
   iii. by Secant method.
   iv. To solve transcendental equations by suitable approximate numerical method.

5. To evaluate trigonometric functions i. $sin\ \theta$ ii. $cos\ \theta$ iii. $tan\ \theta$ using Newton Gregory Forward and Backward difference formula.

Reference Books:

i. Introduction to Numerical Analysis, S.S. Sastry, 5th Edn. , 2012, PHI Learning Pvt. Ltd.
ii. Schaum's Outline of Programming with C++. J. Hubbard, 2000, McGraw-Hill Pub.
iii. Computer Programming in FORTRAN 90 and 95, 19th Edn., 2019, PHI Learning Pvt. Ltd.
iv. Numerical Recipes in C: The Art of Scientific Computing, W.H. Pressetal, 3rd Edn. , 2007, Cambridge University Press.
v. A first course in Numerical Methods, U.M. Ascher & C. Greif, 2012, PHI Learning.
vi. Elementary Numerical Analysis, K.E. Atkinson, 3 r d E d n . , 2 0 0 7 , Wiley India Edition.
vii. Numerical Methods for Scientists & Engineers, R.W. Hamming, 1973, Courier Dover Pub.
viii. An Introduction to computational Physics, T.Pang, 2nd Edn. , 2006,Cambridge Univ. Press
ix. Computational Physics, Darren Walker, 1st Edn., 2015, Scientific International Pvt. Ltd.
x. Scientific Computing in Python, A K Gupta, 2018, TECHNO WORLD.
xi. A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3rd Edn., Cambridge University Press.
xii. Scilab (A free software to Matlab): H.Ramchandran, A.S.Nair. 2011 S.Chand & Company.
xiii. C Language and Numerical Methods C. Xavier (Publisher: New Age International Publishers, 1999).

PHSHCC102T: MECHANICS

Contact Hours: 60

Marks = 70 [ESE (50) CCA(20)]

Pass Marks = 28 [ESE (20) CCA (8)]

(Two questions of 10 marks will be set from each unit, one needs to be answered from each unit)

Unit 1: Fundamentals of Dynamics

Principle of conservation of momentum, Momentum of variable-mass system: motion of rocket. Motion of a projectile in Uniform gravitational field Dynamics of a system of particles. Centre of Mass. Impulse. **(6 Lectures)**

Work and Energy: Work and Kinetic Energy Theorem. Conservative and non-conservative forces. Potential Energy. Energy diagram. Stable and unstable equilibrium. Elastic potential energy. Force as gradient of potential energy. Work & Potential energy. Work done by non-conservative forces. Law of conservation of Energy. **(4 Lectures)**

Collisions: Elastic and inelastic collisions between particles. Centre of Mass and Laboratory frames. **(3 Lectures)**

Unit 2: Rotational Dynamics

Angular momentum of a particle and system of particles.

Torque. Principle of conservation of angular momentum. Rotation about a fixed axis. Moment of Inertia. Calculation of moment of inertia for rectangular, cylindrical and spherical bodies.

Elasticity: Relation between Elastic constants. Twisting torque on a Cylinder or Wire.

(16 Lectures)

Unit 3: Gravitation and Central Force Motion

Law of gravitation, Gravitational potential energy, Inertial and gravitational mass. Potential and field due to spherical shell and solid sphere. **(8 Lectures)**

Kepler's Laws. Satellite in circular orbit and applications. Geosynchronous orbits. Weightlessness. Basic idea of global positioning system (GPS). **(6 Lectures)**

Unit 4: 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. **(9 Lectures)**

Non-Inertial Systems: Non-inertial frames and fictitious forces. Uniformly rotating frame. Laws of Physics in rotating coordinate systems: Coriolis Theorem; Centrifugal force. Coriolis force and its applications. **(5 Lectures)**

Unit 5: Relativity

Reference frames, Inertial frames; Review of Newton's Laws of Motion. Galilean transformations; Galilean invariance; Michelson-Morley Experiment and its outcome. Postulates of Special Theory of Relativity. Lorentz Transformations. Simultaneity and order of events. Lorentz contraction. Time dilation and its experimental verification; Twin Paradox; Relativistic addition of velocities. Variation of mass with velocity. Massless Particles. Mass-energy Equivalence. **(15 Lectures)**

Reference Books:

i. An introduction to mechanics, D. Kleppner, R.J. Kolenkow, 1973, McGraw-Hill.
ii. Mechanics, Berkeley Physics, vol.1, C.Kittel, W.Knight, et.al. 2007, Tata McGraw-Hill.
iii. Physics, Resnick, Halliday and Walker 8/e. 2008, Wiley.
iv. Analytical Mechanics, G.R. Fowles and G.L. Cassiday. 2005, Cengage Learning.
v. Feynman Lectures, Vol. I, R.P.Feynman, R.B.Leighton, M.Sands, 2008, Pearson Education.
vi. Introduction to Special Relativity, R. Resnick, 2005, John Wiley and Sons.
vii. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
viii. A treatise on General Properties of matter, Chatterjee & Sengupta, New Central Book Agency.
ix. Classical Mechanics and properties of Matter, A. B. Gupta, Books and Allied publisher.

PHSHCC102P

Contact Hours: 60

Full Marks = 30 Pass Mark = 12 ESE Time = 3 hours

(One experiment to be performed at the time of ESE)

1. To measure the diameter of a thick wire using vernier caliper, screw gauge and travelling microscope and hence find its cross-section.
2. To determine the Moment of Inertia of unknown body by suitable method.
3. To determine Coefficient of Viscosity of water by suitable method.
4. To determine the Young's Modulus of a Wire by suitable method.
5. To determine the Modulus of Rigidity of a Wire by suitable method.
6. To determine the value of g using Bar Pendulum.
7. To determine the value of g using Kater's Pendulum.
8. To study the Motion of Spring and calculate (a) Spring constant, (b) **g**

Reference Books

i. Advanced Practical Physics for students, B. L. Flint and H.T. Worsnop, 1971, Asia Publishing House.

ii. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers

iii. A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Edn, 2011, Kitab Mahal

iv. Engineering Practical Physics, S.Panigrahi & B.Mallick,2015, Cengage Learning India Pvt. Ltd.

v. Practical Physics, G.L. Squires, 2015, 4th Edition, Cambridge University Press.

vi. Advanced Practical Physics Vol I – B. Ghosh (Shreedhar Publishers).

SEMESTER-II

PHSHCC201T: ELECTRICITY AND MAGNETISM

Contact Hours: 60

Full Marks = 70 [ESE (50) CCA(20)]

Pass Marks = 28 [ESE (20) CCA (8)]

(Two questions of 10 marks will be set from each unit, one needs to be answered from each unit)

Unit 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. The Uniqueness Theorem. Potential and Electric Field of a dipole. Force and Torque on a dipole. **(12 Lectures)**

Unit 2:

Electrostatic energy of system of charges. Electrostatic energy of a charged sphere. Surface charge and force on a conductor. Capacitance of a system of charged conductors. Parallel-plate capacitor. Capacitance of an isolated conductor. Method of Images and its application to: (1) Plane Infinite Sheet and (2) Sphere. **(10 Lectures)**

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. **(6 Lectures)**

Unit 3: 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. **(11 Lectures)**

Unit 4:

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. **(4 Lectures)**

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. **(6 Lectures)**

Unit 5:

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. **(4 Lectures)**

Network theorems: Ideal Constant-voltage and Constant-current Sources. Network Theorems: Thevenin theorem, Norton theorem, Maximum Power Transfer theorem. **(4 Lectures)**

Ballistic Galvanometer: Torque on a current Loop. Ballistic Galvanometer: Current and Charge Sensitivity. **(3 Lectures)**

Reference Books:

i. Electricity, Magnetism & Electromagnetic Theory, S. Mahajan and Choudhury, 2012, Tata McGraw.
ii. Electricity and Magnetism, Edward M. Purcell, 1986 McGraw-Hill Education.
iii. Introduction to Electrodynamics, D.J. Griffiths, 3rd Edn., 1998, Benjamin Cummings.
iv. Feynman Lectures Vol.2, R.P.Feynman, R.B.Leighton, M. Sands, 2008, Pearson Education.
v. Elements of Electromagnetics, M.N.O. Sadiku, 2010, Oxford University Press.
vi. Electricity and Magnetism, J.H.Fewkes & J.Yarwood. Vol. I, 1991, Oxford Univ. Press.

PHSHCC201P

Contact Hours: 60

Full Marks = 30 Pass Mark = 12 ESE Time = 3 hours

(One experiment to be performed at the time of ESE)

1. To study the characteristics of a series RC Circuit connected to an ac/dc source.
2. To determine an unknown Low Resistance using Potentiometer.
3. To determine an unknown Low Resistance using Carey Foster's Bridge.
4. To compare two capacitances using De'Sauty's bridge.
5. To determine the strength of the magnetic field produced at the centre of the tangent galvanometer coil due to a current flowing in it and hence to determine horizontal component of earth's magnetic field.
6. To verify the Thevenin's theorem.
7. To verify the Norton's theorem.
8. To verify the Maximum power transfer theorem.
9. To determine self-inductance of a coil by Anderson's bridge/Maxwell'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 determine the resistance of a given galvanometer by half deflection method.
12. To determine the mutual inductance between two coils by suitable method.

Reference Books

i. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
ii. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
iii. Engineering Practical Physics, S.Panigrahi and B.Mallick, 2015, Cengage Learning.
iv. A Laboratory Manual of Physics for undergraduate classes, D.P.Khandelwal, 1985, Vani Pub.

PHSHCC202T: WAVES AND OPTICS

Contact Hours: 60

Marks = 70 [ESE (50) CCA(20)]

Pass Marks = 28 [ESE (20) CCA (8)]

(Two questions of 10 marks will be set from each unit, one needs to be answered from each unit)

Unit 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 Lectures)**

Superposition of two perpendicular Harmonic Oscillations: Graphical and Analytical Methods. Lissajous Figures with equal an unequal frequency and their uses. **(2 Lectures)**

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 Lectures)**

Unit 2:

Velocity of Waves: Velocity of Transverse Vibrations of Stretched Strings. Velocity of Longitudinal Waves in a Fluid in a Pipe. Newton's Formula for Velocity of Sound. Laplace's Correction. **(6 Lectures)**

Superposition of Two Harmonic Waves: Standing (Stationary) Waves in a String: Fixed and Free Ends. Analytical Treatment. Phase and Group Velocities. Changes with respect to Position and Time. Energy of Vibrating String. Transfer of Energy. Normal Modes of Stretched Strings. Plucked and Struck Strings. Melde's Experiment. Longitudinal Standing Waves and Normal Modes. Open and Closed Pipes. Superposition of N Harmonic Waves. **(7 Lectures)**

Unit 3:

Wave Optics: Electromagnetic nature of light. Definition and properties of wave front. Huygens Principle. Temporal and Spatial Coherence. **(3 Lectures)**

Interference: Division of amplitude and wavefront. Young's double slit experiment. Lloyd's Mirror and Fresnel's Biprism. Phase change on reflection: Stokes' treatment. Interference in Thin

Films: parallel and wedge-shaped films. Fringes of equal inclination (Haidinger Fringes); Fringes of equal thickness (Fizeau Fringes). Newton's Rings: Measurement of wavelength and refractive index. **(9 Lectures)**

Unit 4:

Interferometer: Michelson Interferometer-(1) Idea of form of fringes (No theory required), (2) Determination of Wavelength, (3) Wavelength Difference, (4) Refractive Index, and (5) Visibility of Fringes. Fabry-Perot interferometer. **(4 Lectures)**

Diffraction: Kirchhoff's Integral Theorem, Fresnel-Kirchhoff's Integral formula. (Qualitative discussion only). **(2 Lectures)**

Fraunhofer diffraction: Single slit. Circular aperture, Resolving Power of a telescope. Double slit. Multiple slits. Diffraction grating. Resolving power of grating. **(8 Lectures)**

Unit 5:

Fresnel Diffraction: Fresnel's Assumptions. Fresnel's Half-Period Zones for Plane Wave. Explanation of Rectilinear Propagation of Light. Theory of a Zone Plate: Multiple Foci of a Zone Plate. Fresnel's Integral, Fresnel diffraction pattern of a straight edge, a slit and a wire. **(7 Lectures)**

Holography: Principle of Holography. Recording and Reconstruction Method. Theory of Holography as Interference between two Plane Waves. Point source holograms. **(3 Lectures)**

Reference Books

i. Waves: Berkeley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGraw-Hill.
ii. Fundamentals of Optics, F.A. Jenkins and H.E. White, 1981, McGraw-Hill.
iii. Principles of Optics, Max Born and Emil Wolf, 7th Edn., 1999, Pergamon Press.
iv. Optics, Ajoy Ghatak, 2008, Tata McGraw Hill.
v. The Physics of Vibrations and Waves, H. J. Pain, 2013, John Wiley and Sons.
vi. The Physics of Waves and Oscillations, N.K. Bajaj, 1998, Tata McGraw Hill.
vii. Fundamental of Optics, A. Kumar, H.R. Gulati and D.R. Khanna, 2011, R. Chand Publications.
viii. A text book on Light – B. Ghosh and K. G. Mazumdar (Shreedhar Publishers).
ix. Advanced Practical Physics Vol II – B. Ghosh (Shreedhar Publishers).

PHSHCC202P

Contact Hours: 60

Full Marks = 30 Pass Mark = 12 ESE Time = 3 hours

(One experiment to be performed at the time of ESE)

1. To determine the frequency of an electric tuning fork by Melde's experiment and verify λ^2 –T law.
2. To determine refractive index of the material of a prism using sodium source.
3. To determine the dispersive power and Cauchy constants of the material of a prism using mercury source.
4. To determine the wavelength of sodium source using Michelson's interferometer.
5. To determine wavelength of sodium light using Fresnel Biprism.
6. To determine wavelength of sodium light using Newton's Rings.
7. To draw the D- λ calibration curve and hence find the wavelength of unknown source.
8. To determine wavelength of (1) Na source and (2) spectral lines of Hg source using plane diffraction grating.
9. To determine dispersive power and resolving power of a plane diffraction grating.

Reference Books

i. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
ii. A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal.
iii. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
iv. A Laboratory Manual of Physics for undergraduate classes, D.P.Khandelwal, 1985, Vani Pub.
v. Advanced Practical Physics Vol I – B. Ghosh (Shreedhar Publishers).

SEMESTER-III

PHSHCC301T: MATHEMATICAL PHYSICS-II

Contact Hours: 60

Full Marks = 70 [ESE (50) CCA(20)]

Pass Marks = 28 [ESE (20) CCA (8)]

(Two questions of 10 marks will be set from each unit, one needs to be answered from each unit)

Unit 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.

(11 Lectures)

Unit 2:

Frobenius Method: Singular Points of Second Order Linear Differential Equations and their importance. Frobenius method and its applications to find the solution of Legendre, Bessel, Hermite and Laguerre Differential Equations. **(12 Lectures)**

Unit 3:

Special Functions: Properties of Legendre Polynomials: Rodrigues Formula, Generating Function, Orthogonality. 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 ($J_o(x)$ and $J_1(x)$)and Orthogonality. **(12 Lectures)**

Unit 4:

Some Special Integrals: Beta and Gamma Functions and Relation between them. Expression of Integrals in terms of Gamma Functions. **(5 Lectures)**

Dirac Delta function and its properties: Definition of Dirac delta function. Representation as limit of a Gaussian function and rectangular function. Properties of Dirac delta function.

(6 Lectures)

Unit 5:

Partial Differential Equations: Solutions to partial differential equations using separation of variables: Laplace's Equation in problems of rectangular, cylindrical and spherical symmetry. Wave equation and its solution for vibrational modes of a stretched string, rectangular and circular membranes, diffusion Equation. **(14 Lectures)**

Reference Books:

i. Mathematical Methods for Physicists: Arfken, Weber, 2005, Harris, Elsevier.
ii. Fourier Analysis by M.R. Spiegel, 2004, Tata McGraw-Hill.
iii. Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole.
iv. Differential Equations, George F. Simmons, 2006, Tata McGraw-Hill.
v. Partial Differential Equations for Scientists & Engineers, S.J. Farlow, 1993, Dover Pub.
vi. Engineering Mathematics, S.Pal and S.C. Bhunia, 2015, Oxford University Press.
vii. Mathematical methods for Scientists & Engineers, D.A. McQuarrie, 2003, Viva Books.
viii. Differential Equations – A. K. Ghatak, I. C. Goyal and S. J. Chua (Macmillan).

PHSHCC301P

Contact Hours: 60

Full Marks = 30 Pass Mark = 12 ESE Time = 3 hours

Two experiments to be performed from two groups out of given five groups at the time of ESE.

Use C/C++/FORTRAN/ Scilab/ Python/Matlab/Mathematica/others to solve the following problems:

1. i. To calculate velocity and acceleration from the given position with equidistant time data using forward difference formula.
   ii. To evaluate integral of a function over an interval using Trapezoidal rule.
   iii. To evaluate integral of a function over an interval using Simpson's 1/3 rule.
   iv. To find the area of B-H Hysteresis loop using suitable numerical method.

2. i. To add, multiply two matrices and find transpose of a given matrix.
   ii. To find inverse, eigen values and eigen vectors of a given matrix.

3. i. To find the value of R from a given current(I) with voltage(V) data using least square fitting, assuming that the Ohm's law is obeyed.
   ii. To measure spring constant using Hook's law (neglecting negative sign) from a given displacement(x) with applied force(F) data using least square fitting.

4. i. To solve mesh equations of electric circuits (3 meshes) by Gauss elimination method.
   ii. To solve coupled spring mass system(3 masses) by suitable method.

5. i. Using Rodrigues' formula as a user-defined function, evaluate and plot the first six Legendre polynomials from x=-1 to +1.
   ii. Using the appropriate Frobenius series as a user-defined function, evaluate and plot the first six Bessel functions of the first kind from x=-1 to +1.

Reference Books

i. Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press
ii. Complex Variables, A.S. Fokas & M.J. Ablowitz, 8th Ed., 2011, Cambridge Univ. Press
iii. First course in complex analysis with applications, D.G. Zill and P.D. Shanahan, 1940, Jones & Bartlett.
iv. Computational Physics, D.Walker, 1st Edn., 2015, Scientific International Pvt. Ltd.
v. A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3rd Edn., Cambridge University Press
vi. Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A.V. Wouwer, P. Saucez, C.V. Fernández. 2014 Springer
vii. Scilab by example: M. Affouf 2012, ISBN: 978-1479203444
viii. Scilab (A free software to Matlab): H.Ramchandran, A.S.Nair. 2011 S.Chand & Company
ix. Scilab Image Processing: Lambert M. Surhone. 2010 Betascript Publishing
x. Scientific Computing in Python, A K Gupta, 2018, TECHNO WORLD.
xi. Mathematica by Stephen Wolfram (Publisher: Wolfram Media, 1996).

PHSHCC302T: THERMAL PHYSICS

Contact Hours: 60

Full Marks = 70 [ESE (50) CCA(20)]

Pass Marks = 28 [ESE (20) CCA (8)]

(Two questions of 10 marks will be set from each unit, one needs to be answered from each unit)

Unit 1: Introduction to Thermodynamics

Zeroth and First Law of Thermodynamics: Zeroth Law of Thermodynamics & Concept of Temperature, First Law of Thermodynamics and its differential form, Applications of First Law: General Relation between CP and CV, Work Done during Isothermal and Adiabatic Processes. **(7 Lectures)**

Second Law of Thermodynamics: Reversible and Irreversible process with examples. Conversion of Work into Heat and Heat into Work. Heat Engines. Carnot's Cycle, Carnot engine & efficiency. Refrigerator & coefficient of performance, 2nd Law of Thermodynamics: Kelvin-Planck and Clausius Statements and their Equivalence. Carnot's Theorem. Applications of Second Law of Thermodynamics: Thermodynamic Scale of Temperature and its Equivalence to Perfect Gas Scale. **(8 Lectures)**

Unit 2:

Entropy: Concept of Entropy, Clausius Theorem. Clausius Inequality, Second Law of Thermodynamics in terms of Entropy. Entropy of a perfect gas. Principle of Increase of Entropy. Entropy Changes in Reversible and Irreversible processes with examples. Entropy of the Universe. Entropy Changes in Reversible and Irreversible Processes. Principle of Increase of Entropy. Temperature–Entropy diagrams for Carnot's Cycle. Third Law of Thermodynamics. Unattainability of Absolute Zero. **(9 Lectures)**

Thermodynamic Potentials: Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibb's Free Energy. Their Definitions, Properties and Applications. **(3 Lectures)**

Unit 3:

Maxwell's Thermodynamic Relations: Derivations and applications of Maxwell's Relations, Maxwell's Relations:(1) Clausius Clapeyron equation, (2) Values of C_p-C_v,(3) TdS Equations, (4) Joule-Kelvin coefficient for Ideal and Van der Waal Gases, (5) Energy equations, (6) Change of Temperature during Adiabatic Process.

Phase Transition: First and second order Phase Transitions with examples, Clausius Clapeyron Equation and Ehrenfest equations. **(12 Lectures)**

Unit 4: Kinetic Theory of Gases

Distribution of Velocities: Maxwell-Boltzmann Law of Distribution of Velocities in an Ideal Gas and its Experimental Verification. Doppler Broadening of Spectral Lines and Stern's Experiment. Mean, RMS and Most Probable Speeds. Degrees of Freedom. Law of Equipartition of Energy (No proof required). Specific heats of Gases. **(7 Lectures)**

Molecular Collisions: Basic idea of Mean Free Path. Collision Probability. Transport Phenomenon in Ideal Gases: (1) Viscosity, (2) Thermal Conductivity and (3) Diffusion. Einstein's theory of translational Brownian Motion. **(4 Lectures)**

Unit 5:

Real Gases: Behavior of Real Gases: Deviations from the Ideal Gas Equation.

The Virial Equation. Andrew's Experiments on CO_2 Gas. Critical Constants. Continuity of Liquid and Gaseous State. Vapour and Gas. Boyle Temperature. Van der Waal's Equation of State for Real Gases. Values of Critical Constants. Law of Corresponding States. Comparison with Experimental Curves. P-V Diagrams. Joule's Experiment. Free Adiabatic Expansion of a Perfect Gas. Joule-Thomson Porous Plug Experiment. Joule-Thomson Effect for Real and Van der Waal Gases. Temperature of Inversion. Joule-Thomson Cooling. **(10 Lectures)**

Reference Books:

i. Heat and Thermodynamics, M.W. Zemansky, Richard Dittman, 1981, McGraw-Hill.
ii. A Treatise on Heat, Meghnad Saha, and B.N.Srivastava, 1958, Indian Press
iii. Thermal Physics, S. Garg, R. Bansal and Ghosh, 2nd Edition, 1993, Tata McGraw-Hill
iv. Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer.
v. Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Sears & Salinger. 1988, Narosa.
vi. Concepts in Thermal Physics, S.J. Blundell and K.M. Blundell, 2nd Ed., 2012, Oxford University Press.
vii. Thermal Physics, A. Kumar and S.P. Taneja, 2014, R. Chand Publications.
viii. Thermal physics, A. B. Gupta and H. P. Roy, Books and Allied Publisher.

PHSHCC302P

Contact Hours: 60

Full Marks = 30 Pass Mark = 12 ESE Time = 3 hours

(One experiment to be performed at the time of ESE)

1. To determine Mechanical Equivalent of Heat, J, by Joule's / Callender and Barne's constant flow method.
2. To determine the Coefficient of Thermal Conductivity of Cu by Searle's Apparatus or any suitable method.

3. To determine the coefficient of linear expansion by optical lever method or any other suitable method.
4. To determine the Coefficient of Thermal Conductivity of a bad conductor by Lee and Charlton's disc method or any suitable method.
5. To determine the Temperature Coefficient of Resistance by Platinum Resistance Thermometer (PRT).
6. To study the variation of resistance with temperature by Carry-Foster bridge and hence determine the temperature coefficient of the material using hotplate.
7. To study the variation of Thermo-emf of a Thermocouple with Difference of Temperature of its Two Junctions
8. To calibrate a thermocouple to measure temperature in a specified Range using
    i) Null Method, ii) Direct measurement using Op-Amp difference amplifier and to determine Neutral Temperature.
9. To determine the specific heat of a liquid by the method of cooling.

Reference Books

i. Advanced Practical Physics for students, B. L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
ii. A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal.
iii. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
iv. A Laboratory Manual of Physics for undergraduate classes,D. P. Khandelwal,1985, Vani Pub.
v. Advanced Practical Physics Vol I – B. Ghosh (Shreedhar Publishers).

PHSHCC303T: DIGITAL SYSTEMS AND APPLICATIONS

Contact Hours: 60

Full Marks = 70 [ESE (50) CCA(20)]

Pass Marks = 28 [ESE (20) CCA (8)]

(Two questions of 10 marks will be set from each unit, one needs to be answered from each unit)

Unit 1:

Introduction to CRO: Block Diagram of CRO. Electron Gun, Deflection System and Time Base. Deflection Sensitivity. Applications of CRO: (1) Study of Waveform, (2) Measurement of Voltage, Current, Frequency, and Phase Difference. **(3 Lectures)**

Integrated Circuits (Qualitative treatment only): 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 ICs. **(3 Lectures)**

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. **(6 Lectures)**

Unit 2:

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. **(6 Lectures)**

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

Unit 3:

Arithmetic Circuits: Binary Addition. Binary Subtraction using 2's Complement. Half and Full Adders. Half & Full Subtractors, **(5 Lectures)**

Sequential Circuits: SR, D, and JK Flip-Flops. Clocked Flip-Flops. Preset and Clear operations. Race-around conditions in JK Flip-Flop. M/S JK Flip-Flop. **(6 Lectures)**

Unit 4:

Shift registers: Serial-in-Serial-out, Serial-in-Parallel-out, Parallel-in-Serial-out and Parallel-in-Parallel-out Shift Registers (only up to 4 bits). **(2 Lectures)**

Counters (4 bits): Ring Counter. Asynchronous counters, Decade Counter. Synchronous Counter. **(4 Lectures)**

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

Unit 5:

Intel 8085 Microprocessor Architecture: Main features of 8085. Block diagram. Components. Pin-out diagram. Buses. Registers. ALU. Memory. Stack memory. Timing & Control circuitry. Timing states. Instruction cycle. **(6 Lectures)**

Introduction to Assembly Language: 1 byte, 2 byte & 3 byte instructions. **(4 Lectures)**

Timers: IC 555: block diagram and applications: Astable multivibrator and Monostable multivibrator. **(4 Lectures)**

Reference Books:

i. Digital Principles & Applications, A.P. Malvino, D.P.Leach and Saha, 7th Ed., 2011, Tata McGraw
ii. Fundamentals of Digital Circuits, Anand Kumar, 2nd Edn, 2009, PHI Learning Pvt. Ltd.
iii. Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.
iv. Digital Electronics G K Kharate ,2010, Oxford University Press
v. Digital Systems: Principles & Applications, R.J.Tocci, N.S.Widmer, 2001, PHI Learning
vi. Logic circuit design, Shimon P. Vingron, 2012, Springer.
vii. Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning.
viii. Digital Electronics, S.K. Mandal, 2010, 1st edition, McGraw Hill
ix. Microprocessor Architecture Programming & applications with 8085, 2002, R.S. Goankar, Prentice Hall.

PHSHCC303P

Contact Hours: 60

Full Marks = 30 Pass Mark = 12 ESE Time = 3 hours

(One experiment to be performed at the time of ESE)

1. To verify the truth tables of AND, OR, NOT, NOR and NAND gates.
2. To design a combinational logic system for a specified Truth Table.
3. To convert a Boolean expression into logic circuit and design it using logic gate ICs
4. To design and verify the De Morgan's theorem using breadboard.
5. To design and verify Half Adder and Full Adder.
6. To build Flip-Flop (RS, Clocked RS, D-type and JK) circuits using NAND gates.
7. To build JK Master-slave flip-flop using Flip-Flop ICs
8. To build a 4-bit Counter using D-type/JK Flip-Flop ICs and study timing diagram.
9. To design an astable multivibrator of given specifications using 555 Timer.
10. To design a monostable multivibrator of given specifications using 555 Timer.
11. To measure (a) Voltage, (b) rise and fall times and (c) Time period of a periodic waveform using CRO.
12. Write the following programs using 8085 Microprocessor
    - **a.** Addition and subtraction of numbers using direct addressing mode
    - **b.** Addition and subtraction of numbers using indirect addressing mode
    - **c.** Multiplication by repeated addition.
    - **d.** Use of CALL and RETURN Instruction.

Reference Books:

i. Modern Digital Electronics, R.P. Jain, 4th Edition, 2010, Tata McGraw Hill.
ii. Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-Graw Hill.
iii. Microprocessor Architecture Programming and applications with 8085, R.S. Goankar, 2002, Prentice Hall.
iv. Microprocessor 8085: Architecture, Programming and interfacing, A. Wadhwa, 2010, PHI Learning.
v. Advanced Practical Physics Vol II – B. Ghosh (Shreedhar Publishers).
vi. A Textbook on Electronics by S. Chattopadhay (Publisher: NCBA, 2016).

PHSSEC 301T: WORKSHOP SKILL

Contact Hours: 60

Marks = 50 [ESE (35) CCA(15)]

Pass Marks = 20 [ESE (14) CCA (06)]

(Two questions of 7 marks will be set from each unit, one needs to be answered from each unit during ESE. CCA will be on the basis of Hands on skill test.)

The aim of this course is to enable the students to familiar and experience with various mechanical and electrical tools through hands-on mode.

Unit 1:

Introduction: Measuring units. conversion to SI and CGS. Familiarization with meter scale, Vernier calliper, Screw gauge and their utility. Measure the dimension of a solid block, volume of cylindrical beaker/glass, diameter of a thin wire, thickness of metal sheet, etc. Use of Sextant to measure height of buildings, mountains, etc. **(8 Lectures)**

Unit 2:

Mechanical Skill: Concept of workshop practice. Overview of manufacturing methods: casting, foundry, machining, forming and welding. Types of welding joints and welding defects. Common materials used for manufacturing like steel, copper, iron, metal sheets, composites and alloy, wood. **(8 Lectures)**

Unit 3:

Concept of machine processing, introduction to common machine tools like lathe, shaper, drilling, milling and surface machines. Cutting tools, lubricating oils. Cutting of a metal sheet using blade. Drilling of holes of different diameter in metal sheet and wooden block. Use of bench vice and tools for fitting. **(8 Lectures)**

Unit 4:

Electrical and Electronic Skill: Use of Multimeter. Soldering of electrical circuits having discrete components (R, L, C & diode) and ICs on PCB. Operation of oscilloscope. Making circuits, regulated power supply, IC555 Timer, Electronic switch using transistor and relay. **(8 Lectures)**

Unit 5:

Introduction to prime movers: Mechanism, gear system, wheel, Fixing of gears with motor axel. Lever mechanism, Lifting of heavy weight using lever. Braking systems, pulleys, working principle of power generation systems. Demonstration of pulley experiment. **(8 Lectures)**

Hands on Training: 20 hours.

Reference Books:

i. A text book in Electrical Technology - B L Theraja – S. Chand and Company.
ii. Performance and design of AC machines – M.G. Say, ELBS Edn.
iii. Mechanical workshop practice, K.C. John, 2010, PHI Learning Pvt. Ltd.
iv. Workshop Processes, Practices and Materials, Bruce J Black 2005, 3rd Edn., Editor Newnes [ISBN: 0750660732].
v. New Engineering Technology, Lawrence Smyth/Liam Hennessy, The Educational Company of Ireland [ISBN: 0861674480].

SEMESTER-IV

PHSHCC401T: MATHEMATICAL PHYSICS-III

Contact Hours: 60

Full Marks = 70 [ESE (50) CCA(20)]

Pass Marks = 28 [ESE (20) CCA (8)]

(Two questions of 10 marks will be set from each unit, one needs to be answered from each unit)

Unit 1: Complex Analysis

Brief Revision of Complex Numbers and their Graphical Representation. Euler's formula, De Moivre's theorem, Roots of Complex Numbers. Functions of Complex Variables. Analyticity and Cauchy-Riemann Conditions. Examples of analytic functions. **(12 Lectures)**

Unit 2: Taylor's and Laurent's series

Singular functions: poles and branch points, order of singularity, branch cuts. Integration of a function of a complex variable. Cauchy's Inequality. Cauchy's Integral formula. Simply and multiply connected region. Laurent and Taylor's expansion. **(12 Lectures)**

Unit 3: The Calculus of Residues

Residues at simple pole, Residue at a pole of order greater than unity, Residue at infinity, Cauchy's Residue Theorem, Application in solving Definite Integrals. **(12 Lectures)**

Unit 4: Laplace Transform (LT)

Laplace Transform (LT) of Elementary functions. Properties of LTs: Change of Scale Theorem, Shifting Theorem. LTs of 1^{st} and 2^{nd} order Derivatives and Integrals of Functions, Derivatives and Integrals of LTs. LT of Unit Step function, Periodic Functions. **(12 Lectures)**

Unit 5: Inverse LT and Application of LT

Convolution Theorem. Inverse LT. Application of Laplace Transforms to 2^{nd} order Differential Equations: Damped Harmonic Oscillator, Simple Electrical Circuits, Coupled differential equations of 1^{st} order. Solution of heat flow along infinite bar using Laplace transform.

(12 Lectures)

Reference Books:

i. Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press.
ii. Mathematics for Physicists, P. Dennery and A.Krzywicki, 1967, Dover Publications.
iii. Complex Variables, A.S.Fokas & M.J.Ablowitz, 8th Ed., 2011, Cambridge Univ. Press.
iv. Complex Variables, A.K. Kapoor, 2014, Cambridge Univ. Press.
v. Complex Variables and Applications, J.W. Brown & R.V. Churchill, 7th Ed. 2003, Tata McGraw-Hill.
vi. First course in complex analysis with applications, D.G. Zill and P.D. Shanahan, 1940, Jones & Bartlett.
vii. Complex variables, Murray R. Spigel, Schuam's series.

PHSHCC401P

Contact Hours: 60

Full Marks = 30 Pass Mark = 12 ESE Time = 3 hours

Two experiments to be performed from two groups out of given five groups at the time of ESE.

Use C/C++/FORTRAN/ Scilab/ Python/Matlab/Mathematica/others to solve the following problems:

1. i. Solve a given first order ordinary differential equation (ODE) like (a) Radioactive decay (b) Newton's law of cooling (c) Current in LR, RC circuit with DC source using Euler/RK 4 Order method.

   ii. Solve a given second order ordinary differential equation (ODE) like (a) free harmonic oscillator (b) Damped harmonic oscillator (c) forced harmonic oscillator using RK 4 order method.

   iii. Solve (a) Wave equation (b) Heat equation (c) Poisson Equation (d) Laplace equation.

   iv. Solve differential equations

   i. $\frac{dy}{dx} = e^{-x}$ with $y = 0$ for $x = 0$

   ii. $\frac{dy}{dx} + e^{-x} y = x^2$

   iii. $\frac{d^2y}{dt^2} + 2\frac{dy}{dt} = -y$

   iv. $\frac{d^2y}{dt^2} + e^{-t}\frac{dy}{dt} = -y$

2. Dirac Delta Function:

   Evaluate $\frac{1}{\sqrt{2\pi\sigma^2}} \int e^{\frac{-(x-2)^2}{2\sigma^2}} (x+3)\,dx$, for $\sigma = 1,\ 0.1,\ 0.01$ and show it tends to 5.

3. Fourier Series:

   Program to sum $\sum_{n=1}^{\infty} (0.2)^n$

   Evaluate the Fourier coefficients of a given periodic function (Square wave).

4. Frobenius method and special functions:

   $\int_{-1}^{+1} P_n(\mu) P_m(\mu)\, d\mu = \delta_{n.m}$

   Plot $P_n(x),\ J_n(x)$

   Show recursion relation.

5. i. Calculation of error for each data point of observations recorded in experiments done in previous semesters (choose any two).

   ii. Calculation of least square fitting manually without giving weightage to error. Confirmation of least square fitting of data through computer program.

iii. Evaluation of trigonometric functions e.g. *sin θ,* Given Bessel's function at N points find its value at an intermediate point. Complex analysis: Integrate $1/(x^2+2)$ numerically and check with computer integration.

iv. Compute the n^{th} roots of unity for $n = 2$, 3, and 4.

v. Find the two square roots of $-5+12j$.

vi. Solve Kirchhoff's Current law for any node of an arbitrary circuit using Laplace's transform.

vii. Solve Kirchhoff's Voltage law for any loop of an arbitrary circuit using Laplace's transform.

viii. Perform circuit analysis of a general LCR circuit using Laplace's transform.

Reference Books:

i. Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press.
ii. Mathematics for Physicists, P. Dennery and A. Krzywicki, 1967, Dover Publications.
iii. Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández. 2014 Springer ISBN: 978-3319067896.
iv. A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3rd Edn., Cambridge University Press.
v. Scilab by example: M. Affouf, 2012. ISBN: 978-1479203444.
vi. Scilab (A free software to Matlab): H.Ramchandran, A.S.Nair. 2011 S.Chand & Company.
vii. Scilab Image Processing: Lambert M. Surhone. 2010 Betascript Publishing.
viii. https://web.stanford.edu/~boyd/ee102/laplace_ckts.pdf.
ix. ocw.nthu.edu.tw/ocw/upload/12/244/12handout.pdf.
x. Scientific Computing in Python, A K Gupta, 2018, TECHNO WORLD.
xi. Mathematica by Stephen Wolfram (Publisher: Wolfram Media, 1996).

PHSHCC402T: ELEMENTS OF MODERN PHYSICS

Contact Hours: 60

Marks = 70 [ESE (50) CCA(20)]

Pass Marks = 28 [ESE (20) CCA (8)]

(Two questions of 10 marks will be set from each unit, one needs to be answered from each unit)

Unit 1:

Planck's quantum hypothesis, Planck's constant and light as a collection of photons; Blackbody Radiation: Quantum theory of Light; Matter waves and Wave-particle duality; De Broglie, Davisson-Germer experiment. Wave description of particles by wave packets. Group and Phase velocities and relation between them. Two slit interference experiment with photons, atoms and particles; Probability. Wave amplitude and wave function. **(11 Lectures)**

Unit 2:

Position measurement- gamma ray microscope thought experiment;, Heisenberg uncertainty principle (Uncertainty relations involving Canonical pair of variables): Estimation of radius of Bohr orbit and ground state energy of hydrogen atom using Uncertainty Principle; Energy-time uncertainty principle; Impossibility of an electron being in the nucleus as a consequence of the uncertainty principle. **(13 Lectures)**

Unit 3:

Fundamental postulates of Quantum Mechanics; Time independent Schrodinger equation for non-relativistic particles; Properties of wave function, stationary states; physical interpretation of a wave function, probabilities and normalization; probability current densitiy. Orthogonality of wave functions. **(11 Lectures)**

Unit 4:

Conditions for physical acceptability of wave function, Hamiltonian Operator, and time dependent Schrodinger equation and Dynamical evolution of a quantum state; One dimensional infinitely rigid box- energy eigen values and eigen functions, normalization; Quantum mechanical scattering and tunnelling in one dimension-across a step potential & rectangular potential barrier. **(12 Lectures)**

Unit 5:

Radioactivity: Law of radioactive decay; Mean Life and Half Life: Introductory idea of fission and fusion nuclear reactions, mass defect and generation of energy. **(6 Lectures)**

Lasers: Einstein's A and B coefficients. Metastable states. Spontaneous and Stimulated emissions. Optical Pumping and Population Inversion. Three-Level and Four-Level Lasers. Ruby Laser and He-Ne Laser. Basic lasing. **(4 Lectures)**

Reference Books:

i. Concepts of Modern Physics, Arthur Beiser, 2002, McGraw-Hill.
ii. Introduction to Modern Physics, Rich Meyer, Kennard, Coop, 2002, Tata McGraw Hill
iii. Introduction to Quantum Mechanics, David J. Griffith, 2005, Pearson Education.
iv. Physics for scientists and Engineers with Modern Physics, Jewett and Serway, 2010, Cengage Learning.
v. Quantum Mechanics: Theory & Applications, A.K.Ghatak & S.Lokanathan, 2004, Macmillan.

Additional Books for Reference

i. Modern Physics, J.R. Taylor, C.D. Zafiratos, M.A. Dubson, 2004, PHI Learning.
ii. Theory and Problems of Modern Physics, Schaum`s outline, R. Gautreau and W. Savin, 2nd Edn, Tata McGraw-Hill Publishing Co. Ltd.
iii. Quantum Physics, Berkeley Physics, Vol.4. E.H.Wichman, 1971, Tata McGraw-Hill Co.
iv. Basic ideas and concepts in Nuclear Physics, K.Heyde, 3rd Edn., Institute of Physics Pub.
v. Six Ideas that Shaped Physics: Particle Behave like Waves, T.A.Moore, 2003, McGraw Hill.

PHSHCC402P

Contact Hours: 60

Full Marks = 30 Pass Mark = 12 ESE Time = 3 hours

(One experiment to be performed at the time of ESE)

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 wavelength of H-alpha emission line of Hydrogen atom.
6. To determine the value of e/m by Magnetic focusing/ Bar magnet or by any suitable method.
7. To setup the Millikan oil drop apparatus and determine the charge of an electron.
8. To show the tunnelling effect in tunnel diode using I-V characteristics.
9. To determine the wavelength of laser source using diffraction of single slit.
10. To determine the wavelength of laser source using diffraction of double slits.

Reference Books

i. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
ii. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
iii. A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Edn, 2011,Kitab Mahal.

PHSHCC403T: ANALOG SYSTEMS AND APPLICATIONS

Contact Hours: 60

Full Marks = 70 [ESE (50) CCA(20)]

Pass Marks = 28 [ESE (20) CCA (8)]

(Two questions of 10 marks will be set from each unit, one needs to be answered from each unit)

Unit 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. **(10 Lectures)**

Rectifier Diode: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers, Calculation of Ripple Factor and Rectification Efficiency, C-filter. **(04 Lectures)**

Unit 2:

Two-terminal Devices and their Applications: Zener Diode and Voltage Regulation. Principle and structure of (1) LEDs, (2) Photodiode and (3) Solar Cell. **(6 Lectures)**

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. Active, Cut-off and Saturation Regions. **(6 Lectures)**

Unit 3:

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. **(10 Lectures)**

Unit 4:

Coupled Amplifier: Two stage RC-coupled amplifier and its frequency response. **(2 Lectures)**

Feedback in Amplifiers: Effects of Positive and Negative feedback on input impedance, Output Impedance, Gain, Stability, Distortion and Noise. **(4 Lectures)**

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

Unit 5:

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. **(5 Lectures)**

Applications of Op-Amps: (1) Inverting and non-inverting amplifiers, (2) Adder, (3) Subtractor, (4) Differentiator, (5) Integrator. **(5 Lectures)**

Reference Books:

i. Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill.
ii. Electronics: Fundamentals and Applications, J.D. Ryder, 2004, Prentice Hall.
iii. Solid State Electronic Devices, B.G.Streetman & S.K.Banerjee, 6th Edn.,2009, PHI Learning.
iv. Electronic Devices & circuits, S.Salivahanan & N.S.Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill
v. OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall.
vi. Microelectronic circuits, A.S. Sedra, K.C. Smith, A.N. Chandorkar, 2014, 6th Edn., Oxford University Press.
vii. Electronic circuits: Handbook of design & applications, U.Tietze, C.Schenk,2008, Springer.
viii. Semiconductor Devices: Physics and Technology, S.M. Sze, 2nd Ed., 2002, Wiley India.
ix. Microelectronic Circuits, M.H. Rashid, 2nd Edition, Cengage Learning.
x. Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson India.
xi. Electronic devices and circuits, Sanjeev Gupta and Santosh Gupta, Dhanpat Rai Publications(P), Ltd.

PHSHCC403P

Contact Hours: 60

Full Marks = 30 Pass Mark = 12 ESE Time = 3 hours

(One experiment to be performed at the time of ESE)

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. Study of V-I & power curves of solar cells, and find maximum power point & efficiency.
4. To study the characteristics of a Bipolar Junction Transistor in CE configuration.
5. To design a CE transistor amplifier of a given gain (mid-gain) using voltage divider bias.
6. To study the frequency response of voltage gain of a single stage RC-coupled transistor amplifier.

7. To design a phase shift oscillator of given specifications using BJT.
8. To design a Wien bridge oscillator for given frequency using an op-amp.
9. To study the analog to digital convertor (ADC) IC.
10. To design an inverting amplifier using Op-amp (741,351) for dc input voltage and study its closed loop gain.
11. To design inverting amplifier using Op-amp (741,351) and study its frequency response.
12. To design non-inverting amplifier using Op-amp (741,351) & study its frequency response.
13. To investigate the use of an op-amp (741,351) as an Integrator and Differentiator.
14. To add two dc voltages using Op-amp (741,351) in inverting and non-inverting mode.
15. To investigate the use of an op-amp (741,351) as adder and subtractor.

Reference Books:

i. Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-Graw Hill.
ii. OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall.
iii. Electronic Principle, Albert Malvino, 2008, Tata Mc-Graw Hill.
iv. Electronic Devices & circuit Theory, R.L. Boylestad & L.D. Nashelsky, 2009, Pearson.
v. Advanced Practical Physics Vol II – B. Ghosh (Shreedhar Publishers).
vi. A Textbook on Electronics by S. Chattopadhay (Publisher: NCBA, 2016).

PHSSEC 401T: ELECTRICAL CIRCUITS AND NETWORK

Contact Hours: 60

Marks = 50 [ESE (35) CCA(15)]

Pass Marks = 20 [ESE (14) CCA (06)]

(Two questions of 7 marks will be set from each unit, one needs to be answered from each unit during ESE. CCA will be on the basis of Hands on skill test.)

The aim of this course is to enable the students to design and trouble shoots the electrical circuits, networks and appliances through hands-on mode.

Unit 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. **(8 Lectures)**

Unit 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. Rules to analyze AC sourced electrical circuits. Real, imaginary and complex power components of AC source. Power factor. **(8 Lectures)**

Unit 3:

Electrical Drawing and Symbols: Drawing symbols. Blueprints. Reading Schematics. Ladder diagrams. Electrical Schematics. Reading of circuit schematics.

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

Unit 4:

Electric Motors: Single-phase and three-phase & AC motors. Basic design. Speed & power of ac motor.

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.

Electrical protection: Relays, Fuses and switches. Circuit breakers. Overload devices. Ground-fault protection. Grounding and isolating. Phase reversal. Surge protection. **(8 Lectures)**

Unit 5:

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. **(8 Lectures)**

Hands on Training: 20 hours.

Reference Books:

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

SEMESTER-V

PHSHCC501T: QUANTUM MECHANICS AND APPLICATIONS

Contact Hours: 60

Marks = 70 [ESE (50) CCA(20)]

Pass Marks = 28 [ESE (20) CCA (8)]

(Two questions of 10 marks will be set from each unit, one needs to be answered from each unit)

Unit 1: General formalism of quantum mechanics

Wave Function of a Free Particle. Linearity and Superposition Principles. Eigenvalues and Eigen functions Hamiltonian, stationary states and energy eigenvalues; expansion of an arbitrary wavefunction as a linear combination of energy eigenfunctions; General solution of the time dependent Schrodinger equation in terms of linear combinations of stationary states; Equation of continuity and its significance, conservation of total probability. **(14 Lectures)**

Unit 2: Quantum mechanical Operators

Linear operator, Position operator, Energy and momentum operator, Angular momentum operator, Ladder operator and Energy operator; Hermitian operators, commutator of position and momentum operators; Expectation values of position and momentum. Ehrenfest theorem. Commutation relations and algebras. Simultaneous measurability of observables. **(13 Lectures)**

Unit 3: Applications of Schrodinger equation

Particle in three dimensional rectangular box, Degenerate and non-degenerate states, application of Schrodinger equation to one-dimensional square well potential; Quantum mechanics of simple harmonic oscillator-energy levels and energy eigenfunctions using Frobenius method; Hermite polynomials; ground state, zero point energy & uncertainty principle. **(10 Lectures)**

Unit 4: Quantum theory of hydrogen-like atoms

Time independent Schrodinger equation in spherical polar coordinates; separation of variables for second order partial differential equation; angular momentum operator & quantum numbers; Radial wavefunctions from Frobenius method; Orbital angular momentum quantum numbers l and m; s, p, d,.. shells. **(10 Lectures)**

Electron angular momentum. Space quantization. Electron Spin and Spin Angular Momentum. Larmor's Theorem. Electron Magnetic Moment, Gyromagnetic Ratio and Bohr Magneton, Spin Magnetic Moment. **(6 Lectures)**

Unit 5: Atoms in External Magnetic Field

Zeeman Effect: Normal and Anomalous Zeeman Effects -Classical treatment only. Paschen Back and Stark Effect (Qualitative Discussion only). **(4 Lectures)**

Many electron atoms: Pauli's Exclusion Principle. Symmetric & Antisymmetric Wave Functions. Periodic table. Fine structure. Spin orbit coupling. Spectral Notations for Atomic States. Total angular momentum. Vector atom Model. Stern-Gerlach Experiment. Spin-orbit coupling in atoms-L-S and J-J couplings. Hund's Rule. Term symbols. **(10 Lectures)**

Reference Books:

i. A Text book of Quantum Mechanics, P.M.Mathews and K.Venkatesan, 2nd Ed., 2010, McGraw Hill.
ii. Quantum Mechanics, Robert Eisberg and Robert Resnick, 2nd Edn., 2002, Wiley.
iii. Quantum Mechanics, Leonard I. Schiff, 3rd Edn. 2010, Tata McGraw Hill.
iv. Quantum Mechanics, G. Aruldhas, 2nd Edn. 2002, PHI Learning of India.
v. Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and Bartlett Learning.
vi. Quantum Mechanics: Foundations & Applications, Arno Bohm, 3rd Edn., 1993, Springer.
vii. Quantum Mechanics for Scientists & Engineers, D.A.B. Miller, 2008, Cambridge University Press

Additional Books for Reference

i. Quantum Mechanics, Eugen Merzbacher, 2004, John Wiley and Sons, Inc.
ii. Introduction to Quantum Mechanics, D.J. Griffith, 2nd Ed. 2005, Pearson Education
iii. Quantum Mechanics, Walter Greiner, 4th Edn., 2001, Springer

PHSHCC501P

Contact Hours: 60

Full Marks = 30 Pass Mark = 12 ESE Time = 3 hours

One experiment (either from group-A or group-B) to be performed at the time of ESE

Group A.: Laboratory based experiments:

1. Study of Electron spin resonance- determine magnetic field as a function of the resonance frequency.
2. Study of Zeeman effect: with external magnetic field; Hyperfine splitting.
3. To show the tunneling effect in tunnel diode using I-V characteristics.
4. Quantum efficiency of CCDs.

Group B.: Laboratory based experiments:

Use C/C++/FORTRAN/ Scilab/ Python/Matlab/Mathematica/others to solve the following problems (For all the following problems, energy eigen value searching programmes or algorithms may be used)

1. Solve the s-wave Schrodinger equation for the ground state and the first excited state of the hydrogen atom:

$$\frac{d^2u(r)}{dr^2} = A(r)u(r),\ A(r) = \frac{2m}{\hbar^2}\left[V(r) - E\right], \quad \text{where } V(r) = -\frac{e^2}{r}$$

Where, ***m*** is the reduced mass of the electron. Obtain the energy eigenvalues and plot the corresponding wave-functions. Remember that the ground state energy of the hydrogen atom is $-13.6\ eV$. Take $e = 3.795\left(eVA^0\right)^{1/2}$, $\hbar c = 1973(eVA^0)$ and $m = 0.511\times10^6\ eV/c^2$.

2. Solve the s-wave radial Schrodinger equation for an atom:

$$\frac{d^2u(r)}{dr^2} = A(r)u(r),\ A(r) = \frac{2m}{\hbar^2}\left[V(r) - E\right]$$

where ***m*** is the reduced mass of the system (which can be chosen to be the mass of an electron) for the screened coulomb potential $V(r) = -\frac{e^2}{r} e^{-r/a}$.

Find the energy (in eV) of the ground state of the atom to an accuracy of three significant digits. Also, plot the corresponding wavefunction. Take $e = 3.795\left(eVA^0\right)^{1/2}$, $m = 0.511 \times 10^6\ eV/c^2$ and $a = 3A^0,\ 5A^0,\ 7A^0$. In these units $\hbar c = 1973(eVA^0)$. The ground state energy is expected to be above $-12\ eV$ in all three cases.

3. Solve the s-wave radial Schrodinger equation for a particle of mass ***m***:

$$\frac{d^2u(r)}{dr^2} = A(r)u(r),\ A(r) = \frac{2m}{\hbar^2}\left[V(r) - E\right]$$

For anharmonic oscillator potential $V(r) = \frac{1}{2}kr^2 + \frac{1}{3}br^3$

for the ground state energy (in MeV) of particle to an accuracy of three significant digits. Also, plot the corresponding wave function. Choose $m = 940\ MeV/c^2$, $k = 100\ MeV\ fm^{-2}$, $b = 0,\ 10,\ 30\ MeV\ fm^{-3}$. In these units $\hbar c = 197.3\ MeV\ fm$. The ground state energy is expected to lie between 90 and 110 MeV for all three cases.

4. Solve the s-wave radial Schrodinger equation for the vibrations of hydrogen molecule:

$$\frac{d^2u(r)}{dr^2} = A(r)u(r),\ A(r) = \frac{2\mu}{\hbar^2}\left[V(r) - E\right]$$

Where μ is the reduced mass of the two-atom system for the Morse potential

$$V(r) = D\left(e^{-2ar'} - e^{-ar'}\right),\ r' = \frac{r - r_0}{r}$$

Find the lowest vibrational energy (in MeV) of the molecule to an accuracy of three significant digits. Also plot the corresponding wave function. Take: $m = 940 \times 10^6\ eV/c^2$, $D = 0.755501\ eV$, $a = 1.44$, $r_0 = 0.131349\ A^0$.

Reference Books:

i. Schaum's outline of Programming with C++. J.Hubbard, 2000,McGraw-Hill Publication.
ii. Numerical Recipes in C: The Art of Scientific Computing, W.H. Pressetal., 3rd Edn., 2007, Cambridge University Press.
iii. An introduction to computational Physics, T.Pang, 2nd Edn.,2006, Cambridge Univ. Press.
iv. Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific & Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández.2014 Springer.
v. Scilab (A Free Software to Matlab): H. Ramchandran, A.S. Nair. 2011 S. Chand & Co.
vi. A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3rd Edn., Cambridge University Press.
vii. Scilab Image Processing: L.M.Surhone.2010 Betascript Publishing ISBN:978-6133459274.
viii. Mathematica by Stephen Wolfram (Publisher: Wolfram Media, 1996).

PHSHCC502T: SOLID STATE PHYSICS

Contact Hours: 60

Marks = 70 [ESE (50) CCA(20)]

Pass Marks = 28 [ESE (20) CCA (8)]

(Two questions of 10 marks will be set from each unit, one needs to be answered from each unit)

Unit 1:

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

Unit 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. **(10 Lectures)**

Unit 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. **(10 Lectures)**

Unit 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. **(8 Lectures)**

Ferroelectric Properties of Materials: Classification of crystals, Piezoelectric effect, Pyroelectric effect, Ferroelectric effect, Electrostrictive effect, Curie-Weiss Law, Ferroelectric domains. **(6 lectures)**

Unit 5:

Elementary Band Theory: Kronig Penny model. Band Gap. Conductor, Semiconductor (P and N type) and insulator. Conductivity of Semiconductor, mobility, Hall Effect. & Hall coefficient. **(8 Lectures)**

Superconductivity: Experimental Results. Critical Temperature. Critical magnetic field. Meissner effect. Type I and type II Superconductors, London's Equation and Penetration Depth. Isotope effect. Idea of BCS theory (No derivation). **(6 Lectures)**

Reference Books:

i. Introduction to Solid State Physics, Charles Kittel, 8th Edition, 2004, Wiley India Pvt. Ltd.
ii. Elements of Solid State Physics, J.P. Srivastava, 4th Edition, 2015, Prentice-Hall of India
iii. Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw Hill
iv. Solid State Physics, N.W. Ashcroft and N.D. Mermin, 1976, Cengage Learning
v. Solid-state Physics, H. Ibach and H. Luth, 2009, Springer
vi. Solid State Physics, Rita John, 2014, McGraw Hill
vii. Elementary Solid State Physics, 1/e M. Ali Omar, 1999, Pearson India
viii. Solid State Physics, M.A. Wahab, 2011, Narosa Publications

PHSHCC502P

Contact Hours: 60

Full Marks = 30 Pass Mark = 12 ESE Time = 3 hours

(One experiment to be performed at the time of ESE)

1. Measurement of susceptibility of paramagnetic solution by (Quinck`s Tube Method)/suitable method.
2. To measure the Magnetic susceptibility of Solids.
3. To measure the Dielectric Constant of a dielectric Material by suitable method.
4. To study the PE Hysteresis loop of a Ferroelectric Crystal.
5. To draw the BH curve of Fe using Solenoid/transformer & determine energy loss from Hysteresis.
6. To measure the resistivity of a semiconductor (Ge) with temperature by four-probe method (room temperature to 150 ^{o}C) and to determine its band gap.
7. To determine the Hall coefficient of a semiconductor sample.

Reference Books

i. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
ii. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
iii. A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal.
iv. Elements of Solid State Physics, J.P. Srivastava, 2nd Ed., 2006, Prentice-Hall of India.

PHSDSE 501T (A): CLASSICAL DYNAMICS

Contact Hours: 90

Marks = 100 [ESE (70) CCA(30)]

Pass Marks = 40 [ESE (28) CCA (12)]

(Two questions of 14 marks will be set from each unit, one needs to be answered from each unit)

Unit: 1: Classical Mechanics

Dynamics of a system of particles-Centre of mass of two particle system, Velocity, acceleration and linear momentum of centre of mass of two particle system, constraints, Constrained motion and degrees of freedom.

Characteristics of motion under central force, Reduction of two-body central force problem to the equivalent one body problem, Central force and motion in a plane, Equations of motion under central force. Keplers laws of motion and their deductions. **(15 Lectures)**

Unit 2: Lagrangian formalism

Generalized coordinates and velocities, D'Alembert's Principle. Constraints and their classification. Hamilton's principle, Lagrangian and the Euler-Lagrange equations, one-dimensional examples of the Euler-Lagrange equations- one-dimensional Simple Harmonic Oscillations and falling body in uniform gravity. **(15 Lectures)**

Unit: 3: Hamiltonian Formalism

Canonical momenta & Hamiltonian. Hamilton's equations of motion. Applications: Hamiltonian for a harmonic oscillator, solution of Hamilton's equation for Simple Harmonic Oscillations; particle in a central force field- conservation of angular momentum and energy. **(15 Lectures)**

Unit: 4: Small Amplitude Oscillations

Equilibrium and its types, Stability, Stability of simple pendulum. Minima of potential energy and points of stable equilibrium, expansion of the potential energy around a minimum, small amplitude oscillations about the minimum, Examples of system performing small oscillations. Calculation of frequency of vibration of diatomic molecule. Normal modes of oscillations- example of N identical masses connected in a linear fashion to (N -1) - identical springs. Normal coordinate and frequency. **(15 Lectures)**

Unit 5: Fluid Dynamics

Density ρ and pressure P in a fluid, an element of fluid and its velocity, continuity equation and mass conservation, stream-lined motion, laminar flow, Poiseuille's equation for flow of a liquid through a pipe, qualitative description of turbulence, Reynolds number. **(15 Lectures)**

Tutorials: 15 hours

Reference Books:

i. Classical Mechanics, H.Goldstein, C.P. Poole, J.L. Safko, 3rd Edn. 2002,Pearson Education.
ii. Mechanics, L. D. Landau and E. M. Lifshitz, 1976, Pergamon.
iii. Classical Electrodynamics, J.D. Jackson, 3rd Edn., 1998, Wiley.
iv. The Classical Theory of Fields, L.D Landau, E.M Lifshitz, 4th Edn., 2003, Elsevier.
v. Introduction to Electrodynamics, D.J. Griffiths, 2012, Pearson Education.
vi. Classical Mechanics, P.S. Joag, N.C. Rana, 1st Edn., McGraw Hall.
vii. Classical Mechanics, R. Douglas Gregory, 2015, Cambridge University Press.
viii. Classical Mechanics: An introduction, Dieter Strauch, 2009, Springer.
ix. Solved Problems in classical Mechanics, O.L. Delange and J. Pierrus, 2010, Oxford Press.
x. Classical Mechanics and properties of Matter, A. B. Gupta, Books and Allied publisher.

PHSDSE 501T (B): BIOLOGICAL PHYSICS

Contact Hours: 90

Marks = 100 [ESE (70) CCA(30)]

Pass Marks = 40 [ESE (28) CCA (12)]

(Two questions of 14 marks will be set from each unit, one needs to be answered from each unit)

Unit 1:

The boundary, interior and exterior environment of living cells. Processes: exchange of matter and energy with environment, metabolism, maintenance, reproduction, evolution. Self-replication as a distinct property of biological systems. Time scales and spatial scales. Universality of microscopic processes and diversity of macroscopic form. Types of cells. Multicellularity. Allometric scaling laws. **(9 lectures)**

Unit 2:

Metabolites, proteins and nucleic acids. Their sizes, types and roles in structures and processes. Transport, energy storage, membrane formation, catalysis, replication, transcription, translation, signaling. Typical populations of molecules of various types present in cells, their rates of production and turnover. Energy required to make a bacterial cell.

Simplified mathematical models of transcription and translation, small genetic circuits and signaling pathways. Random walks and applications to biology. Mathematical models to be studied analytically and computationally. **(22 lectures)**

Unit 3:

The numbers of distinct metabolites, genes and proteins in a cell. Complex networks of molecular interactions: metabolic, regulatory and signalling networks. Dynamics of metabolic networks; the stoichiometric matrix. Living systems as complex organizations; systems biology. Models of cellular dynamics. The implausibility of life based on a simplified probability estimate, and the origin of life problem. **(15 lectures)**

Unit 4:

Numbers and types of cells in multicellular organisms. Cell types as distinct attractors of a dynamical system. Stem cells and cellular differentiation. Pattern formation and development.

Brain structure: neurons and neural networks. Brain as an information processing system. Associative memory models. Memories as attractors of the neural network dynamics.

(15 lecures)

Unit 5:

The mechanism of evolution: variation at the molecular level, selection at the level of the organism. Models of evolution. The concept of genotype-phenotype map. Examples. Self-sustaining ecosystems.

(14 Lectures)

Tutorials: 15 hours

References:

i. Physics in Molecular Biology; Kim Sneppen & Giovanni Zocchi (CUP 2005).
ii. Biological Physics: Energy, Information, Life; Philip Nelson (W H Freeman & Co, NY, 2004).
iii. Physical Biology of the Cell (2nd Edition), Rob Phillips et al (Garland Science, Taylor & Francis Group, London & NY, 2013).
iv. An Introduction to Systems Biology; Uri Alon (Chapman and Hall/CRC, Special Indian Edition, 2013).
v. Evolution; M. Ridley (Blackwell Publishers, 2009, 3rd edition).

PHSDSE 502T (A): NUCLEAR & PARTICLE PHYSICS

Contact Hours: 90

Marks = 100 [ESE (70) CCA(30)]

Pass Marks = 40 [ESE (28) CCA (12)]

(Two questions of 14 marks will be set from each unit, one needs to be answered from each unit)

Unit 1:

General Properties of Nuclei: Constituents of nucleus and their Intrinsic properties, quantitative facts about size, mass, charge density (matter energy), 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.

(15 Lectures)

Unit 2:

Nuclear Models: Liquid drop model approach, semi empirical mass formula and significance of various terms, condition of nuclear stability, evidence for nuclear shell structure, nuclear magic numbers, basic assumption of shell model, concept of nuclear force, Meson theory of nuclear force. **(15 Lectures)**

Unit 3:

Radioactivity decay: (a) Alpha decay: basics of α-decay processes, Range of alpha particle and its determination, Geiger Nuttall law, α-ray spectra. (b) Beta-decay: energy kinematics for beta-decay, positron emission, electron capture, Beta ray spectrum and neutrino hypothesis. (c) Gamma decay: Gamma rays emission & kinematics, internal conversion. **(10 Lectures)**

Nuclear Reactions: Types of Reactions, Conservation Laws, kinematics of reactions, Q-value, reaction rate. **(7 Lectures)**

Unit 4:

Interaction of Nuclear Radiation with matter: Cerenkov radiation, Gamma ray interaction through matter, photoelectric effect, Compton scattering, pair production. **(5 Lectures)**

Detector for Nuclear Radiations: Ionization chamber, proportional counter and GM Counter. **(5 Lectures)**

Particle Accelerators: Cyclotron, Betatrons, Accelerator facility available in India. **(4 Lectures)**

Unit 5:

Particle physics: 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 model. Standard model, CPT theorem. **(14 Lectures)**

Tutorials: 15 hours

Reference Books:

i. Introductory nuclear Physics by Kenneth S. Krane (Wiley India Pvt. Ltd., 2008).
ii. Concepts of nuclear physics by Bernard L. Cohen. (Tata Mcgraw Hill, 1998).
iii. Introduction to the physics of nuclei & particles, R.A. Dunlap. (Thomson Asia, 2004)
iv. Introduction to Elementary Particles, D. Griffith, John Wiley & Sons.
v. Quarks and Leptons, F. Halzen and A.D. Martin, Wiley India, New Delhi.
vi. Basic ideas and concepts in Nuclear Physics - An Introductory Approach by K. Heyde (IOP- Institute of Physics Publishing, 2004).
vii. Radiation detection and measurement, G.F. Knoll (John Wiley & Sons, 2000).
viii. Lecture notes in Physics: Particle Physics, Sabyasachi Roy (Tirthabhumi Publication, 2017).
ix. Theoretical Nuclear Physics, J.M. Blatt & V.F.Weisskopf (Dover Pub.Inc., 1991).

PHSDSE 502T (B): ADVANCED MATHEMATICAL PHYSICS

Contact Hours: 90

Marks = 100 [ESE (70) CCA(30)]

Pass Marks = 40 [ESE (28) CCA (12)]

(Two questions of 14 marks will be set from each unit, one needs to be answered from each unit)

Unit 1:

Abstract Systems. Binary Operations and Relations. Introduction to Groups and Fields. Vector Spaces and Subspaces. Linear Independence and Dependence of Vectors. Basis and Dimensions of a Vector Space. Change of basis. Homomorphism and Isomorphism of Vector Spaces. Linear Transformations. Algebra of Linear Transformations, Non-singular Transformations, Representation of Linear, Transformations by Matrices. **(15 Lectures)**

Unit 2:

Orthogonal and Unitary Matrices, Trace of a Matrix. Inner Product, Eigen-values and Eigenvectors of Matrices, Cayley- Hamiliton Theorem, Diagonalization of Matrices, Solutions of Coupled Linear Ordinary Differential Equations, Functions of a Matrix. **(15 Lectures)**

Unit 3:

Definition, Group multiplication table, Subgroup, Coset, Direct product, Homomorphism, Isomorphism, Matrix representation, Reducible and irreducible representation. **(15 Lectures)**

Unit 4:

Certesian Tensors: Transformation of Co-ordinates. Einstein's Summation Convention. Relation between Direction Cosines. Tensors. Algebra of Tensors. Sum, Difference and Product of Two Tensors. Contraction. Quotient Law of Tensors. Symmetric and Anti-symmetric Tensors. Invariant Tensors: Kronecker and Alternating Tensors. Association of Antisymmetric Tensor of Order Two and Vectors. Vector Algebra and Calculus using Cartesian Tensors: Scalar and Vector Products, Scalar and Vector Triple Products. Differentiation. Gradient, Divergence and Curl of Tensor Fields. Vector Identities. **(15 Lectures)**

Unit 5:

General Tensors: Transformation of Co-ordinates. Minkowski Space. Contravariant & Covariant Vectors. Contravariant, Covariant and Mixed Tensors. Kronecker Delta and Permutation Tensors. Algebra of Tensors. Sum, Difference & Product of Two Tensors. Contraction. Quotient Law of Tensors. Symmetric and Anti-symmetric Tensors. Metric Tensor. **(15 Lectures)**

Tutorials: 15 hours

Reference Books:

i. Mathematical Tools for Physics, James Nearing, 2010, Dover Publications.
ii. Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, and F.E. Harris, 1970, Elsevier.
iii. Modern Mathematical Methods for Physicists and Engineers, C.D. Cantrell, 2011, Cambridge University Press.
iv. Introduction to Matrices and Linear Transformations, D.T. Finkbeiner, 1978, Dover Pub.
v. Linear Algebra, W. Cheney, E.W.Cheney & D.R.Kincaid, 2012, Jones & Bartlett Learning.
vi. Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole.
vii. Mathematical Methods for Physicists & Engineers, K.F.Riley, M.P.Hobson, S.J.Bence, 3rd Ed., 2006. Cambridge University Press.

SEMESTER-VI

PHSHCC601T: ELECTROMAGNETIC THEORY

Contact Hours: 60

Marks = 70 [ESE (50) CCA(20)]

Pass Marks = 28 [ESE (20) CCA (8)]

(Two questions of 10 marks will be set from each unit, one needs to be answered from each unit)

Unit 1:

Maxwell Equations: Review of Maxwell's equations. Displacement Current. Vector and Scalar Potentials. Gauge Transformations: Lorentz and Coulomb Gauge. Boundary Conditions at interface between Different Media. Wave Equations. Plane Waves in Dielectric Media. Poynting Theorem and Poynting Vector. Physical Concept of Electromagnetic Field Energy Density, Momentum Density and Angular Momentum Density. **(12 Lectures)**

Unit 2:

EM Wave Propagation in Unbounded Media: Plane EM waves through vacuum and isotropic dielectric medium, transverse nature of plane EM waves, refractive index and dielectric constant, wave impedance. Propagation through conducting media, relaxation time, skin depth. Plasma: Its definition, composition and characteristics, microscopic and macroscopic descriptions of plasma. Motion of charged particle in combined uniform electric and magnetic field. Solar corona and Solar wind, Van Allen radiation belt. **(10 Lectures)**

Unit 3:

EM Wave in Bounded Media: Boundary conditions at a plane interface between two media. Reflection & Refraction of plane waves at plane interface between two dielectric media-Laws of Reflection & Refraction. Fresnel's Formulae for perpendicular & parallel polarization cases, Brewster's law. Reflection & Transmission coefficients. Total internal reflection, evanescent waves. Metallic reflection (normal Incidence). **(10 Lectures)**

Unit 4:

Polarization of Electromagnetic Waves: Description of Linear, Circular and Elliptical Polarization. Propagation of E.M. Waves in Anisotropic Media. Fresnel's Formula. Uniaxial and Biaxial Crystals. Light Propagation in Uniaxial Crystal. Double Refraction. Polarization by Double Refraction. Nicol Prism. Ordinary & extraordinary refractive indices. Production & detection of Plane, Circularly and Elliptically Polarized Light. Quarter-Wave and Half-Wave Plates. Babinet Compensator and its Uses. **(17 Lectures)**

Unit 5:

Wave Guides: Planar optical wave guides. Planar dielectric wave guide. Condition of continuity at interface. Phase shift on total reflection. Eigenvalue equations. Phase and group velocity of guided waves. Field energy and Power transmission. **(6 Lectures)**

Optical Fibres: Numerical Aperture. Step and Graded Indices (Definitions Only). Single and Multiple Mode Fibres (Concept and Definition Only). **(6 Lectures)**

Reference Books:

i. Introduction to Electrodynamics, D.J. Griffiths, 3rd Ed., 1998, Benjamin Cummings.
ii. Elements of Electromagnetics, M.N.O. Sadiku, 2001, Oxford University Press.
iii. Introduction to Electromagnetic Theory, T.L. Chow, 2006, Jones & Bartlett Learning
iv. Fundamentals of Electromagnetics, M.A.W. Miah, 1982, Tata McGraw Hill
v. Electromagnetic field Theory, R.S. Kshetrimayun, 2012, Cengage Learning
vi. Engineering Electromagnetic, Willian H. Hayt, 8th Edition, 2012, McGraw Hill.
vii. Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer.
viii. Introduction to Plasma Physics & Controlled fusion, Francis F. Chen, Springer.
ix. Elements of Plasma Physics, S. N. Goswami, NCBA, Publisher.

Additional Books for Reference

i. Electromagnetic Fields & Waves, P.Lorrain & D.Corson, 1970, W.H.Freeman & Co.
ii. Electromagnetics, J.A. Edminster, Schaum Series, 2006, Tata McGraw Hill.
iii. Electromagnetic field theory fundamentals, B. Guru and H. Hiziroglu, 2004, Cambridge University Press.

PHSHCC601P

Contact Hours: 60

Full Marks = 30 Pass Mark = 12 ESE Time = 3 hours

(One experiment to be performed at the time of ESE)

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 suitable method (using a Babinet's compensator).
4. To study the polarization of light by reflection and determine the polarizing angle and hence determine the refractive index of the material.
5. To verify the Stefan's law of radiation and to determine Stefan's constant.
6. To determine the Boltzmann constant using V-I characteristics of PN junction Diode.

Reference Books

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

PHSHCC602T: STATISTICAL MECHANICS

Contact Hours: 60

Marks = 70 [ESE (50) CCA(20)]

Pass Marks = 28 [ESE (20) CCA (8)]

(Two questions of 10 marks will be set from each unit, one needs to be answered from each unit)

Unit 1: Classical Statistics

Macrostate & Microstate, Elementary Concept of Ensemble, Phase Space, Entropy and Thermodynamic Probability, Maxwell-Boltzmann Distribution Law, Partition Function, Thermodynamic Functions of an Ideal Gas, Classical Entropy Expression, Gibbs Paradox, Sackur Tetrode equation, Law of Equipartition of Energy (with proof) – Applications to Specific Heat and its Limitations. **(16 Lectures)**

Unit 2: Classical Theory of Radiation

Properties of Thermal Radiation. Blackbody Radiation. Pure temperature dependence. Kirchhoff's law. Stefan-Boltzmann law: Thermodynamic proof. Radiation Pressure. Wien's Displacement law. Wien's Distribution Law. Saha's Ionization Formula. Rayleigh-Jean's Law. Ultraviolet Catastrophe. **(11 Lectures)**

Unit 3: Quantum Theory of Radiation

Spectral Distribution of Black Body Radiation. Planck's Quantum Postulates. Planck's Law of Blackbody Radiation: Experimental Verification. Deduction of (1) Wien's Distribution Law, (2) Rayleigh-Jeans Law, (3) Stefan-Boltzmann Law, (4) Wien's Displacement law from Planck's law. **(13 Lectures)**

Unit 4: Bose-Einstein Statistics

B-E distribution law, Thermodynamic functions of a strongly Degenerate Bose Gas, Bose Einstein condensation, properties of liquid He (qualitative description), Radiation as a photon gas and Thermodynamic functions of photon gas. Bose derivation of Planck's law. **(10 Lectures)**

Unit 5: Fermi-Dirac Statistics

Fermi-Dirac Distribution Law, Thermodynamic functions of a Completely and strongly Degenerate Fermi Gas, Fermi Energy, Electron gas in a Metal, Specific Heat of Metals, Relativistic Fermi gas (Qualitative Idea), White Dwarf Stars, Chandrasekhar Mass Limit.

(10 Lectures)

Reference Books:

i. Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2nd Ed., 1996, Oxford University Press.
ii. Statistical Physics, Berkeley Physics Course, F. Reif, 2008, Tata McGraw-Hill.
iii. Statistical and Thermal Physics, S. Lokanathan and R.S. Gambhir. 1991, Prentice Hall.
iv. Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Francis W. Sears and Gerhard L. Salinger, 1986, Narosa.
v. Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer.
vi. An Introduction to Statistical Mechanics & Thermodynamics, R.H. Swendsen, 2012, Oxford Univ. Press.

PHSHCC602P

Contact Hours: 60

Full Marks = 30 Pass Mark = 12 ESE Time = 3 hours

(One experiment to be performed at the time of ESE)

Use C/C++/FORTRAN/ Scilab/ Python/Matlab/Mathematica/others to solve the following problems:

1. Computation of the partition function $Z(\beta)$ for examples of systems with a finite number of single particle levels (e.g., 2 level, 3 level, etc.) and a finite number of non-interacting particles N under Maxwell-Boltzmann, Fermi-Dirac and Bose-Einstein statistics:
   - **a.** Study of how $Z(\beta)$, average energy $\langle E \rangle$, energy fluctuation ΔE, specific heat at constant volume C_v, depend upon the temperature, total number of particles N and the spectrum of single particle states.
   - **b.** Ratios of occupation numbers of various states for the systems considered above
   - **c.** Computation of physical quantities at large and small temperature T and comparison of various statistics at large and small temperature T.

2. Plot Planck's law for Black Body radiation and compare it with Raleigh-Jeans Law at high temperature and low temperature.

3. Plot Specific Heat of Solids (a) Dulong-Petit law, (b) Einstein distribution function, (c) Debye distribution function for high temperature and low temperature and compare them for these two cases.

4. Plot the following functions with energy at different temperatures
   - **a.** Maxwell-Boltzmann distribution
   - **b.** Fermi-Dirac distribution
   - **c.** Bose-Einstein distribution

Reference Books:

i. Elementary Numerical Analysis, K. E. Atkinson, 3rd Edn. 2007, Wiley India Edition.
ii. Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2nd Ed., 1996, Oxford University Press.
iii. Introduction to Modern Statistical Mechanics, D. Chandler, Oxford University Press, 1987.
iv. Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Francis W. Sears and Gerhard L. Salinger, 1986, Narosa.
v. Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer.
vi. Statistical and Thermal Physics with computer applications, Harvey Gould and Jan Tobochnik, Princeton University Press, 2010.
vii. Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández. 2014 Springer ISBN: 978-3319067896.
viii. Scilab by example: M. Affouf, 2012. ISBN: 978-1479203444.
ix. Scilab Image Processing: L.M.Surhone. 2010, Betascript Pub., ISBN: 978-6133459274.
x. Mathematica by Stephen Wolfram (Publisher: Wolfram Media, 1996).

PHSDSE601T (A): ASTRONOMY & ASTROPHYSICS

Contact Hours: 90

Full Marks = 100 [ESE (70) CCA(30)]

Pass Marks = 40 [ESE (28) CCA (12)]

(Two questions of 14 marks will be set from each unit, one needs to be answered from each unit)

Unit 1: Basic concepts of positional astronomy

Celestial Sphere, Geometry of a Sphere, Spherical Triangle, Astronomical Coordinate Systems, Geographical Coordinate Systems, 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.

(20 Lectures)

Unit 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). **(15 Lectures)**

Unit 3: Sun

The sun: Solar Parameters, Solar Photosphere, Solar Atmosphere, Chromosphere. Corona, Solar Activity.

The solar family (Solar System: Facts and Figures, Origin of the Solar System: The Nebular Model, Tidal Forces and Planetary Rings.

Stellar spectra and classification Structure (Atomic Spectra Revisited, Stellar Spectra, Spectral Types and Their Temperature Dependence, Black Body Approximation, H R Diagram.)

(18 Lectures)

Unit 4: The milky way

Galaxy Morphology, Hubble's Classification of Galaxies, Basic Structure and Properties of the Milky Way, Nature of Rotation of the Milky Way Stars and Star Clusters of the Milky Way, Properties of and around the Galactic Nucleus. **(15 Lectures)**

Unit 5: Large scale structure & expanding universe

Cosmic Distance Ladder (An Example from Terrestrial Physics, Distance Measurement using Cepheid Variables), Hubble's Law (Distance- Velocity Relation), Virial theorem and Introduction to Dark Matter, Big-bang theory. **(12 Lectures)**

Tutorials: 15 hours

Reference Books:

i. Modern Astrophysics, B.W. Carroll & D.A. Ostlie, Addison-Wesley Publishing Co.
ii. Introductory Astronomy and Astrophysics, M. Zeilik and S.A. Gregory, 4th Edition, Saunders College Publishing.
iii. The physical universe: An introduction to astronomy, F.Shu, Mill Valley: University Science Books.
iv. Fundamental of Astronomy (Fourth Edition), H. Karttunen et al. Springer
v. Baidyanath Basu, 'An introduction to Astro physics', Second printing, Prentice -Hall of India Private limited, New Delhi,2001.
vi. Textbook of Astronomy and Astrophysics with elements of cosmology, V.B. Bhatia, Narosa Publication.

PHSDSE601T (B): NANO-MATERIALS AND APPLICATIONS

Contact Hours: 90

Full Marks = 100 [ESE (70) CCA(30)]

Pass Marks = 40 [ESE (28) CCA (12)]

(Two questions of 14 marks will be set from each unit, one needs to be answered from each unit)

Unit 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. **(15 Lectures)**

Unit 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. (**15 Lectures**)

Unit 3:

Characterization: X-Ray Diffraction. Optical Microscopy. Scanning Electron Microscopy. Transmission Electron Microscopy. Atomic Force Microscopy. Scanning Tunneling Microscopy. **Electron transport**: Carrier transport in nanostrcutures. Coulomb blockade effect, thermionic emission, tunneling and hoping conductivity. Defects and impurities: Deep level and surface defects. **(15 Lectures)**

Unit 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. **(15 Lectures)**

Unit 5:

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). **(15 Lectures)**

Tutorials: 15 hours

Reference Books:

i. C.P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology (Wiley India Pvt. Ltd.).
ii. S.K. Kulkarni, Nanotechnology: Principles & Practices (Capital Publishing Company).
iii. K.K. Chattopadhyay and A.N. Banerjee, Introduction to Nanoscience & Technology (PHI Learning Private Limited).
iv. Richard Booker, Earl Boysen, Nanotechnology (John Wiley and Sons).
v. C.P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology (Wiley India Pvt. Ltd.).
vi. S.K. Kulkarni, Nanotechnology: Principles & Practices (Capital Publishing Company).
vii. K.K. Chattopadhyay and A. N. Banerjee, Introduction to Nanoscience and Technology (PHI Learning Private Limited).
viii. Richard Booker, Earl Boysen, Nanotechnology (John Wiley and Sons).
ix. M. Hosokawa, K. Nogi, M. Naita, T. Yokoyama, Nanoparticle Technology Handbook (Elsevier, 2007).
x. Introduction to Nanoelectronics, V.V. Mitin, V.A. Kochelap and M.A. Stroscio, 2011, Cambridge University Press.
xi. Bharat Bhushan, Springer Handbook of Nanotechnology (Springer-Verlag, Berlin, 2004).

PHSDSE602T (A): DISSERTATION

Contact Hours: 90

Full Marks = 100 [ESE (70) CCA(30)]

Pass Marks = 40 [ESE (28) CCA (12)]

A project of 100 marks to be done on topics in/related to any advanced theoretical/ experimental/ computational Topics under the supervision of one of the course teachers.

End semester exam will comprise of presentation (40 marks) as well as evaluation of the Report (30 marks) by an external examiner.

PHSDSE602T (B): PHYSICS OF DEVICES AND COMMUNICATION

Contact Hours: 90

Full Marks = 100 [ESE (70) CCA(30)]

Pass Marks = 40 [ESE (28) CCA (12)]

(Two questions of 14 marks will be set from each unit, one needs to be answered from each unit)

Unit 1:

Devices: Characteristic and small signal equivalent circuits of UJT and JFET. Metal-semiconductor Junction. Metal oxide semiconductor (MOS) device. SiO2-Si based MOS. MOSFET– their frequency limits. Enhancement and Depletion Mode MOSFETS, Tunnel diode. **(15 Lectures)**

Unit 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.

Multivibrators: Astable and Monostable Multivibrators using transistors.

Phase Locked Loop (PLL): Basic Principles, Phase detector, Voltage Controlled Oscillator (Basics, Varactor). **(15 Lectures)**

Unit 3:

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. **(15 Lectures)**

Unit 4:

Digital Data Communication Standards: Universal Serial Bus (USB): USB standards, Types and elements of USB transfers.

Parallel Communications: General Purpose Interface Bus (GPIB), GPIB signals and lines, Handshaking and interface management, Implementation of a GPIB on a PC. Basic idea of sending data through a COM port. **(15 Lectures)**

Unit 5:

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 and Pulse modulation. **(15 Lectures)**

Tutorial: 15 hours

Reference Books:

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