SRI DHARMASTHALA MANJUNATHESHWARA COLLEGE, UJIRE-574240

(Autonomous)

(Re-Accredited by NAAC at 'A' Grade with CGPA 3.61 out of 4)

DEPARTMENT OF PG STUDIES AND RESEARCH IN PHYSICS

SYLLABUS

(With effect from 2019-20)

SRI DHARMASTHALA MANJUNATHESHWARA COLLEGE, UJIRE-574240

(Autonomous)

(Re-Accredited by NAAC at ‘A’ Grade with CGPA 3.61 out of 4)

DEPARTMENT OF PG STUDIES AND RESEARCH IN PHYSICS

Syllabus of

Masters’ Degree in

PHYSICS

(CHOICE BASED CREDIT SYSTEM)

2019- 2020 onwards.

Approved by the BOS meeting held on 31th August, 2019

Academic Council meeting, held on 10-10-2019

PREAMBLE

Revision of syllabus for the two years' Master Degree Programme in Physics

Board of Studies in Physics has revised and prepared the Syllabus (CBCS scheme) for the Physics course in its meeting held on 31th August, 2019 based on the UGC letter (Ref, No. MU/ACC/CR.38/CBCS (PG)/2015-16 dated 05-05-2016) to offer Hardcore, Softcore and Open Elective courses with total 92 credits for the entire programme.

The BOS has prepared the syllabus by adopting the pattern of 13 hardcore and 10 softcore along with one project. Total credits for hardcore is 48, softcore is 34, 4 for project and 6 credits for open elective.

Detailed syllabus is prepared for all the four semesters

Course Credit Pattern

Semester	Theory (Hard core)	Credits	Practical (Soft/ Hard)	Credits	Theory (Elective) Soft	Credits	Theory (Open Elective)	Credits	Project (Hard /Soft)	Credits	Total Credits
I	4 H	4 x 4 = 16	2 S	6	-	-	-	-	-	-	22
II	4 H	4 x 4 = 16	2 S	6	-	-	1	3*	-	-	25
III	2 H	2 x 4 = 8	2 S	6	2 S	2 x 4 = 8	1	3*	-	-	25
IV	2 H	2 x 4 = 8	-	-	2 S	2 x 4 = 8	-	-	1 H	4	20
Total credit from all the four semesters (I, II, III and IV): 22 + 25 + 25 + 20 = **92**											

Details of course and credits for four semesters:

Hardcore Credits with %	Softcore Credits with %	Total Credits Hard + Soft without Open Elective	Open Elective Credits	Total Credits Hard + Soft + Open Elective
52 (60.47)	34 (39.53)	86	6*	86 + 6* = 92

Total credits from all the four semesters = 86+6*= 92

Total hardcore credits = 48

Project (Hardcore) Credits = 04

Total Softcore credits = 34

Open elective credits = 6*

Open electives are graded and not included in the CGPA.

NOTE:

FIRST SEMESTER: The first semester consists of four theory courses which are hardcore (4 hours per week for each course and shall carry 4 credits for each course) and two practicals (softcore 6 hours per week for each practical course and each practical course carries 3 credits). The duration of the lab is 3 hours. The students have to come twice a week for each of the practical course. Two hours of seminars/tutorials/skill components per week.

SECOND SEMESTER: The second semester consists of four theory courses which are hardcore (4 hours per week for each course and shall carry 4 credits for each of the course) and two practical (softcore 6 hours per week for each practical course and each practical course shall carry 3 credits). The duration of the lab is 3 hours. The students have to come twice a week for each of the practical course. In addition there shall be an open elective course to be opted by the student from other departments. The open elective course is a softcore course (3 hours per week and shall carry 3 credits). Two hours of seminars/tutorials/skill components per week.

THIRD SEMESTER: The third semester consists of four theory courses, two general theory courses and two elective courses. The elective courses are offered in each of the two specializations, condensed matter physics and electronics. The two general courses are hardcore (4 hours per week and shall carry 4 credits). The two elective courses offered in each of the two specializations are softcore courses (4 hours per week and shall carry 4 credits). The two practical courses for each of the above mentioned specialization are softcore courses (6 hours per week and shall carry 3 credits for each of the practical course). The duration of the lab is 3 hours for each practical. The students have to come twice a week for each of the practical courses. In addition there is an open elective course to be opted by the student from other departments. The open elective is a softcore course (3 hours per week and shall carry 3 credits). Two hours of seminars/tutorials/skill components per week.

FOURTH SEMESTER: The fourth semester consists of four theory courses, two general theory courses and two elective courses. The elective courses are offered in each of the two specializations, condensed matter physics and electronics. The two general courses are hardcore (4 hours per week and shall carry 4 credits). The two elective courses offered in each of the two specializations are softcore courses (4 hours per week and shall carry 4 credits). There shall be a compulsory project work which has to be under taken by all the students of the fourth semester. The project work is a hardcore having 8 hours per week with 4 credits. Two hours of seminars/tutorials/skill components per week.

SDM COLLEGE (AUTONOMOUS), UJIRE

M Sc DEGREE PROGRAMME IN PHYSICS

CONTENT OF THE COURSE AND SCHEME OF EXAMINATION

Semester	Theory/ Practicals	Exam Hours	Marks End Semester + Internal Assessment	Credits	Total
I	4 Theory courses (Hardcore)	3 hrs each	70 + 30* each	4 x 4 = 16	400
	2 Practicals (Softcore)	3 hrs each	70 + 30* each	2 x 3 = 6	200
II	4 Theory courses (Hardcore)	3 hrs each	70 + 30* each	4 x 4 = 16	400
	2 Practicals (Softcore)	3 hrs each	70 + 30* each	2 x 3 = 6	200
	1 Open Elective (Theory)	3 hrs	70 + 30*	1 x 3 = 3	100
III	4 Theory courses i) 2 Hardcore (4 Credits) ii) 2 Softcore (4 Credits)	3 hrs each	70 + 30* each	2 x 4 = 8 2 x 4 = 8	400
	2 Practicals (Softcore)	3 hrs each	70 + 30* each	2 x 3 = 6	200
	1 Open Elective (Theory)	3 hrs	70 + 30*	1 x 3 = 3	100
IV	4 Theory courses i) 2 Hardcore (4 Credits) 2 Softcore (4 Credits)	3 hrs each	70 + 30* each	2 x 4 = 8 2 x 4 = 8	400
	Project (Hardcore)		100	1 x 4 = 4	100
Grand Total					**2500**

*Internal Assessment

NOTE:

BASIS FOR INTERNAL ASSESSMENT: Internal assessment marks in theory courses shall be based on two tests in each theory course, attendance, assignments, seminars and the total internal assessment marks for each course is 30. Practical internal assessment marks is based on model examination, viva-voce, practical records and regular practical performance in the semesters and carries 30 marks for each practical course.

PROJECT REPORT: There shall be a project in the fourth semester for all the two specializations. The project report shall be in the form of a project report/dissertation and carries 100 marks and has 4 credits. A dissertation/project report shall be evaluated by two examiners, one external and one internal from out of the panel of examiners prepared by the B.O.S.

M Sc DEGREE PROGRAMME IN PHYSICS: SEMESTER SCHEME

(Effective from the Academic year 2019- 2020)

COURSE PATTERN AND SCHEME OF EXAMINATION

SEMESTER	Description of the courses	Teaching Hrs/ week	Credit Hard(H)/Soft(S)/ Open elective(OE)	Max Marks: Exam + IA = Total
I SEMESTER				
PHH 401	Methods of Mathematical Physics – I	4	4 H	70 + 30
PHH 402	Quantum Mechanics I	4	4 H	70 + 30
PHH 403	Classical Mechanics	4	4 H	70 + 30
PHH 404	Electrodynamics	4	4 H	70 + 30
PHP 405	Physics Practicals I (General)	6	3 S	70 + 30
PHP 406	Physics Practicals II (General)	6	3 S	70 + 30
II SEMESTER				
PHH 451	Mathematical Physics II and C Programming	4	4 H	70 + 30
PHH 452	Quantum Mechanics II	4	4 H	70 + 30
PHH 453	Nuclear and Radiation Physics	4	4 H	70 + 30
PHH 454	Condensed Matter Physics and Electronics	4	4 H	70 + 30
PHE 455	Natural Phenomena and Energy Sources	3*	3S (OE)	70 + 30
PHP 456	Physics Practicals III (General)	6	3 S	70 + 30
PHP 457	Physics Practicals IV (Electronics)	6	3 S	70 + 30

SEMESTER	Description of the courses	Teaching Hrs/ week	Credit Hard(H)/Soft(S) /Open elective(OE)	Max Marks: Exam + IA = Total
III SEMESTER				
PHH 501	Atomic and Molecular Physics	4	4 H	70 + 30
PHH 502	Thermodynamics and Statistical Physics	4	4 H	70 + 30
PHS 503	Condensed Matter Physics I	4	4 S	70 + 30
PHS 504	Electronics I	4	4 S	70 + 30
PHS 505	Condensed Matter Physics II	4	4 S	70 + 30
PHS 506	Electronics II	4	4 S	70 + 30
PHE 507	Applied Physics	3*	3 S (OE)	70 +30
PHP 508	Condensed Matter Physics - Practicals I	6	3 S	70 + 30
PHP 509	Electronics - Practicals I	6	3 S	70 + 30
PHP 510	Condensed Matter Physics - Practicals II	6	3 S	70 + 30
PHP 511	Electronics - Practicals II	6	3 S	70 + 30
IV SEMESTER				
PHH 551	Lasers, Vacuum Techniques and Cryogenics	4	4 H	70 + 30
PHH 552	Astrophysics and Relativity	4	4 H	70 + 30
PHS 553	Condensed Matter Physics III	4	4 S	70 + 30
PHS 554	Electronics III	4	4 S	70 + 30
PHS 555	Condensed Matter Physics IV	4	4 S	70 + 30
PHS 556	Electronics IV	4	4 S	70 + 30
PHP 557	Project work (with viva)	8	4 H	100

I SEMESTER

PHH 401: METHODS OF MATHEMATICAL PHYSICS I

Teaching hours: 4 per week

No of credits: 4

Objectives & Skill Components:

- To acquaint the students with various mathematical techniques used in Physics
- To familiarize the notations, symbols & terminologies associated with (Mathematical) Physics
- To teach the mathematical principles involved in solving problems in Physics
- To acclimatize the various applications of mathematical methods of Physics

Unit I– Vector analysis and curvilinear coordinates: 13 hrs.

Integration of vector functions - line integrals, surface integrals and volume integrals – Mention of vector theorems (Gauss, Green's and Stokes') and their applications in physics. Generalized coordinates - elements of curvilinear coordinates - transformation of coordinates - orthogonal curvilinear coordinates - unit vectors - expression for arc length, volume element. The gradient, divergence and curl in orthogonal curvilinear coordinates. Laplacian in orthogonal curvilinear coordinates, spherical polar coordinates, cylindrical coordinates.

Unit II - Complex analysis: 13 hrs.

Review of functions of a complex variable–Cauchy Riemann conditions. Contour integrals. Cauchy integral theorem, Cauchy integral formula. Taylor and Laurentz series. Zero isolated singular points, simple pole, m^{th} order pole. Cauchy's residue theorem. Cauchy principle value. Evaluation of different forms of definite integrals. A digression on Jordan's lemma.

Unit III – Partial differential equations: 13 hrs.

Review of differential equations. First order partial differential equations for a function of two variables. Linear second order partial differential equations. Classification into elliptic, parabolic and hyperbolic types. Boundary value problems - solutions by method of separation of variables - solution of 1, 2& 3- dimensional wave equation and diffusion equation in Cartesian, plane, cylindrical and spherical polar coordinates.

Unit IV – Special functions: 13 hrs.

Review of power series method for ordinary differential equations– description of beta and gamma functions. Bessel's functions–solution of Bessel's equation- generating function and recurrence relations–orthogonality of Bessel functions. Legendre polynomials – solution of Legendre equation–generating function and recurrence relations– orthogonality of Legendre polynomials. Solution of Hermite equation – Hermite polynomials – generating functions and recurrence relations. orthogonality of Hermite's polynomials.

Textbooks:

1. Arfken G, 'Mathematical Methods for Physicists' (Academic Press)
2. Chattopadhyaya P K, 'Mathematical Physics' (Wiley Eastern, 1990)

Reference books:

1. Harper C, 'Introduction to Mathematical Physics' (PHI, 1978)
2. Harry Lass, 'Vector and Tensor Analysis' (McGraw Hill, 1950)
3. Mary L Boas, 'Mathematical Methods in the Physical sciences' (John Wiley)
4. Joshi A W, 'Matrices and Tensors in Physics' (Wiley Eastern, 1995)
5. Ayres F, 'Differential Equations' (Schaum series, McGraw Hill)
6. Spiegel M R, 'Vector Analysis' (Schaum series, McGraw Hill, 1997)
7. Ayres F, 'Differential Equations' (Schaum series, McGraw Hill)
8. Sneddon I A, 'Elementary Partial Differential Equations' (McGraw Hill, 1957)
9. Bose A K and Joshi M C, 'Methods of Mathematical Physics' (McGraw Hill)
10. Sokolnikoff and Redheffer, 'Mathematics of Physics and Modern Engineering, (McGraw Hill, 1958)
11. Irving J and Mullneu N, 'Mathematics in Physics and Engineering' (Academic Press, 1959)
12. Kreysig E, 'Advanced Engineering Mathematics' (Wiley Eastern, 1969)
13. Mathews J and Walker R L, 'Mathematical Methods of Physics' (W A Benjamin, Inc, 1979).
14. Joglekar.S, 'Mathematical Physics Vol 1&2' (Universities Press, 2005).
15. Shankar Rao, "Partial Differntial Equations" (PHI Learning Pvt. Ltd., 2010).

PHH 402: QUANTUM MECHANICS I
Teaching hours: 4 per week
No of credits: 4

Objectives & Skill Components:

- To introduce the students to the world of microscopic particles and their *seemingly* bizarre nature
- To familiarize them to the limitations of Classical, Newtonian laws
- To teach the laws of the micro-world, its nature and implications
- To teach them the scope, nature and interpretation of the quantum world.

Unit I - General formulation of quantum mechanics: 13 hrs.

Review of basic concepts, Schrodinger's equation & probability interpretation, principle of superposition, normalisation, equation of continuity, Wave packet and uncertainty relations, postulates of QM, states & dynamical variables, operators & expectation values, eigenvalues & eigenfunctions, Ehrenfest theorem & its physical implication, Schrodinger equation as an eigenvalue problem, Dirac delta function, completeness & normalisation of eigenfunctions, closure, expansion coefficients.

Unit II– Matrix formalism of quantum mechanics: 13 hrs.

Linear vector spaces & its properties - orthogonality and linear independence, bases and dimensions, completeness, Hilbert space, Hermiticity & Hermitian operators, Unitarity & unitary operators. Bra & Ket notation, Schwarz inequality, generalised uncertainty relation, time evolution & quantum equations of motion- Schrodinger & Heisenberg pictures, Interaction picture (qualitative), Solution of the Linear Harmonic Oscillator with Operator Method.

Unit III – Stationary states and eigenvalue problems: 13 hrs.

The time independent Schrodinger equation - particle in square well - bound states - normalised states. Potential step and rectangular potential barrier - reflection and transmission coefficients - tunnelling of particles. Simple harmonic oscillator - Schrödinger equation and its energy eigen values and eigen functions. Properties of stationary states.

Unit IV – Angular momentum, parity and bound state problem: 13 hrs.

Angular momentum operators, eigen value equation for L^2 and L_z-Separation of variables. Admissibility conditions on solutions - eigen values, eigen functions. Physical interpretation. Concept of parity. Rigid rotator. Particle in a central potential-radial equation. Three-dimensional square well. The hydrogen atom - solution of the radial equation - energy levels. Stationary state wave functions -bound states.

Textbooks:

1. Ghatak A K and Lokanathan S, 'Quantum Mechanics', III Edn. (McMillan India, 1985)
2. Shankar R, 'Principles of Quantum Mechanics' (Plenum, 1980)
3. Griffith D. J., 'Quantum Mechanics', (Pearson Education Inc, 2005)
4. Merzbacker, 'Quantum Mechanics', (Wiley,1998)

Reference books:

1. Powell and Crassman, 'Quantum Mechanics'(Addison Wesley, 1961)
2. Mathews P M and Venkatesan K, 'A Text Book of Quantum Mechanics' (Tata McGraw Hill, 1977)
3. Sakurai J J, 'Modern Quantum Mechanics', Revised Edn. (Addison Wesley, 1994)
4. Cohen Tannoudji C, Diu B and Laloe, 'Quantum Mechanics', Vol. I (John Wiley, 1977)
5. Schiff L I, 'Quantum Mechanics', III Edn. (McGraw Hill)
6. French A P and Taylor E F, `An introduction to Quantum Physics' (W W Norton, 1978)
7. Gasirowicz, 'Quantum Physics' (Wiley, 1974)
8. Wichmann E H, 'Quantum Physics' (McGraw Hill, 1971)
9. V Devanathan, 'Quantum Mechanics', (Alpha Science International, 2011)
10. Arul Das, 'Quantum Mechanics', (PHI Learning Pvt. Ltd., 2010)
11. Zettili, 'Quantum Mechanics', (Wiley, 2009)
12. Liboff, 'Quantum Mechanics', (Pearson Education Inc, 2009)

PHH 403: CLASSICAL MECHANICS
Teaching hours: 4 per week
No of credits: 4

Objectives & Skill Components:

- Basic principles of classical physics such as space, time, mass, force and equation of motion of body serve as foundation to modern topics like quantum mechanics, nuclear physics, solid state physics, electronics etc.

Unit I - System of particles and Lagrangian formulation: 13 hrs.

System of Particles: Centre of mass, total momentum, angular momentum and kinetic energy of a system of particles, Newton's laws, conservation of linear momentum, angular momentum and energy.

Lagrangian Formulation: Constraints and their classification, degree of freedom, generalized co-ordinates, virtual displacement, D'Alembert's principle

Symmetry of space and time: Conservation of linear momentum, angular momentum and energy.

Unit II - Hamiltonian formalism and canonical transformations: 13 hrs.

Hamiltonian formalism: Generalized momenta, Hamiltonian function, Physical significance and the Hamilton's equations of motion, Examples of (a) The Hamiltonian of a particle in a central force field, (b) the simple harmonic oscillator. Principle of least action: derivation of equation of motion, variation and end points.

Canonical transformations: Generating functions (four basic types), examples of canonical transformations, the Harmonic oscillator in one dimension, Poisson brackets, equations of motion in terms of Poisson brackets, properties of Poisson brackets (anti-symmetry, linearity and Jacobi Identity), The Hamilton-Jacobi equation, Solution of linear harmonic oscillator using Hamilton-Jacobi method.

Unit III - Central forces: 13 hrs.

Definition and characteristics. Reduction of two particle equations of motion to the equivalent one-body problem, reduced mass of the system, conservation theorems (First integrals of the motion), equations of motion for the orbit, classification of the orbits, conditions for closed orbits, stability of orbits, Kepler's laws of planetary motion. Newton's law of gravitation.

Unit IV - Non-linear dynamics: 13 hrs.

Classification of dynamical systems- conservative systems, integrable systems. Kolmogorov-Arnold-Moser theorem (qualitative). Hamiltonian chaos. Dissipative systems, continuous systems, Duffing oscillator, discrete systems, Logistic map, fixed points, period doubling, limit cycles, chaotic attractors – Lyapunov exponent, fractal dimensions, fractals, Koch curve.

Synchronization in dynamical systems, Winfree and Kuramoto models (qualitative), phase coupled oscillators, stability and equilibrium, critical points, various applications.

Textbooks:

1. Goldstein H, ‘Classical Mechanics’, II Edn. (Wiley Eastern, 1985)
2. Takwale R G and Puranik P S, ‘Introduction to Classical Mechanics’ (Tata McGraw Hill, 1979)
3. J C Upadhyaya, “Classical Mechanics”

Reference books:

1. Rana N C and Joag P S, ‘Classical Mechanics’ (Tata McGraw Hill, 1991)
2. Sommerfeld A, ‘Mechanics’ (Academic Press, 1964)
3. Chaos in Classical and Quantum Mechanics – M C Gutzwiller
4. Chaotic Dynamics- An Introduction – G L Baker and J P Gollub
5. Deterministic Chaos – N Kumar, University Press

404: ELECTRODYNAMICS
Teaching hours: 4 per week
No of credits: 4

Objectives & Skill Components:

- Electromagnetism explains about basic topics such as Maxwell's equations, Planewave solutions, electrostatics, magnetostatics fields etc.

Unit I – Electrostatics and magnetostatics: 13hrs.

Review of Gauss' law and applications, Electric Potential, Poisson's equations, Work, energy in electrostatics. Laplace's equations and its solution in one, two and three dimensional problems (Cartesian coordinates). Boundary conditions and uniqueness theorem. Method of images and applications. Multipole expansion. Electric dipole field, Field inside a dielectric.

Biot–Savart law and applications, Ampere's law and applications, Magnetic vector potential, Boundary conditions. Multipole expansion of vector potential. Review of magnetisation. Magnetic field inside matter.

Unit II – Electromagnetic waves 13hrs.

Review of Maxwell's equations, Electromagnetic wave equations, plane wave solution of EM wave. Propagation through linear media, reflection and transmission of electromagnetic waves: plane waves in conducting media, skin depth, dispersion of electromagnetic waves in non conductors, wave guides, transmission of electromagnetic waves in rectangular wave guide.

Unit III – Electromagnetic radiation and plasma physics: 13hrs.

Scalar and vector potentials. Gauge transformations. Coulomb gauge and Lorentz gauge. Energy and momentum in electrodynamics. Poynting Theorem. Retarded potentials. Electric and magnetic dipole radiation. Lienard-Wiechert potentials.

Plasma - definition, Debye shielding distance. Plasma confinement, Pinch effect, Plasma oscillations, Magnetic mirrors, Applications.

Unit IV- Polarization of EM waves 13hrs.

Polarization: Overview, Polarization states, Polarization ellipse, Polarization elements, Depolarization. Polarized light in nature: Stokes polarimeters, Polarized, partially polarized, and unpolarized light. Polarization of the sky.

Electromagnetic description of polarized light: Jones & Stokes vectors, Poincare sphere. Coherence, Interference of polarized light & Fresnel equations (qualitative).

Polarization Calculus & Applications: Jones & Mueller calculus, Depolarization, Pauli matrix decompositions and the structure of the polarization calculi.

Textbooks:

1. D.J. Griffiths, 'Introduction to Electrodynamics', III Edn. (PHI, 2003)
2. J.D. Jackson, 'Classical Electrodynamics' (Wiley eastern,2003)
3. E. Hecht, Optics, 2nd edn., Addison-Wesley (1987)

Reference books:

1. B.B. Laud 'Electromagnetics' (New age International PVT. LTD)
2. P. Lorrain and D. Corson, 'Electromagnetic field and waves'(CBS)
3. I.S Grant and W.R. Phillips 'Electromagnetism' (John Wiley and sons Ltd.)
4. Pramanik, 'Electromagnetism' (PHI,2010)
5. Reitz J R, Milord F J, Christy R W, 'Foundations of Electromagnetic Theory', III Edn. (Narosa Publishing House, 1990)
6. Purcell E M, `Electricity and Magnetism', II Edn. (McGraw Hill, 1985)
7. A.R. Choudhari, 'The Physics of fluids and plasmas' (Cambridge UP 1998)
8. Chen Francis, 'Plasma Physics', II Edn. (Plenum Press, 1984)
9. Bitten Court J A, 'Fundamentals of Plasma Physics' (Pergamon Press, 1988)
10. Paul Bellan, 'Fundamentals of Plasma Physics' (CUP 2006)
11. Harland G.Tompkins Thin & Eugene A. I., 'Handbook of Ellipsometry' (Springer).
12. Krauss John D, 'Electromagnetics', II Edn. (Tata McGraw Hill, 1973)
13. Singh R N, 'Electromagnetic Waves and Fields' (Tata McGraw Hill, 1991)
14. Masud Mansuripur, Classical Optics and its Applications, 2nd edn. (CUP, 2009)
15. Dennis Goldstein, Polarized Light, 3d Edition, (CRC Press, 2010)
16. Jay Damask, Polarization Optics in Telecommunications, (Springer, 2005)
17. C. Brosseau, Fundamentals of Polarized Light, (Wiley, 1998)
18. D. Kliger, J. Lewis, C. Randall, Polarized Light in Optics and Spectroscopy (1990)
19. R.M.A. Azzam, and N. M. Bashara, Ellipsometry and Polarized Light, 2nd edn. (North-Holland, Amsterdam, 1987)
20. P. Yeh and C. Gu, Optics of Liquid Crystal Displays, (John Wiley & Sons, 1999)
21. Fowles, G, Introduction to Modern Optics, 2nd edn., (Dover, 1989)

PHP 405: PHYSICS PRACTICALS I (General)
Teaching hours: 6 per week
No of credits: 3

1. Characteristics and efficiency of a GM counter.
2. Determination of energy gap of a semiconductor.
3. Susceptibility by Quinke`s method.
4. Modes of vibration of a fixed free bar.
5. To determine Young's modulus of given material.
6. Constant deviation Spectrometer
7. Ultrasonic Interferometer
8. Babinet Compensator

   *** Additional experiments may be included.**

PHP 406: PHYSICS PRACTICALS II (General)
Teaching hours: 6 per week
No of credits: 3

1. Clipper circuits.
2. Clamper circuits.
3. Inverting & non-inverting amplifiers.
4. V to I & I to V converter using opamp.
5. Active clipper & active clamper.
6. Phase-shift oscillator using opamp.
7. Intergrator & differentiator using opamp.
8. Collpit's oscillator.

*** Additional experiments may be included.**

II SEMESTER

PHH 451: MATHEMATICAL PHYSICS II AND C PROGRAMING

Teaching hours: 4 per week

No of credits: 4

Objectives & Skill Components:

- To acquaint the students with various mathematical techniques used in Physics
- To teach the mathematical principles involved in solving problems in Physics
- To teach C, a very basic and important programming language
- To improve programming skills and understand how programming can be used in Physics.

Unit I - Tensor analysis and calculus: 13 hrs.

Introduction - rank of a tensor. Transformation of coordinates in linear spaces - transformation law for the components of a second rank tensor. Contravariant, covariant and mixed tensors - First rank tensor, higher rank tensors, symmetric and antisymmetric tensors. Tensor algebra - outer product - contraction - inner product - quotient law. The fundamental metric tensor - associate tensors. Levi Civita & Christoffel symbols, transformation laws. Covariant derivative of tensors. Tensors in Physics.

Unit II – Numerical Methods and Probability theory: 13 hrs.

Introduction and types of probability (with examples). Probability distributions- binomial, Poisson & normal; Standard, discrete & continuous distributions. Applications of probability.Numerical Techniques: Solution of a system of linear simultaneous equations: Gauss - Jordan method, Gauss-Seidel iterative method. Curve fitting: principles of least squares method. Examples (linear and general functions). Interpolation: Definition of interpolating polynomial - finite difference operators - Newton's forward and backward interpolation formulas with examples. Numerical integration - Simpson's $1/3^{rd}$ rule - examples. Runge - Kutta method of order 4 with examples.

Unit III - Fundamentals of problem solving, introduction to C: 13 hrs.

Prerequisites: Problem solving, phases of problem solving- definition, analysis, designing solution using Algorithm & flowcharts. Introduction to C language: Background, Structure of C program, creating & running C programs (with examples). C character set, C tokens, Identifiers, keywords, constants, variables, data types. Operators & Expressions: Arithmetic operators, Increment & Decrement, Relational, Assignment, logical, bitwise, special & conditional operators. Arithmetic & relational expressions, evaluating arithmetic expressions, precedence of operators, mathematical library functions [sqrt(), abs(), log()

etc:]. Input & output in C: Reading a character [getchar() etc:], writing a character [putchar()], formatted input [scanf()], formatted output [printf()]. Control statements: Definition, simple if, if..else, if..else..if (else if ladder), nested if, switch(), programing examples. Looping statements: Definition, while loop, do while loop, for loop, jump statement, programing examples.

Unit IV - Arrays, structures, functions & pointers: 13 hrs.

Arrays: One & two dimensional arrays, declaration, initialization, accessing array elements, programing examples. Strings: Declaration, Initialisation, string functions [strcpy(), strcat() etc:]. Structures: Definition, structure variable, accessing structure elements, array of structures, unions. Functions: Definition (syntax), function call, return type, function prototype, types of functions, local & global variables, programing examples. Pointers: Declaration of pointers, address operators, pointer arithmetic, pointers & arrays, pointers to function, array of pointers, dynamic memory allocation, programing examples.

Textbooks:

1. Joshi A W, 'Matrices & Tensors for Physicists' (Wiley Eastern, 1995)
2. Spiegel M R, 'Vector Analysis' (Schaum series, McGraw Hill)
3. Arfken & Weber, Methods of Mathematica Physics
4. E. Balaguruswamy , "ANSI C"

Reference books:

5. Chattopadhyaya P K, 'Mathematical Physics' (Wiley Eastern, 1990)
6.
7. Kryzig, Advanced Engineering Mathematics, Wiley
8. Sokolnikoff and Redheffer, 'Mathematics of Physics and Modern Engineering, (McGraw Hill, 1958)
9. Irving J and Mullneu N, 'Mathematics in Physics and Engineering' (Academic Press, 1959)
10. Mary L Boas, 'Mathematical Methods in the Physical Sciences' (John Wiley, 1983)
11. Mathews J and Walker R L, 'Mathematical Methods of Physics' (WA Benjamin, 1979)
12. Kernighan & Ritchie, "The C Programming Language"
13. Mullish & Cooper, "The Spirit of C"
14. Yashwant Kanetkar, "Let Us C "
15. P.B. Kotur , "Computer Concepts & C Programming "

PHH 452: QUANTUM MECHANICS II
Teaching hours: 4 per week
No of credits: 4

Objectives & Skill Components:

- To teach the laws of the micro-world, its nature and implications
- To teach them the scope, nature and interpretation of the quantum world
- To teach the students how quantum mechanical principles can be used in understanding the properties of matter
- To set the stage for them to explore advanced concepts in the subject

Unit I - Angular momentum: **13 hrs.**

Angular momentum Algebra– Angular momentum operator, commutation relations - raising and lowering operators - eigenvalues and eigenfunctions of L^2 and L_z (using ladder operators) - addition of two angular momenta, Spin angular momentum algebra, addition of spin angular momenta, eigenvalues & eigenfunctions of S^2 & S_z, Pauli spin matrices, spinors & spinor algebra(qualitative), Clebsch-Gordan coefficients, Wigner's 3j symbols.

Unit II- Approximation methods: **13 hrs.**

Perturbation theory for discrete levels - equations in various orders of perturbation theory - non-degenerate and degenerate cases, simple examples. Time dependent perturbation theory, Fermi golden rule, harmonic perturbation. The variation method - the hydrogen molecule - exchange interaction. The WKB method- tunnelling through a barrier, alpha decay (qualitative).

Unit III - Scattering theory: **13 hrs.**

Laboratory and center of mass frames, differential and total scattering cross-sections, scattering amplitude; Scattering by spherically symmetric potentials; Partial wave analysis and phase shifts; Relation between sign of phase shift and attractive or repulsive nature of the potential, Optical theorem. Applications of scattering.

Unit IV- Relativistic quantum mechanics & elements of second quantization: **13 hrs.**

Klein-Gordon equation for a free particle - Dirac equation - Dirac matrices - negative energy solution, spin and magnetic moment of the electron, free particle solution, non-relativistic limit. Dirac equation in a central field. Transition from particle to field theory, Second quantization of the Schrodinger equation. Creation and annihilation operators - commutation and anti-commutation relation and their physical implications.

Textbooks:

1. Thankappan V K, ‘Quantum Mechanics’ (Wiley Eastern Ltd., 1985)
2. Ghatak A K and Lokanathan S, ‘Quantum Mechanics’ (Macmillan, India, 1984)
3. Edmonds, ‘Angular Momentum in Quantum Mechanics’ (Princeton University Press, 1960)
4. V Devanathan, ‘Quantum Mechanics’, Narosa

Reference books:

1. Mathews P M and Venkatesan K, ‘Text Book of Quantum Mechanics’ (Tata McGraw Hill, 1976)
2. Powell J L and Crasemann B, ‘Quantum Mechanics’ (Addison Wesley, 1961)
3. Schiff L I, ‘Quantum Mechanics’, III Edn. (McGraw Hill, 1969)
4. Merzbecher E, ‘Quantum Mechanics’, III Edn. (John Wiley & Sons, 1998)
5. Shankar R, ‘Principles of Quantum Mechanics’ (Plenum, 1980)
6. Sakurai J J, ‘Modern Quantum Mechanics’ Revised Edn. (Addison-Wesley, 1994)
7. Arul Das, ‘A text book of Quantum Mechnics’, New Age
8. S N Biswas, ‘Text Book of Quantum Mechanics’

PHH 453: NUCLEAR AND RADIATION PHYSICS
Teaching hours: 4 per week
No of credits: 4

Objectives & Skill Components:

1. To have a basic knowledge of nuclear size, shape, bindingenergy.etc and also the
2. Characteristics of nuclear force in detail.
3. To be able to gain knowledge about various nuclear models and potentials associated.
4. To acquire knowledge about nuclear decay processes and their outcomes to have a wide
5. Understanding regarding beta and gamma decay.
6. To understand and quantify the effects of nuclear radiations in the environment.
7. To understand how various types of nuclear detector woks.
8. To grasp knowledge about Nuclear reactions, Fission and Fusion and their characteristics.
9. To understand the basic forces in nature and classification of particles and study in detail
10. Conservations laws and quark models in detail.
11. To identify and to quantify the high radiation matrices in the environment
12. To have hands on experience and knowledge of use of various nuclear detectors and calibration.
13. To practically gain the skills of use of nuclear medicines.
14. To gain the skills of protecting the public and themselves from nuclear accidents.
15. To gain the skills of removal of unwanted radiations from labs, hospitals and from environment.
16. To acquire the skills to review Nuclear and radiations physics research works.

Unit I - General properties of nucleus and nuclear decay: 13 hrs.

General properties of nucleus: Constituents of nucleus and their properties. Mass of the nucleus-binding energy. Charge and charge distribution. Nuclear radius from mirror nuclei - spin statistics and parity. Magnetic moment of the nucleus. Quadrupole moment.
Nuclear decay: Alpha decay - quantum mechanical tunnelling. Beta decay - continuous beta ray spectrum - neutrino hypothesis. Fermi's theory of beta decay - Kurie plots and ft-values - selection rules. Detection of neutrino - non-conservation of parity in beta decay. Gamma decay - selection rules - multipolarity - Internal conversion (qualitative only)

Unit II-Nuclear models, nuclear reactions and reactor physics: 13 hrs.

Nuclear models: Review of nuclear models - liquid drop model - semi empirical mass formula - stability of the nuclei against beta decay - mass parabola. Shell model.

Nuclear reactions: Cross section for a nuclear reaction. 'Q' equation of a reaction in laboratory system - threshold energy for a reaction. Centre of mass system for nucleus-

nucleus collision. Relation between angles and cross sections in lab and CM systems.

Reactor physics: fission chain reaction. Slowing down of neutrons - moderators. Conditions for controlled chain reactions in bare homogeneous thermal reactor. Critical size. Brief introduction of nuclear fuel cycle. Breeder Reactors.

Unit III - Interaction of radiation with matter, radiation detectors and ionising radiations: 13hrs.

Interaction of radiation with matter: Energy loss of heavy charged particles in matter, Bethe-Bloch formula (qualitative). Interaction of electrons with matter. Bremsstrahlung. Interaction of gamma rays with matter - photoelectric effect, Compton scattering, Klein-Nishina formula (qualitative discussion) and pair production processes.

Radiation detectors: Gas filled counters - general features - ionization chamber, proportional counter and GM counter. Scintillation detector – principle and working of NaI(Tl) gamma ray spectrometer. Semiconductor detector – principle and working of HPGe detector (qualitative).

Ionising radiations and applications: Sources of ionising radiations in the environment – natural, TENORM and artificial radiation sources. Radiation quantities and units. Production of radioisotopes in reactors. Application radioisotopes and ionising radiations.

Unit IV -Nuclear forces, particle physics and symmetries & conservation laws: 13 hrs.

Nuclear forces: Characteristics of nuclear force. Ground state of the deuteron using square well potential - relation between range and depth of the potential. Yukawa's theory of nuclear forces and explanation of anomalous magnetic moment of the nucleus.

Elementary particle physics: Classification of fundamental forces. Elementary particles and their quantum numbers (charge, spin, Types of interactions between elementary particles, hadrons and leptons

Symmetries and conservation laws: Conservation of energy, momentum, angular momentum, charge and isospin, parity, symmetry, handedness of neutrinos, Lepton number conservation, Lepton family and three generations of neutrinos. Charge conjugation symmetry, CP violation in weak interactions, Strange particles, conservation of strangeness in strong interactions, Baryon number conservation, Gell-Mann Nishijima formula, eight fold way (qualitative only), quark model, quark content of baryons and mesons.

Textbooks:

1. Ghoshal S N, ‘Atomic and Nuclear Physics’, Vol. I & II S Chand & Company, 1994.
2. Krane K S, ‘Introductory Nuclear Physics’ John Wiley, 1988.
3. Knoll G F, Radiation Detection and Measurement’, II Edn. John Wiley, 1989.

Reference books:

1. Segre E, ‘Nuclei and Particles’, II Edn. Benjamin, 1977.
2. Eisenbud M, ‘Environmental Radioactivity’, Academic Press, 1987.
3. Aruthur Beiser, ‘Concepts of Modern Physics’, McGraw-Hill, New York 2003
4. Patel S B, ‘Nuclear Physics - An Introduction’ Wiley Eastern, 1991.
5. Roy R K and Nigam P P, ‘Nuclear Physics - Theory and Experiment’ Wiley Eastern Ltd., 1993
6. Singru R M, ‘Experimental Nuclear Physics’ Wiley Eastern, 1972.
7. Zweifel P F, ‘Reactor Physics’, International Student Edn. McGraw Hill, 1973.
8. Kapoor S S and Ramamurthy V S, ‘Radiation Detectors’ Wiley Eastern, 1986.
9. I. S. Hughes, ‘Elementary Particles’ Cambridge (1991).
10. F. Halzen and A. D. Martin, ‘Quarks and Leptons’, John Wiley.
11. D. Griffiths: ‘Introduction to Elementary particles’, John Wiley, 1987.
12. J. M. Longo, II Edition, ‘Elementary Particles’, Mc Graw-Hill, New York, 1973.
13. D. Perkins, ‘Introduction to High Energy Physics’; Oxford University Press, 2005.
14. Abraham Seiden, ‘Introduction to particle physics’, Pearson, 2013

PHH 454: CONDENSED MATTER PHYSICS AND ELECTRONICS
Teaching hours: 4 per week
No of credits: 4

Objectives & Skill Components:

- To understand the elements of crystal diffraction & crystal structure.
- To understand the enormously rich behaviour of condensed matter systems under a wide variety of conditions.
- To understand the behaviour of systems consisting of combinations of the hundred or so elements in the form of solids, quantum dots, small clusters, liquids, and dense gases, and in which the multitude of constituent parts are all interacting with one another.
- To understand superconductivity and super fluidity.
- To know the operation and application of the analog building blocks like diodes, BJT, FET etc for performing various functions.
- To design various combinational and sequential circuits.
- To understand the basic concepts of operational amplifiers.

Unit I - Elementary crystallography & X-ray diffraction elementary crystallography: 13 hrs.

Concept of crystallography, unit cell, primitive and non-primitive, base, Bravais lattice in two and three dimension, crystal structure, coordination numbers, Miller indices, Crystal structures of NaCl, CsCl, diamond and copper. Close packing system.

X-ray diffraction**:** Scattering of X rays by an electron, by an atom and by a crystal. Atomic scattering factor, Bragg law. Geometric structure factor. Reciprocal lattice - its properties, Ewald's sphere - its construction. Laue and powder experimental methods.

Unit II - Free electron theory and band theory of solids: 13 hrs.

Free electron in one dimensional potential well, three dimensional potential well, quantum state and degeneracy, density of states, Fermi Dirac Statistics and distribution with temperature, free electron theory of metals, Fermi energy above 0 K, Electronic specific heat. Electrical conductivity of metal, Relaxation time and mean free path, Wiedemann-Franz law. Failures of free electron model. Kronig-Penney mode and Effective mass.

Classification of solids - metal, semiconductors, insulators. intrinsic and extrinsic semiconductors. Carrier concentration in intrinsic semiconductors (qualitative), impurity states-donor states, acceptor states. Electrical conductivity of semiconductor.

Unit III - Phasors and devices: 13 hrs.

Phasors - Phasor relations for R, L and C - Sinusoidal steady state response of a series RLC circuit. BJT, JFET and MOSFET devices. Voltage divider bias. Small signal analysis of BJT and FET amplifiers in CE/CS configuration. UJT characteristics and its use in a relaxation oscillator. SCR characteristics and its use in ac power control.

Unit III - Operational amplifiers and digital electronics: 13 hrs.

Operational amplifier - voltage/current feedback concepts (series & parallel). Inverting and noninverting configurations. Basic applications of opamps - comparator and Schmitt trigger. IC555 timer - monostable and astable multivibrators. Crystal oscillator using opamp. Voltage regulators – three terminal, Review of Boolean algebra, Simplification of Boolean functions using K-map, Tristate devices. Decoders and encoders. Multiplexers and demultiplexers with applications.

Textbooks:

1. Kittel C, 'Introduction to Solid State Physics', IV Edn. (Wiley Eastern, 1974)
2. Omar M A, 'Elementary Solid State Physics' (Addison Wesley, 1975)
3. M A Wahab " Solid State Physics" Narosa Publication, second edition 2005
4. Boylestad R L & Nashelsky L, 'Electronic Devices & Circuit Theory', VIII Edn. (Prentice Hall, 2002).
5. Floyd T L, 'Digital Fundamentals', VII Edn. (Pearson Education Asia, 2002).
6.

Reference books

1. Hayt W H, Kemmerly J E & Durbin S M, 'Engineering Circuit Analysis', VI Edn. (McGraw-Hill, 2002).
2. Boylestad R L, 'Introductory Circuit Analysis', VIII Edn. (Prentice Hall, 1997)
3. Floyd T L, 'Electronic Devices', V Edn. (Pearson Education Asia, 2001).
4. Gayakwad R A, 'Opamps and Linear Integrated Circuits', III Edn. (PHI, 1993).
5. Cullity B D and Stock S R, 'Elements of X-ray diffraction', III Edn. (PH, 2001)
6. Ashcroft F W & Mermin N D, 'Solid State Physics' (Harcourt, 1976)
7. Verma A R and Srivastava O N, 'Crystallography Applied to Solid State Physics', II Edn. (New Age, 1991)
8. McKelvey J P 'Solid State and Semiconductor Physics' (Robert E. Kreiger, 1982)
9. Dekker A J, 'Solid State Physics' (Macmillan, 1971).
10. Singh J, 'Semiconductor Devices' (John Wiley, 2001)
11. Alexander C K and Sadiku M N O, 'Fundamentals of Electric Circuits' (McGraw Hill International Edition, 2000)
12. Donald Neamen, 'Electronic Circuit Analysis and Design' II Edn. (Tata McGraw Hill, 2002)
13. Sedra A & Smith K C, 'Microelectronics', IV Edn. (Oxford University Press, India, 1998)
14. Horenstein M N, 'Microelectronic Circuits and Devices', II Edn. (PHI, 1996)
15. David Bell, 'Electronic devices and Circuits', 5th edition (Oxford, 2008)

PHE 455: NATURAL PHENOMENA AND ENERGY SOURCES (Open Elective)
Teaching hours: 3 per week
No of credits: 3

Objectives & Skill Components:

- To introduce the concepts of natural phenomena in a scientific perspective.
- To create awareness about energy sources.
- To teach the uses & applications of various energy sources.
- To practically demonstrate power generation and acquaint students with energy production.

Unit I - Our earth and nature: 13 hrs.

A discussion on length scales and dimensions, Galaxies, The solar system and Planet Earth, Rotation and revolution of the Earth, Seasons, Calendars in history and the recording of time. Clouds, lightning, cyclones, earthquake, Tsunami, Volcano. Laws of nature – a discussion of principles, theories and models, Gravitation, Planetary motion. Living matter.

Unit II - Energy sources: 13 hrs.

Renewable energy resources, Fossil fuels, time scale of fossil fuels and solar energy as an option. Solar energy for clean environment Sun as the source of energy and its energy transport to the Earth, solar radiations, Basics of the wind energy: Wind energy origin and classification of winds, Aerodynamics of windmill.

Biomass energy and biogas technology: Nature of biomass as a fuel, Biomass energy conversion processes, Direct combustion: heat of combustion, combustion with improved Chulha and cyclone furnace. Types of biogas plants, Applications of biogas.

Unit III - Basics of radiation physics: 13 hrs.

Radioisotopes, Production of radio nuclides, allocation of radioactive traces, isotopic tracer method. Assay using radioactive substances. Radiation biophysics: Radiation sources, Interaction of radiation with matter (general discussion), energy transfer process, measurement of radiation, Dosimetry, Biological effects of radiation, effect of radiation on living systems, radiation protection and radiation therapy.

Textbooks:

1. Essential of Biophysics– P. Narayanan, 2nd Edn. New Age International Publications, 2008.
2. Halliday D, Resnick R, Walker J, `Fundamentals of Physics', (VI Edn. Wiley NY, 2001)

Reference books:

1. Aspects of Biophysics- William Hughes, John Wiley and Sons, 1979
2. Biochemistry of Nucleic acids- Adams et al. Chapmann and Hall, 1992
3. Biophysics- Vasantha Pattabi and N. Goutham, Narosa Publishing House, New Delhi, 2002.
4. Biophysics- Cotterill.
5. Peter A., ‘Advances in energy systems and technology’,(Academic Press, USA, 1986).
6. Neville C.R., ‘Solar energy conversion: The solar cell’, (Elsevier North-Holland, 1978).
7. Dixon A.E. and Leslie J.D., ‘Solar energy conversion’, (Pergamon Press, New York, 1979) .
8. Ravindranath N.H., ‘Biomass, energy and environment’, (Oxford University Press, 1995).
9. Tom Duncan, `Electronics for Today and Tomorrow', (BPB Publications, 1997)
10. `Radiation Safety Manual', (Veterans A_airs, Palo Alto Health Care System, 2010)
11. D. P. Kothari, K. C. Singal, Rakesh Rajan, `Renewable Energy Sources And Emerging Technologies', (PHI Learning Pvt. Ltd., 2008)
12. Sharma S R `Disaster Management' (A P H publications-2011)
13. Desai A V, `Non conventinal energy', (ABP, 2008)
14. Prothero D S R, `Catastrophes', (John Hopkins University press)
15. G.S. Sawhney, `Non Conventional Resources of Energy', (PHI 2012)
16. Boxwell M, `Solar Electricity Handbook', (Greenstream Publishers, 2014)

PHP 456: PHYSICS PRACTICALS III (General)
Teaching hours: 6 per week
No of credits: 3

1. Study of beta ray attenuation in matter.
2. Gamma ray Spectrum of Cs-137
3. Ferroelectric Curie temperature
4. Quarter wave-plate.
5. To measure the variation of dielectric constant with temperature and verification of Curie Weiss law.
6. Study of mass attenuation using gamma source.
7. Determination of temperature sensitivity of thermocouple.
8. C programming (as many programs as possible).

*** Additional experiments may be included.**

PHP 457: PHYSICS PRACTICALS IV (Electronics)

Teaching hours: 6 per week

No of credits: 3

1. Astable & monostable multivibrator using IC 555
2. Comparator & Schmitt trigger using IC 741.
3. Binary to Gray & Gray to binary code converter.
4. UJT characteristics - relaxation oscillator.
5. Voltage regulator (with series pass transistor) / 3 pin regulator.
6. FET characteristics.
7. Encoder & decoder.
8. Multiplexer & demultiplexer.

***Additional experiments may be included.**

III SEMESTER

PHH 501: ATOMIC AND MOLECULAR PHYSICS

Teaching hours: 4 per week

No of credits: 4

Objectives & Skill Components:

- To understand the spectra of hydrogen, sodium etc. which is based on quantum mechanical principles.
- To understand X-ray spectrum and doublet structure of X-ray, theoretical explanations of fine and hyperfine structure.
- To explain spin of electron in both experimental and theoretical explanations. NMR and ESR.
- To learn about microwave spectra, infrared spectra, Raman spectroscopy, Mossbauer spectroscopy.
- To understand molecular spectroscopy.

Unit I - Spectra of single and multi electron atoms: 13 hrs.

Spectra of single and multi electron atoms: Review of atomic models. Simple spectra of hydrogen and hydrogen like ions - energy levels, quantum numbers, electron spin, Stern - Gerlach experiment, fine structure, total angular momentum, Spin-orbit coupling, hydrogen energy levels, relativistic correction, radiation corrections, transition rates, selection rules.

Exclusion principle, ground state of multi electron atoms, periodic table. Spectra of two valence atom - alkali spectra, term values, doublet structure, transition and intensity rules. Spectra of alkaline earth elements, triplet structure, penetrating and non-penetrating orbitals: LS and JJ coupling. Paschen-Back effect.

Unit II - X-ray spectra and resonance spectroscopy: **13 hrs.**

Review of emission & absorption of X-ray spectra (critical voltage, absorption coefficient, edge, filters) regular and irregular doublet law, Auger spectra. Spin and an applied field, nuclear magnetic resonance- principle, techniques & instrumentation, structural study. Electron spin resonance spectroscopy.

Unit III - Microwave spectra, infrared spectra and Raman spectroscopy: 13 hrs.

Theory of rotational spectra of diatomic molecules - Experimental technique – Microwave spectrometer, structural information.

Theory of vibrating rotator, vibration - rotation spectra, IR spectrometer. Application in chemical analysis (Qualitative).

Quantum theory of Raman effect. Rotational and vibrational Raman spectra. Raman spectrometer. Laser Raman studies. FT Raman spectroscopy (qualitative)

Unit IV - Electronic spectroscopy: 13 hrs.

Electronic spectra of diatomic molecules - coarse structure - Frank-Condon principle - rotational fine structure - formation of band head and shading of bands - determination of I, r and band origin.

Fluorescence and phosphorescence: mirror image symmetry of absorption and fluorescence bands. Basic principles of photoelectron spectra. Instrumentation. Determination of ionization potential.

Mossbauer spectroscopy: Principles of Mossbauer spectroscopy. Mossbauer spectrometer. Applications.

Textbooks:

1. HE White, 'Introduction to Atomic Spectra', McGraw-Hill (International Series in Pure and Applied Physics)

2. Banwell C N and E M McCash, 'Fundamentals of Molecular Spectroscopy', IV Edn. (Tata McGraw Hill, 1994)

Reference books:

1. Ghoshal S N, 'Atomic and Nuclear Physics', Vol. I & II (S Chand & Company, 1994)
2. Beiser A, `Concept of Modern Physics' V Edn. (Tata McGraw Hill, 1997)
3. Kuhn H G, 'Atomic Spectra', III Edn. (Benjamin, 1977)
4. Haken H & Wolf H C, 'Atomic and Quantum Physics', V Edn. (Springer-Verlag, 1997)
5. Henry Semat & John R AlBright, 'Introduction to Atomic and Nuclear Physics' V Edn. (Chapman & Hall, 1972)
6. Chatwall Gurdeep, 'Spectroscopy', III Edn. (Himalayas, 1994)
7. Robert Eisberg & R Resnick, 'Quantum Physics of Atoms, Molecules, Solids, Nuclei & Particles', II Edn. (John Wiley & Sons)
8. Straughan B P and Walker S, 'Spectroscopy', Vol. I, II and III (Chapmann & Hall, 1976)
9. Svanberg S, 'Atomic and Molecular Spectroscopy', II Edn. (Springer Verlag, 1992)
10. Herzberg, 'Molecular Spectra and Molecular Structure', Vol. I, II & III (Van Nostrand Co., 1966)

PHH 502: THERMODYNAMICS AND STATISTICAL PHYSICS
Teaching hours: 4 per week
No of credits: 4

Objectives & Skill Components:

- Explain the laws of thermodynamics and its applications.
- To understand and explain the physical significance of Maxwell thermodynamic relations.
- Explain statistical physics and thermodynamics as logical consequences of the postulates of statistical mechanics
- Apply the principles of statistical mechanics to selected problems
- Grasp the basis of ensemble approach in statistical mechanics to a range of situations
- To learn the fundamental differences between classical and quantum statistics and learn about quantum statistical distribution laws.
- Study important examples of ideal Bose systems and Fermi systems.
- To understand the theoretical demonstrations of fluctuations.
- To understand the time evolution of thermodynamic systems using non-equilibrium equation of motions.
- Skills to develop experiments form the knowledge of Thermodynamics laws
- Skills to develop simulation experiments to practically demonstrate the applications of statistical mechanics.
- Skills to solve numerical problems in statistical mechanics using python program.
- To acquire the skills to review a statistical physics and thermodynamics research works.
- Skills to apply statistical mechanics to interdisciplinary subjects like to study share market perditions.

Unit I - Thermodynamics: 13 hrs.

Concept of entropy - principle of entropy increase - entropy and disorder. Enthalpy – Helmoltz and Gibb's functions. Maxwell's relations - TdS equations - energy equations - Heat capacity equations - heat capacity at constant pressure and volume. Phase space and ensembles - Lioullis theorem, probability - thermal equilibrium.

Unit II - Classical statistics: 13 hrs.

Boltzmann distribution, calculation of velocities - average and r.m.s veleocities Gibbs' paradox, Sackur - Tetrode equation, partition functions - translational partition funciotn, vibrational, rotational and electronic partition functions. Boltzmann equipartition theorems. Application to specific heats.

Unit III - Quantum statistics: 13 hrs.

Bosons and Fermions - Bose-Einstein and Fermi-Dirac distributions - degenerate Fermi and Bose gases - Bose-Einstein condensation - Planck's law of black-body radiation. Liquid helium - Lambda transition.

Fluctuations - Fluctuations in canonical, grand canonical and microcanonical ensembles. Number fluctuations in quantum gases.

Unit IV - Brownian motion: 13 hrs.

Langevin equation for random motion, Random walk problem. Diffusion and Einstein relation for mobility.

Time dependence of fluctuations: power spectrum of fluctuations, persistence and correlation of fluctuations. Wiener - Khinchin theorem, Johnson noise and Nyquist theorem. Shot noise, Fokker-Planck equation.

Textbooks:

1. Zeemansky M W and Dittman R H, 'Heat and Thermodynamics', VII Edn. (McGraw Hill International Edn., 1999)
2. Gopal E S R, 'Statistical Mechanics and Properties of Matter' (Macmillan, 1976)
3. Agarwal B K and Melvine Eisner, 'Statistical mechanics' (Wiley Eastern Ltd., 1991)
4. Pathria RK, 'Statistical Mechanics', III Edn. (Associated Press)

Reference books:

1. Kittel C and Kroemer H, 'Thermal Physics', II Edn. (CBS Publ., 1980)
2. Chandler D, 'Introduction to Modern Statistical Mechanics' (Oxford university Press, 1987)
3. Reichl L E, 'A Modern Course in Statistical Physics' (University of Texas Press, 1980)
4. Landau and Lifshitz, 'Statistical Physics', III Edn. (Oxford, Pergamon, 1980)
5. Gupta M C, 'Statistical Thermodynamics' (New Age, 1995)
6. Reif F, 'Fundamentals of Statistical and Thermal Physics' (McGraw Hill, 1965)

PHS 503: CONDENSED MATTER PHYSICS I
Teaching hours: 4 per week
No of credits: 4

Objectives & Skill Components:

- To understand the basic concepts about crystal structures and symmetries.
- To understand the principle and applications of the phonons in crystal lattice.
- To understand the dielectric and optical properties of the crystals.
- To understand optical properties of the solids.

Unit I – Crystallography: 13 hrs.

Symmetries elements, translations vectors – screw axes and glide plane symmetries. Space groups – illustrations, Concept of point groups, Influence of symmetry on physical properties, derivation of equivalent point positions (with examples from triclinic and monoclinic systems), experimental determination of space group. Disordered solid structure - Amorphous solid, quasi crystal and liquid crystal.

Unit II - Elastic properties and thermal properties: 13 hrs.

Analysis of elastic strains and stresses, Elastic compliance and stiffness constants, Energy density, Cubic crystals and isotropic solids, Elastic waves in cubic crystals, Experimental determination of elastic constants.

Thermal properties of insulators, Normal modes of diatomic lattice, Phonon momentum, Inelastic scattering of photons and neutrons by phonons, Thermal expansion, Lattice thermal conductivity - normal and Umklapp processes.

Unit III - Dielectric and ferroelectric properties of solids: 13 hrs.

Dielectric : Polarization, Dielectric susceptibility, Dielectric constant, Complex dielectric constant, Dielectric loss and loss angle. Local electric field, Polarizability, Clausius - Mossotti relation, Electronic, ionic and dipolar polarizability. Frequency dependent dielectric function, Dipole orientation in solids, Langevin function, Debye relaxation time.

Ferroelectrics: Basic properties of ferroelectrics, Classification, Barium titanate, Thermodynamics of paraelectric - ferroelectric transition, ferroelectric domain, Polarization catastrophe, Antiferroelectricity. Pyroelectric, piezoelectric and ferroelectric crystals. Piezoelectricity and its applications.

Unit IV - Optical properties of solids: 13 hrs.

Dielectric function of the free electron gas, Plasma optics, Dispersion relation for electromagnetic waves, Transverse optical modes in a plasma, Transparency of alkalis in the ultraviolet, Longitudinal plasma oscillations, Plasmons and their measurement; Electrostatic screening, Screened Coulomb potential, Mott metal-insulator transition, Screening and phonons in metals; Optical reflectance, Kramers-Kronig relations, Electronic inter band transitions- direct and indirect transition, Absorption in insulators; Polaritons; One-phonon absorption; Optical properties of metals, skin effect and anomalous skin effect. Excitons: Frenkel and Mott-Wannier excitons.

Text Booksss:

1. Kittel C, 'Introduction to Solid State Physics', IV Edn. (Wiley Eastern, 1974), VII Edn. (John Wiley, 1995)
2. Verma A R and Srivastava O N, 'Crystallography Applied to Solid State Physics', II Edn. (New Age, 1991)
3. Wahab M A, 'Solid State Physics", III Edn. (Narosa Publishing House Pvt. Ltd, 2015)

Reference books:

1. Ashcroft N W and Mermin N D, 'Solid State Physics' (Harcourt, 1976)
2. Srivastava J P, 'Element of Solid State Physics' IV Edn (Prentice Hall India Learning Pvt Ltd, 2014)
3. Cullity B D and Stock S R 'Elements of X ray Diffraction', III Edn. (Prentice Hall, 2001)
4. Woolfson M M, 'An Introduction to X-ray Crystallography' (Cambridge-Vikas, 1970)
5. Buerger M J, 'X-ray Crystallography' (John Wiley, 1942)
6. Brusch P : 'Phonons : Theory & Experiments', Vol I, II & III (Springer Verlag, 1987)
7. Ibach H and Luth H, 'Solid State Physics', II Edn. (Springer, 1996)
8. Ziman J M, 'Principles of the Theory of Solids', II Edn. (Vikas Publ., 1979).
9. Applied Solid State Physics by Rajnikant.
10. Solid State Physics: An Introduction to Theory and Experiment by H. Ibach and H. Luth.

PHS 504: ELECTRONICS I

Teaching hours: 4 per week

No of credits: 4

Objectives & Skill Components:

- To introduce the basic concepts of microprocessors.
- To teach the programming techniques of microprocessor 8085 using assembly language.
- To familiarize students with the concepts of interfacing devices with microprocessors.

Unit I - Structure of computer systems and 8085 architecture: 13 hrs.

Review of binary and hexadecimal number system - negative number representation.

Basic structure of computer systems – Microprocessors, Single chip micro controller system. Introduction to CPU architecture and interfacing the devices. Instruction classification, instruction, data format and storage.

8085 architecture - register organization – Memory, input and output devices, Example of microcomputer system. 8085 instruction set – classification.

Instruction cycle, machine cycle, timing diagram.

Unit II - Programming with 8085: 13 hrs.

8085 instructions – data transfer, arithmetic, logic and branch operations. Writing assembly language programs. Programming techniques with additional instructions. Counters and time delays.

Stack and subroutines, conditional CALL and RETURN instructions.

Interrupts – 8085 interrupts – vectored interrupts, software interrupt instructions .

Unit III - Peripherals: 13 hrs.

8155, 8255, 8254, 8259A, DMA 8237.Interfacing data converters – ADC and DAC
Introduction to 16 bit microprocessors. 8086/8088

Unit IV - Microcontrollers: 13 hrs.

CISC and RISC processors, Von Neumann & Harvard architectures. Comparison of microprocessor and microcontroller, Types of microcontrollers, Microcontroller architectures, Features of 8051, 8051 microcontroller register set, Instruction set and programming. Interfacing applications of 8051.

Textbooks:

1. Gaonkar R S, ‘Microprocessor architecture, programming and applications with the 8085’, IV Edn. (Penram International, 2000)

Reference books:

1. Hall D V, ‘Microprocessors and interfacing, programming and hardware’, II Edn. (Tata McGraw Hill, 1992)
2. Mazidi M A & Mazidi J G, ‘The 8051 Microcontroller’, (Pearson Education Asia, 2001).
3. Ayala Kenneth J, ‘The 8051 microcontroller’ (Penram International, 1996)
   Ayala K J, ‘The 8086 Microprocessor’, (Penram International, 1995)

PHS 505: CONDENSED MATTER PHYSICS II

Teaching hours: 4 per week

No of credits: 4

Objectives & Skill Components:

- To understand band structures in crystals using NFE and TBA theories.
- To understand transport properties and its application to the solids.
- To understand the principle and applications of semiconductor devices.

Unit I - Band theory of solids: 13 hrs.

Bloch theorem. Nearly Free electron approximation. Tight binding approximation. Applications of the tight binding method to cubic crystals: width of energy bands, the effective mass of electrons in a simple cubic lattice based on tight binding approximation. The shape of constant surfaces and Fermi surfaces, Density of states curve for the simple cubic lattice. Construction of Brillouin zones for a two-dimensional square lattice. General expression for density of states function and calculation of density of states curve for the simple cubic lattice based on tight binding approximation. Overlapping of energy bands and Jones explanation of structural phase transitions in binary alloys.

Quantization of electron orbits in magnetic fields. Experimental methods in Fermi surface studies - de Haas – van Alphven effect in Fermi surface determination.

Unit III - Transport properties: 13 hrs.

Boltzmann transport equation. Electrical conductivity. Thermal conductivity, Thermoelectric effects and thermopower power. Scattering of electrons. Temperature variation of electrical resistance. Linearized Boltzmann transport equation. AC conductivity of metals. Hall effect, High field effects and magnetoresistance. Cyclotron resonance. Plasma frequency and plasmons.

Unit III - Semiconductors I: 13 hrs.

Extrinsic semiconductors. Impurity ionization energy Fermi energy - variation with impurity density and temperature. Electrical conductivity. Cyclotron resonance in semiconductors.

Excess carriers. Quasi-Fermi levels. Recombination of carriers.Continuity equation. P-N junctions: Abrupt and graded junctions. Junction space charge, electric field, electric potential and width. Rectification process. Derivation of ideal current-voltage characteristics. P-N junction capacitance.
Metal semiconductor contacts : Formation of rectifying/ Schottky contacts, Depletion layer, Interface states and Fermi level pinning. Current transport processes, Derivation of ideal current voltage characteristics of schottky diodes based on thermionic emission

theory. Capacitance of Schottky diodes. Ohmic contacts.

Unit IV - Semiconductors II: 13 hrs.

Low-dimensional Semiconductor structures: Basics of semiconductor alloys and heterostructures. Basics of Fundamentals of quantum wells, quantum wires and quantum dots. Two-dimensional electron gas in uniform electric and magnetic field –Landau levels. Quantum Hall and Shubnikov de Haas effect (qualitative). Degenerate semiconductor. Esaki diode.

Amorphous semiconductor: Introduction, Band structures and density of states. Structure of amorphous semiconductors and structural models. Electrical and Optical properties.

Organic Semiconductors: Introduction, and doping, electrical and optical properties. Organic semiconductor Devices.

Optolectronic devices (Qualitative aspects only): Photodetectors, Photoconductor, P-N and P-I-N Photodiodes, Heterojunction Photodiodes, Avalanche photodiodes (APDs), Phototransitors. Solar cells. Light emitting diodes.

Text Books:

1. Mckelvey J P, 'Solid State and Semiconductor Physics' (Robert E Kreiger, 1982)
2. Ziman J M, 'Principles of the Theory of Solids' II Edn. (Vikas Publ., 1979)
3. Sze S M, 'Semiconductor Devices Physics and Technology' (John Wiley, 2003)

Reference books:

1. Wahab M A, 'Solid State Physics", III Edn. (Narosa Publishing House Pvt. Ltd, 2015)
2. Pillai S O, 'Solid state Physics', (New Age International, 2018)
3. Ibach H and Luth H, 'Solid State Physics' II Edn. (Springer, 1996)
4. S. M, Sze and K. K. Ng, 'Physics of Semiconductor Devices' (3rd Edn, Wiley 2006).
5. B. G. Streetman and S. Banerjee, 'Solid State Electronic Devices' 4th to 6th Edition (PHI)
6. P. Bhattacharya, 'Semiconductor Optoelectronic Devices, 2nd Edition (PHI, 2009).
7. J. H. Davies, 'The Physics of Low-diemnsional Semiconductors: An Introduction, (Cambidge University Press, 1998).
8. M. Li, 'Modern Semiconductor Quantum Physics' (World Scientific, 1994).
9. J. Singh and K. Shimakawa, Advances in Amorphous Semiconductors, (Advances in condensed matter science, Vol.5, D. D. Sharma, G. Kotliar andY. Tokura. Taylor& Fransis,
10. S. R. Elliot, 'Physics of Amorphous Materials, 2nd Ed. (Longman Scientific & Technical, London).

PHS 506: ELECTRONICS II

Teaching hours: 4 per week

No of credits: 4

Objectives & Skill Components:

- To study the different types of analog and digital communication.
- To study wired and wireless communication.
- To study waveguides and principle of antennas.
- To study microwave devices and their applications.

Unit I - Transmission lines: 13 hrs.

Distributed parameters, types of transmission lines, calculation of line parameters. Inductance and capacitance of parallel round conductors, coaxial cables. Voltage, current and impedance relations. Characteristic impedance, reflection coefficient, propagation constant. Line distortion and attenuation. Line parameters at high frequencies, Line termination. Standing wave ratio. Quarter and half wavelength lines. Impedance matching, quarter wave transformer, stub matching. Smith chart and its applications.

Unit II - Waveguides and antenna: 13 hrs.

Basic concepts, guided waves between parallel planes. TE & TM waves. Rectangular wave guides. Qualitative treatment of circular wave guides, comparison with coaxial cable, wave guide coupling. Matching and attenuation, cavity resonators. Directional couplers, Electromagnetic radiation, elementary doublet, current and voltage distribution, resonant and non resonant antennas, radiation pattern, antenna gain, effective radiated power, antenna resistance, bandwidth, beam width, polarisation, grounded and ungrounded antennas. Effect of antenna height. Microwave antennas (qualitative).

Unit III - Analog modulation and demodulation: 13 hrs.

Need for modulation, AM generation, power and bandwidth calculations. FM generation, power and bandwidth calculation. AM & FM transmitters (block diagram).

Demodulation: receivers for AM & FM signals. AVC & AFC circuits. Pre-emphasis and De-emphasis. Digital modulation: sampling theorem, PAM, PDM, PPM system comparison. PCM technique. ASK, FSK, PSK & QPSK systems.

Unit IV - Microwave devices and satellite communication: 13 hrs.

Multicavity klystron, reflex klystron, parametric amplifiers, Gunn diode, Microwave transistors & FETs.

Communication subsystems, description of the communication system transponders, spacecraft antennas, frequency reuse antennas, multiple access schemes, frequency division multiple access, time division multiple access, code division multiple access. Tracking geostationary satellites. Examples of satellite communication systems - IRS & INSAT series.

Textbooks:

1. Kennedy and Davis, 'Electronic Communication Systems', IV Edn. (Tata McGraw Hill, 1993)
2. Ryder J D, 'Networks, Lines and Fields' II Edn. (PHI, 1997)

Reference books:

1. Tomasi Wayne, 'Electronic Communication Systems', (Pearson Education Asia, 2001)
2. Dennis Roddy and John Coolen, 'Electronic Communications', IV Edn. (PHI, 1995)
3. Kraus & Fleisch, 'Electromagnetics with Applications', V Edn. (McGraw Hill, 1999)
4. Taub & Schilling, 'Principles of Communication System', II Edn. (McGraw Hill, ISE, 1986)
5. Liao S Y, 'Microwave Devices and Circuits', III Edn. (PHI)
6. Roddy D, 'Satellite Communications', III Edn. (McGraw Hill, 2001)
7. Giridhar, 'Microwaves & Radar'
8. Pratt, Bostian & Allnutt, 'Satellite Communications', II Edn. (Wiley)

PHE 507: APPLIED PHYSICS (Open Elective)
Teaching hours: 3 per week
No of credits: 3

Objectives & Skill Components:

- Present syllabus is designed for students one who want to learn basic concepts of physics such as atomic models and its origin, introduction to nuclear physics, evaluation of stars, basics of satellites, properties of crystal ,structural features and chemical compositions, X-ray production and its application in medical and research field, theories about light, comparative study between classical and quantum physics.

Unit I - Astronomy and space science: 13 hrs.

Brief introduction of evolution of stars (star birth, white dwarfs, neutron stars and black holes). Methods of determining the distances of stars and galaxies. Theories about the origin of the universe. Expanding universe. Hubble's law. Dark matter and dark energy. Requisites for the existence of life in outer space. Basics of satellites, geostationary and remote sensing satellites**.**

Unit II - Principles of optics and quantum mechanics: 13 hrs.

Theories about the nature of light. Electromagnetic spectrum. Total internal reflection of light. Optical fiber - structure functioning and applications. Polarization of light. Polaroid, sun glass. Interference, anti-reflection coating. Physics of the micro world. Necessity for the shift from classical concept to quantum concept. De Broglie's hypothesis. Dual nature. Principle of electron microscope. Heisenberg's uncertainty principle and its significance. Wave function Ψ its meaning, the concept of probability and its applications.
Schrodinger's explanation of quantum reality.

Unit III - Condensed matter physics: 13 hrs.

States of matter, crystalline and amorphous materials, Thin films and nano structures. X-rays - production and detection, applications. Luminescence in solids. Conductors, semiconductors and superconductors. Magnetism in solids, classification, magnetic materials and applications.

Textbooks:

1. 1. Alan Cromer – Physics for life sciences
2. French A P - Quantum mechanics

Reference books:

1. Cullity B D and Stock S R ‘Elements of X ray Diffraction’, III Edn. (Prentice Hall, 2001)
2. Kittel C, ‘Introduction to Solid State Physics’, IV Edn. (Wiley Eastern, 1974), VII Edn.
3. Ashcroft N W and Mermin N D, ‘Solid State Physics’ (Harcourt, 1976)
4. Kittel C and Kroemer H, ‘Thermal Physics’, II Edn. (CBS Publ., 1980)
5. Gupta M C, ‘Statistical Thermodynamics’ (New Age, 1995)
6. Basu : Introduction to Astrophysics, PHI

PHP 508: CONDENSED MATTER PHYSICS - PRACTICALS I
Teaching hours: 6 per week
No. of credits: 3

1. Characteristic of solar cell
2. Characteristics of LED and LASER diode
3. Characteristics of Photodiode
4. Dielectric Constants of solids and liquids
5. Electron Spin Resonance
6. XRD simulation
7. Thermoluminescence
8. Optical constants of metals

***Additional experiments may be included.**

PHP 509: ELECTRONICS –PRACTICALS I
Teaching hours: 6 per week
No. of credits: 3

1. Two stage CS amplifier
2. Cascode amplifier
3. Complimentary symmetry push - pull power amplifier
4. 3bit asynchronous up/down counter
5. Full wave precision rectifier with equal resisters
6. Frequency multiplication using PLL565
7. Phase shifter using opamp
8. R-2R ladder type DAC
9. Instrumentation amplifier
10. 8085 programming examples

***Additional experiments may be included.**

PHP 510: CONDENSED MATTER PHYSICS - PRACTICALS II
Teaching hours: 6 per week
No. of credits: 3

1. Determination of Stefan Boltzmann Constant
2. Determination of energy gap of a semiconductor using p-n junction diode
3. B H curve
4. Lattice dynamics
5. Determination of Planck's constant using LED
6. Hall effect
7. PN junction characteristics
8. Thermoelectric effect

***Additional experiments may be included.**

PHP 511: ELECTRONICS –PRACTICALS II

Teaching hours: 6 per week
No. of credits: 3

1. Amplitude modulation
2. Demodulating AM voltage
3. PLL565 – Frequency synthesis
4. Frequency modulation using IC 8038
5. Pulse width modulation
6. Frequency shift keying using PLL565
7. Pre-emphasis and de-emphasis
8. Wave generators
9. Voltage controlled oscillator.
10. Active filters

***Additional experiments may be included.**

IV SEMESTER

PHH 551: LASER PHYSICS, VACUUM TECHNIQUES AND CRYOGENICS

Teaching hours: 4 per week

No. of credits: 4

Objectives & Skill Components:

- To learn how vacuum can be created using different methods and sustained
- To understand different types of vacuum systems in different range and vacuum gauges
- To learn about applications of Vacuum technology in thin film deposition
- To understand the definition, production & applications of lasers
- To understand different methods of production of cryogenic temperature, cryo engines.

Unit I - Lasers and non-linear optics: 13 hrs.

Lasers - introduction - directionality, intensity, monochromaticity, coherence. Einstein coefficients - stimulated emission. Basic principles of lasers - the threshold condition - laser pumping.

Some specific laser systems - Neodymium lasers - He-Ne laser - ion lasers - CO_2 laser - Semiconductor lasers - dye lasers - chemical lasers – X-ray lasers, free electron laser, Q-switching.

Unit II - Holography and non-linear optics: 13 hrs.

Principle of holography - some distinguishing characteristics of holographs - practical applications of holography.

Non-linear optics: harmonic generation - second harmonic generation - phase matching - third harmonic generation Z scan technique - optical mixing - parametric generation of light - self focussing of light. Electro optic effect.

Multiquantum photoelectric effect - two photon processes - multiphoton processes - three photon processes.

Unit III - Vacuum techniques: 13 hrs.

Units of vacuum - vacuum spectrum (ranges - low - medium - high - ultra high). Applications - freeze drying - vacuum coating - industrial applications. Conductance of pipes - pumping speed - throughput - pumpdown time.

Vapour pressure - vacuum gauges and the relevant range of vacuum - Pirani gauge - thermocouple gauge - Pennning gauge. Vacuum pumps - rotary vane pump (pumping speed and ultimate pressure) - oil diffusion pump - baffle and trap - cryopump - turbomolecular pump – sorption pump. Vacuum feedthroughs - vacuum valves (diaphragm valve, slide valve, ball valve).

Unit IV - Cryogenic techniques: 13 hrs.

Overview of the techniques of liquefaction of gases (Nitrogen, Hydrogen and Helium). Gas purification - Stirling cycle refrigeration and liquefaction of helium.

Properties of cryogenic fluids (Nitrogen and Helium 4). Storage and transfer of cryogenic fluids: Dewars for nitrogen and helium. Liquid level indicators and gauges.

Measurement of temperature: Resistance thermometers (metal, alloys & semiconductors). Thermocouple - (Au + Fe) vs chromel. Magnetic thermometer.

Cooling by evaporation of helium 4 and helium 3 - cooling by adiabatic demagnetisation. Cryostats for low temperature experiments. Applications of cryogenics: Hydrogen bubble chamber - Rocket propulsion system - superconducting magnets.

Textbooks:

1. 1. Silfvast W T, 'Laser Fundamentals' (Cambridge University Press, 1998)
2. Ghatak A K and Thyagarajan, 'Optical Electronics' (Cambridge University Press 1991)
3. Laud B B, 'Lasers & Nonlinear Optics' (Wiley Eastern, 1985)
4. Roth A, `Vacuum Technology', II Edn. (North Holland, 1982)
5. Barron R F, `Cryogenic Systems' II Edn. (Oxford University Press, 1985)

Reference books:

6. Mills D L, 'Nonlinear Optics – Basic Concepts' (Narosa Publishing, 1991)
7. Wilks J and Betts D S, `An Introduction to Liquid Helium' (Oxford University Press, 1987)
8. Shen Y R, 'The Principles of Nonlinear Optics' (John Wiley, 1984)
9. Boyd R W, 'Nonlinear Optics' (Academic Press, 1992)
10. Zernike F & Midwinter, 'Applied Nonlinear Optics' (Wiley, 1973)
11. Oshea D C, Callen W R & Rhodes W T, 'Introduction to Lasers & Their Applications' (Addison Wesley, 1977)
12. Harris N S, `Modern Vacuum Practice' (McGraw Hill, 1989)
13. O'Hanlon J F, `A User's Guide to Vacuum Technology' (John Wiley, 1980)
14. West C D, `Principles and Applications of Stirling Engines' (Van Nostrand Reinhold, 1986)

PHH 552: ASTROPHYSICS AND RELATIVITY

Teaching hours: 4 per week

No. of credits: 4

Objectives & Skill Components:

- To study the concepts of Astronomy, origin & theories about the Universe
- To study basic concepts of Special & General relativity, its uses & applications

Unit I- Astronomy: **13 hrs.**

Introduction, constellations, solstices, equinoxes, zodiac, temperature of stars and their classification, visible and invisible astronomy. Asteroids, Comets and Meteorites. Doppler effect. Hubble's law. Origin and evolution of solar system. Apparent and absolute magnitudes of stars. Measurement of stellar distances – method of heliocentric parallax, statistical parallax method, apparent luminosity method, spectroscopic parallax method. Variable star distances. Nova distances.

Unit II - Astrophysics: **13 hrs.**

Energy generation in stars, contents of Milky-way galaxy, Hertzsprung – Russel diagram – it's uses. Evolution of stars – star birth, evolution to, on and off the main sequence, evolution to the end. White dwarfs, neutron stars, stellar explosions – nova, pulsars, black holes, binary X-ray systems and quasars. Cosmological models – steady state and Big-Bang models. Evolution of Universe. Origin of life on earth.

Unit III - Special theory of relativity: **13 hrs.**

Review of Newtonian Mechanics, Galilean transformation equations & consequences. Aether & Measurement of speed of light – Michelson Morley experiment & its results. Inertial & non-inertial frames, Postulates of relativity, space-time continum, Minkowski's world. Relativistic force law and dynamics of single particle. Equivalence of mass and energy. Lorentz transformation, length contraction, time dilation, 4 dimensional line element. 4 velocity, 4 acceleration, 4 momentum and 4 force. Maxwell's equations in covariant form.

Unit IV - General theory of relativity: **13 hrs.**

Review of tensor calculus and Riemannian geometry, Parallel transport, Geodesies, The curvature tensor, Riemannian metric & space, Riemann tensor. Einstein's equations: The Principle of Equivalence and general covariance, inertial & gravitational mass, Eotvas' experiment, equivalence principle, gravitation as space time curvature, Gravitational field equations of Einstein and its Newtonian limits. The Schwarzschild metric, Schwarzschild line element. Perihelion advance of planets, gravitational red shift, gravitational bending of light. Experimental validation of General relativity. Singularity and black holes (brief)

Textbooks:

1. Introduction to Astrophysics 'Baidyanath Basu' (PHI, 1997).
2. Resnik R, 'Introduction to Special Relativity' (Wiley Eastern, 1972)
3. Schutz B F, 'A First Course in General Relativity' (Cambridge University Press, 1985)

Reference books:

1. Michael Feilik and John Gaustad 'Astronomy the Cosmic Prospective' (John Wiley & Sons, Inc., 1990)
2. Rindler W, 'Introduction to Special Relativity', II Edn. (Oxford University Press, 1991)
3. P G Bergman , Theory of Relativity, Asian Publishers
4. Srivastava , General Relativity and Cosmology, PHI
5. J Hartle, Gravitation
6. Feilik M, 'Astronomy – the Evolving Universe' III Edn (Harper and Row, 1982)
7. Moller C, Theory of Relativity II Edn. (Claredon Press, 1972)
8. D Mc Gillivray 'Physics and Astronomy' (McMillan, 1987)
9. Ray d'Inverno, 'Introducing Einstein's Relativity' (Oxford University Press, 1992)
10. Adler R, Bazin M & Schiffer M, 'Introduction to General Relativity', II Edn. (McGraw Hill, 1975)
11. Marc L Kutner "Astronomy a physical perspective (2^{nd} edition) Cambridge University Press 2003.
12. K D Abyankar, 'Stars and Galaxies', Univ. Press
13. A Unsold, 'The new Cosmos', Springer
14. Carrol and Osftie, 'Modern Astrophysics', Addison Wesley

PHS 553: CONDENSED MATTER PHYSICS III

Teaching hours: 4 per week

No. of credits: 4

Objectives & Skill Components:

- To teach the basics and origin of the concept of magnetism in solids.
- To understand the classification of the solids based on magnetic behavior.
- To familiarize students with nano- materials and its properties.
- Understanding various principles and theories about magnetic materials

Unit I - Ferromagnetism: 13 hrs.

Classical molecular field theory. Heisenberg exchange interaction. Ising model. Spin waves and magnons. Bloch $T^{3/2}$ law. Band theory of ferromagnetism. Magnetisation of ferromagnets. Crystalline anisotropy. Domains. Bloch wall. Ferromagnetic materials. Neutron diffraction - magnetic structure.

Unit II - Antiferro and ferrimagnetism: 13 hrs.

Molecular field theory. Indirect exchange interaction. Antiferromagnetic materials. Helimagnetism. Molecular field theory for ferrimagnetic materials. Spinels and garnets. Magnetic bubbles.

Unit III - Paramagnetic relaxation and magnetic resonance: 13 hrs.

Paramagnetic relaxation: Susceptibility in alternating magnetic field. Thermodynamic theory of Casimir and Dupre for spin lattice relaxation. Spin - spin relaxation.

Electron paramagnetic resonance: Introduction. Phenomenological theory of resonance. line width, hyperfine structure. Spectra of transition group ions. ESR spectrometer.

Nuclear magnetic resonance (NMR): Elements of the theory of NMR – Bloch equations. Solutions of the Bloch equations weak RF filed. NMR line shape and width. Resonance in non- metallic solids. Influence of nuclear motion on NMR line width. Chemical shift. Quadrupole effect in NMR. NMR Experimental aspects. Ferromagnetic resonance. Introduction, shape effects in ferromagnetic resonance.

Unit IV - Nanomaterials and nanostructures: 13 hrs.

Introduction. Physical properties of the materials at the nanoscale: Melting points and lattice constants. Mechanical properties. Optical properties- Surface plasmon resonance, Quantum size effects in optical absorption and photoluminescence. EIectrical conductivity-Surface scattering, Quantum transport. Bottom-Up and Top-Down Approaches of nanomaterials synthesis.

Zero-Dimensional nanostructures - nanoparticles: Introduction, Nanoparticles through homogeneous nucleation. Nanoparticles through Heterogeneous Nucleation.

One-Dimensional Nanostructures:- Nanowires and Nanorods: Intoruduction, Synthesis of one-dimensional nanostructures.

Fabrication of nanoscale structures with physical techniques : Lithographic techniques, Nanomanipulation and nanolithography, Soft lithography, Self-assembly of nanoparticles or nanowires.

A brief introduction on carbon fullerenes, nanotubes and graphene.

Text Books:

1. A. H. Morrish, 'The Physical Principles of Magnetism' (Wiley-Blackwell, 2001)
2. G. Cao, Nanostructures & Nanomaterials: Synthesis, Properties & Applications' (World Scientific, 2011).

Reference books:

1. J. Crangle, 'Solid State Magnetism' (Edmond-Arnold, 1991).
2. C. Kittel, 'Introduction to Solid State Physics', 4^{th} to 8^{th} Edition.
3. D. J. Dekker, 'Solid State Physics' (Macmillan India)
4. P Slichter 'Principles of Magnetic Resonance' (Springer, 1996).
5. P. Poole and F. J. Owens, 'Introduction to Nanotechnology' (Wiley, 2006).
6. Ibach H & Luth H 'Solid State Physics' II Edn. (Springer, 2000)
7. K. Yosida, 'The Theory of Magnetism' (Springer, 1998).
8. Ashcroft N W and Mermin N D, 'Solid State Physics' (Harcourt, 1976)
9. Rogalski M S and Palmer S B 'Solid State Physics' (Gordon & Breach, 2000)
10. Yury Gogotsi Ed., 'Nanomaterials Hand Book' (CRC Press, Taylor & Francis Group, 2006)

PHS 554: ELECTRONICS III

Teaching hours: 4 per week

No. of credits: 4

Objectives & Skill Components:

- To study the development of printed circuit boards.
- To know the linear and nonlinear applications of operational amplifiers.
- To study the power devices and importance of power amplifiers.
- To study programmable logic devices.

Unit I – Printed circuit board design and IC fabrication techniques: 13 hrs.

Printed circuit board design techniques: Layout scale, grid system, board types. Materials and aids, documentation – circuit diagram, component list, layout sketch, mechanical drawing. PCB parameters – resistance, inductance, capacitance. Component spacing, conductor spacing, cooling requirements and packing density. PCB manufacturing – copper clad laminates, Types of laminates and properties of laminates. Mentions of plating. Etching – different etchants, pollution minimisation. Multilayer boards. Soldering techniques – wave soldering.

IC fabrication technologies: Wafer preparation- chemical vapour deposition - diffusion - ion implantation-photolithography. Fabrication of resistors, capacitors, BJT & MOS devices.

Unit II - Characteristics and simple applications of special semiconductor devices: 13 hrs.

Schottky barrier diode - varactor diode - Tunnel diode - Photo diode – LED - Thermistor - solar cell, IGBT. CMOS inverter.

Amplifiers: cascade amplifiers - cascode amplifiers. Darlington connection. Power amplifiers - Class A, Class B & Class AB amplifiers. Power transistor heat sinking. Silicon controlled switch, DIAC and TRIAC applications.

Unit III - Operational amplifiers: 13 hrs.

Voltage Reference books (5V) - voltage level detector - Comparator IC 311 - Phase shifter - precision rectifier - peak detector - instrumentation amplifier. Active filters - 40 dB/decade roll off (low pass, high pass & band pass).

Precision triangle & square wave generator - IC AD630. Voltage to frequency and frequency to voltage converter. Analog multiplier - IC AD633 - squaring a dc voltage and doubling the frequency of ac. Frequency multiplier using phase locked loop IC565.

Unit IV - Sequential circuits and data converters: **13 hrs.**

Review of Latches, Flip-flops, Counters and Registers, Sample and hold circuit, Digital to analog conversion -Types. Analog to digital conversion- Types. Digital to analog converter AD558. Analog to digital conversion - Successive approximation ADC - microprocessor compatible ADC AD670. Programmable logic devices - Programmable array logic PAL 16L8 - Generic array logic GAL 22V10.

Textbooks:

1. Walter C Bosshart, 'Printed Circuit Boards - Design and Technology' (Tata McGraw Hill, 1983)
2. Coughlin R F & Driscoll F F, 'Operational Amplifiers and Linear Integrated Circuits', VI Edn. (Pearson Education Asia, 2002).
3. Gayakwad R A, 'Opamps and Linear Integrated Circuits' IV Edn. (PHI, 2002)
4. Floyd T L, 'Digital Fundamentals', VII Edn. (Pearson Education Asia, 2002)

Reference books:

1. Henry W Ott, 'Noise Reduction Techniques in Electronic Systems' (John Wiley, 1989)
2. Jaspreet Singh, 'Semiconductor Devices' (McGraw Hill, 1994)
3. Boylestad R & Nashelsky L, 'Electronic Devices and Circuit Theory' VIII Edn. (PHI, 2002)
4. Neamen Donald, 'Electronic Circuit Analysis and Design' II Edn. (Tata McGraw Hill, 2002)
5. Floyd T L, 'Electronic Devices', V Edn. (Pearson Education Asia, 2001)
6. Franco S, 'Designing with Operational Amplifiers and Analog Integrated Circuits', III Edn. (McGraw Hill, 2001)
7. Tocci R J, 'Digital Systems, Principles and Applications', VIII Edn. (Pearson Education Asia, 2001)
8. Wakerly, 'Digital design', III Edn. (Expanded), (Pearson Education Asia, 2002)
9. Winzer J, 'Linear integrated circuits' (Saunders College Publ., 1992).
10. Millman and Halkias, "Integrated Electronics" (McGraw Hill).
11. David Bell, 'Electronic devices and Circuits', 5th edition (Oxford, 2008)

PHS 555: CONDENSED MATTER PHYSICS IV
Teaching hours: 4 per week
No. of credits: 4

Objectives & Skill Components:

- To understand the concept of crystal defect.
- To impart in-depth knowledge of basics and applications of thin film technology.
- To familiarize students with superconductivity, polymers and liquid crystals.
- To acquire skills in synthesizing and characterizing thin films.

Unit I - Crystal defects: 13 hrs.

Imperfections in crystals: classification of defects in crystals - point defects - their energy of formation - diffusion - ionic conductivity in pure and doped halides - colour centers – polorons, excitons. Dislocations - Burger's vector. Observation of dislocation - dislocations and crystal growth. Planar defects. Luminescence in solids: Thermoluminescence – Electroluminescence.

Unit II - Thin films: 13 hrs.

Introduction. Physical vapour deposition methods – Evaporation – general considerations. Evaporation methods. Sputtering – Sputtering methods. Chemical vapour deposition (CVD) methods – Typical chemical reactions. Reaction kinetics, Transport phenomena, CVD methods. Atomic Layer Deposition (ALD). Liquid-based growth methods.

Nucleation, growth and structure of thin films: Nucleation- condensation process, theories of nucleation, nucleation modes. Growth Process. Aspects of physical structure of thin films. Crystallographic structures of thin films. Epiaxial growth of thin films.

Characterization of Thin Films: Thickness measurement. Structural and morphological characterization, chemical and optical characterization, electrical characterization.

Brief Applications of thin films.

Unit III - Superconductivity: 13 hrs.

Thermodynamics of superconductivity. Coherence length. A brief overview of BCS theory of superconductivity: Instability of Fermi Sea and Cooper pairs, BCS ground state, Consequences of the BCS theory and comparison with experimental results. Magnetic flux quantization in a superconducting ring.

Single particle and Coper-pair -Josephson tunnelling. AC and DC Josephson effects, Macroscopic Quantum Interference, Superconducting Quantum Interference Devices (SQUIDS). DC and AC SQUIDs. Applications of SQUIDs.

High T_C superconductors: Discovery YBCO, Important families of high temperature superconductors.

Unit IV - Polymers and liquid crystals: 13 hrs.

Polymers : Introduction. Classification. Molecular weight. Configuration. Polymerisation reactions. Polymer processing. Crystallanity. Conducting polymers. Applications.

Liquid crystals : Classification. Structure and texture. Orientational and translational order. Mechanical, optical, magnetic and electrical properties. Liquid crystal displays.

Text Books:

1. Ashcroft N W and Mermin N D, 'Solid State Physics' (Harcourt, 1976)
2. Chopra K L and Malhotra L K (Ed) 'Thin film Technology and applications' (Tata McGraw Hill, 1985)
3. Tinkham M 'Introduction to Superconductivity' II Edn. (McGraw Hill, 1996)
4. Gowarikar V R, Vishwanathan N V and Shridhar J, 'Polymer Science' (Wiley Eastern, 1986)
5. Chandrasekhar S, 'Liquid Crystals', II Edn. (Cambridge, 1992)

Reference books:

1. Kittel C, 'Introduction to Solid State Physics', IV Edn. (Wiley Eastern, 1974), VII Edn. (John-Wiley, 1995)
2. Dekker A J, 'Solid State Physics' (MacMillan, 1971)
3. Ibach H and Luth H 'Solid State Physics', II Edn. (Springer, 2000)
4. Hass G and Thun R E, 'Physics of Thin Films', Vol. IV (Academic Press, 1967)
5. Chopra K L 'Thin Film Phenomena' (Robert E Kreiger, 1979)
6. Goswami A, 'Thin film fundamentals' (New Age, 1996)
7. M. Ohring: The Materials science of thin films, (Academic Press, 1992, 2nd Ed.
8. Chiaken P and Lubensky T C, 'Principles of Condensed Matter Physics' (Cambridge, 1995)
9. Rogalski M S and Palmer S B 'Solid State Physics' (Gordon & Breach, 2000)

PHS 556: ELECTRONICS IV
Teaching hours: 4 per week
No. of credits: 4

Objectives & Skill Components:

- To familiarize students with the working principle of optical fibres.
- To teach the recent developments in optic fibre communication.
- To orient the students towards the advanced concepts in signal processing.

Unit I - Optic fibre communication: 13 hrs.

Relevance and advantages of OFC, description of a simple OFC link, types of optical fibres, Ray theory of light guiding in optical fibres, modal analysis of optical fibres (qualitative), single mode fibres, graded index fibres, signal attenuation and dispersion in optical fibres. Optical source to fibre coupling (basics), optical fibre splicing and connectors (basics).

Unit II - Optical sources & detectors: 13 hrs.

Structure and working of a laser diode. Single mode lasers (basic). Output characteristics and modulation characteristics of LED & laser diodes.

Optical detectors: Structure and working of PIN diode and avalanche photodiode. Quantum efficiency, responsivity and response speed of photodiodes. Noise characteristics of photo diodes. Optical receiver systems, digital and analog transmission systems. Power and rise time budget analysis.

Unit III - Digital signal processing: 13 hrs.

Classification of signals, properties of discrete time signals and systems – linearity, stability and causality concepts. LTI systems – convolution. Fourier analysis of discrete time signals and systems. Sampling and modulation principles, aliasing effect, sampling theorem. Z-transforms - transfer function – properties of Z-transform, pole-zero plot, inverse Z-transforms (partial fraction method and long division method.

Unit IV - Discrete fourier transform (DFT) and IDFT: 13 hrs.

Circular convolution – properties of DFT, FFT algorithms (Radix 2) – flow charts.

Discrete system realization: IIR structures - direct form I & II, CSOS and PSOS structures. Finite impulse response (FIR) structures: direct form and cascade structures. IIR filter design: qualitative analysis of impulse invariance and bilinear transformation methods. FIR filters - linear phase FIR design using window functions, Gibbs' phenomenon.

Textbooks:

1. Keiser G, 'Optical Fibre Communications', III Edn. (McGraw Hill ISE, 2000)
2. Senior J M, 'Optical Fibre Communication', II Edn. (PHI, 1996)
3. A Nagoor Kani, 'Digital Signal Processing', II Edn. (McGraw Hill Pub.)

Reference books:

4. Ghatak A & Thyagarajan K, 'Introduction to Fibre Optics' (Cambridge University Press, 1999)
5. Haykin S, 'Signals and Systems' (John Wiley, 1998)
6. Oppenheim A V, Willsky A S and Nawab S H, 'Signals and Systems', II Edn. (PHI, 1997)
7. Proakis J G and Manolakis D G, 'Digital Signal Processing', III Edn., (PHI, 1992)
8. Salivahanan S, Vallavaraj A & Gannapriya G, 'Digital Signal Processing', (Tata McGraw Hill, 2001)
9. Mitra S K, 'Digital Signal Processing' (Tata McGraw Hill, 1998)
10. Oppenheim A V and Schafer R W, 'Discrete-Time Signal Processing' (PHI, 1992)
11. Roman Kuc, 'Introduction to Digital Signal Processing' (McGraw Hill, 1988).
12. Joseph C. Palais, 'Fiber Optic Communications', 5th Edition (Pearson)

PHP 557: PROJECT WORK

Teaching hours: 8 per week

No. of credits: 4

SDM COLLEGE (AUTONOMOUS), UJIRE
M Sc DEGREE PROGRAMME IN PHYSICS
Question paper pattern for hardcore and softcore (4 credits)

PATTERN

The examination marks for hardcore (4 credits), softcore (3/4 credits) and open elective (3 credits) theory course is 70.

Each hard/soft theory course syllabus is divided into 4 units. The semester ending examination will be aimed at testing the student's proficiency and understanding in every unit of the syllabus. The blue print for the question paper pattern is as follows: Each question paper will consists of 5 parts I, II, III, IV and V. Each of the parts from Part I to Part IV carries 15 marks. Each Part consists of two full questions and one full question from each part is to be chosen. Part V is compulsory which consists of seven questions and five questions are to be answered. Part V carries 10 marks. The model question paper is given below.

M.Sc. Degree Examination

PHYSICS

PHH/PHS XXX: Model paper (CBCS) (Hardcore/Softcore (4 credits))

Time: 3 Hours **Max. Marks: 70**

Note: Answer any **four** questions choosing **one** from each of the Parts **I** to **IV** and **five** questions in Part **V.**

PART - I

1a)

b)

c) (15)

OR

2 a)

b)

c) (15)

PART - II

3 a)

b)

c) (15)

OR

4 a)

b)

c) (15)

PART - III

5 a)

b)

c) (15)

OR

6 a)

b)

c) (15)

PART - IV

7 a)

b)

c) (15)

OR

8 a)

b)

c) (15)

PART V

9 Answer **any five** of the following: (5x2 =10)

a)

b)

c)

d)

e)

f)

g)

Question paper pattern for open elective

PATTERN

Each open elective theory course syllabus is divided into 3 units. The semester ending examination will be aimed at testing the student's proficiency and understanding in every unit of the syllabus. The blue print for the question paper pattern is as follows: Each question paper will consists of 4 parts I, II, III and IV. Each of the parts from Part I to Part III carries 20 marks. Each Part consists of two full questions and one full question from each part is to be chosen. Part IV is compulsory which consists of seven questions and five questions are to be answered. Part IV carries 10 marks. The model question paper is given below.

M.Sc. Degree Examination

PHYSICS
PHE XXX: Model paper
(CBCS) (Open elective)

Time: 3 Hours **Max. Marks: 70**

Note: Answer any **three** questions choosing **one** from each of the Parts **I** to **III** and **five** questions in Part I**V.**

PART – I

1 a)

b)

c) (20)

OR

2 a)

b)

c) (20)

PART - II

3 a)

b)

c) (20)

OR

4 a)

b)

c) (20)

PART - III

5 a)

b)

c) (20)

OR

6 a)

b)

c) (20)

PART IV

9 Answer **any five** of the following: (5x2 =10)

a)

b)

c)

d)

e)

f)

g)

PRACTICAL EXAMINATION: Semester end practical examination for each practical course in all the semesters is for 100 marks. Maximum marks for final practical examination shall be 70. The marks shall be awarded in the examination based on the procedure, conduct of the practicals, results and viva related to the practicals. Remaining 30 marks is for internal assessment.