VIJAYANAGARA SRI KRISHNADEVARAYA UNIVERSITY

DEPARTMENT STUDIES AND RESEARCH IN PHYSICS

Jnana Sagara Campus, Ballari-583 105

SYLLABUS

of

MASTER OF SCIENCE IN PHYSICS

Choice Based Credit System (CBCS)

With effect from

2019-20

VIJAYANAGARA SRI KRISHNADEVARAYA UNIVERSITY

DEPARTMENT OF PHYSICS

M. Sc. (CBCS) Syllabus 2019-20

Semester	Course code	Title of the paper	Credits	Teaching hours/wk	Duration of examination theory/practical hours	Max. marks at semester end examination	Max. marks at internal examination	Total Max. Marks
I	PH HCT 110	Mathematical physics I	04	04	03	70	30	100
	PH HCT 120	Classical Mechanics	04	04	03	70	30	100
	PH HCT 130	Atomic, molecular and Optical Physics	04	04	03	70	30	100
	PH SCT 140	Electronics	04	04	03	70	30	100
	PH HCP 150	Practical I (Physics Lab I)	04	04	04	70	30	100
	PH HCP 160	Practical II (Physics Lab II)	04	04	04	70	30	100
	PH SCT 141	Astrophysics	04	04	03	70	30	100

Semester	Course code	Title of the paper	Credits	Teaching hours/wk	Duration of examination theory/practical hours	Max. marks at semester end examination	Max. marks at internal examination	Total Max. Marks
II	PH HCT 210	Mathematical physics II	04	04	03	70	30	100
	PH HCT 220	Quantum mechanics I	04	04	03	70	30	100
	PH SCT 230	Elements of Solid state Physics	04	04	03	70	30	100
	PH SCT 240	Elements of Nuclear Physics	04	04	03	70	30	100
	PH HCP 260	Practical III (Physics Lab III)	04	04	04	70	30	100
	PH HCP 270	Practical IV (Physics Lab IV)	04	04	04	70	30	100
	PH SCT 241	Atmosphere and Space Science	04	04	03	70	30	100
	PH OET 250	Modern Physics	04	04	03	70	30	100
	PH OET 251	General Physics	04	04	03	70	30	100

Semester	Course code	Title of the paper	Credits	Teaching hours/wk	Duration of examination theory/practical hours	Max. marks at semester end examination	Max. marks at internal examination	Total Max. Marks
III	PH HCT 310	Quantum mechanics II	04	04	03	70	30	100
	PH HCT 320	Statistical Mechanics	04	04	03	70	30	100
	PH SCT 330	Solid State Physics I	04	04	03	70	30	100
	PH SCT 331	Nuclear Physics I	04	04	03	70	30	100
	PH SCT 340	Solid state Physics II	04	04	03	70	30	100
	PH SCT 341	Nuclear Physics II	04	04	03	70	30	100
	PH HCP 350	Practical V (Solid state physics Lab I)	04	04	04	70	30	100
	PH HCP 351	Practical V (Nuclear Lab I)	04	04	04	70	30	100
	PH HCP 360	Practical VI (Solid state physics Lab II)	04	04	04	70	30	100
	PH HCP 361	Practical VI (Nuclear Lab II)	04	04	04	70	30	100
	PH OET 370	Energy science	04	04	03	70	30	100
	PH OET 371	Radiation physics	04	04	03	70	30	100

Semester	Course code	Title of the paper	Credits	Teaching hours/wk	Duration of examination theory/practical hours	Max. marks at semester end examination	Max. marks at internal examination	Total Max. Marks
IV	PH HCT 410	Classical Electrodynamics	04	04	03	70	30	100
	PH HCT 420	Analytical techniques & instrumentation	04	04	03	70	30	100
	PH SCT 430	Solid State Physics III	04	04	03	70	30	100
	PH SCT 431	Nuclear Physics III	04	04	03	70	30	100
	PH SCT 440	Solid state Physics IV	04	04	03	70	30	100
	PH SCT 441	Nuclear Physics IV	04	04	03	70	30	100
	PH HCP 450	Practical VII (Solid state physics Lab III)	04	04	04	70	30	100
	PH HCP 451	Practical VII (Nuclear Lab III)	04	04	04	70	30	100
	PH HCP 460	Project	04	04	04	70	30	100

In the beginning of the Semester I-IV, the Department will notify the actual soft core course that it wants to offer depending on the availability of staff and facility. Accordingly, the students will be allotted to soft core course.

COURSE STRUCTURE AND SCHEME OF EXAMINATION

M.Sc DEGREE IN PHYSICS

Semester	Course code	Title of the paper	Contact Hours per Week & Credits	Total Marks per Paper	Assessment Weightage		Semester End Exam Duration (hrs) & Assessment Weightage
					I Internal	II Internal	
I	**Hard Core Papers**						
	PH HCT 110	Mathematical Physics I	4h & 4	100	15%	15%	3h & 70%
	PH HCT 120	Classical Mechanics	4h & 4	100	15%	15%	3h & 70%
	PH HCT 130	Atomic, molecular and Optical Physics	4h & 4	100	15%	15%	3h & 70%
	Soft Core Papers						
	PH SCT 140	Electronics	4h & 4	100	15%	15%	3h & 70%
	PH SCT 141	Astrophysics	4h & 4	100	15%	15%	3h & 70%
	Practicals						
	PH HCP 150	Practical I (Physics Lab I)	4h & 4	100	15%	15%	3h & 70%
	PH HCP 160	Practical II (Physics Lab II)	4h & 4	100	15%	15%	3h & 70%

Semester	Course code	Title of the paper	Contact Hours per Week & Credits	Total Marks per Paper	Assessment Weightage		Semester End Exam Duration (hrs) & Assessment Weightage
					I Internal	II Internal	
II	**Hard Core Papers**						
	PH HCT 210	Mathematical physics II	4h & 4	100	15%	15%	3h & 70%
	PH HCT 220	Quantum mechanics I	4h & 4	100	15%	15%	3h & 70%
	Soft Core Papers						
	PH SCT 230	Elements of Solid state Physics	4h & 4	100	15%	15%	3h & 70%
	PH SCT 240	Elements of Nuclear Physics	4h & 4	100	15%	15%	3h & 70%
	PH SCT 241	Atmosphere and Space Science	4h & 4	100	15%	15%	3h & 70%
	Practicals						
	PH HCP 260	Practical III (Physics Lab III)	4h & 4	100	15%	15%	3h & 70%
	PH HCP 270	Practical IV (Physics Lab IV)	4h & 4	100	15%	15%	3h & 70%
	Open Elective Theory (For Non-Physics students only)						
	PH OET 250	Modern Physics	4h & 4	100	15%	15%	3h & 70%
	PH OET 251	General Physics	4h & 4	100	15%	15%	3h & 70%

Semester	Course code	Title of the paper	Contact Hours per Week & Credits	Total Marks per Paper	Assessment Weightage		Semester End Exam Duration (hrs) & Assessment Weightage
					I Internal	II Internal	
III	**Hard Core Papers**						
	PH HCT 310	Quantum mechanics II	4h & 4	100	15%	15%	3h & 70%
	PH HCT 320	Statistical Mechanics	4h & 4	100	15%	15%	3h & 70%
	Soft Core Papers						
	PH SCT 330	Solid State Physics I	4h & 4	100	15%	15%	3h & 70%
	PH SCT 331	Nuclear Physics I	4h & 4	100	15%	15%	3h & 70%
	PH SCT 340	Solid state Physics II	4h & 4	100	15%	15%	3h & 70%
	PH SCT 341	Nuclear Physics II	4h & 4	100	15%	15%	3h & 70%
	Practicals						
	PH HCP 350	Practical V (Solid state physics Lab I)	4h & 4	100	15%	15%	3h & 70%
	PH HCP 351	Practical V (Nuclear Lab I)	4h & 4	100	15%	15%	3h & 70%
	PH HCP 360	Practical VI (Solid state physics Lab II)	4h & 4	100	15%	15%	3h & 70%
	PH HCP 361	Practical VI (Nuclear Lab II)	4h & 4	100	15%	15%	3h & 70%
	Open Elective Theory (For Non-Physics students only)						
	PH OET 370	Energy science	4h & 4	100	15%	15%	3h & 70%
	PH OET 371	Radiation physics	4h & 4	100	15%	15%	3h & 70%

Semester	Course code	Title of the paper	Contact Hours per Week & Credits	Total Marks per Paper	Assessment Weightage		Semester End Exam Duration (hrs) & Assessment Weightage
					I Internal	II Internal	
IV	**Hard Core Papers**						
	PH HCT 410	Classical Electrodynamics	4h & 4	100	15%	15%	3h & 70%
	PH HCT 420	Analytical techniques & instrumentation	4h & 4	100	15%	15%	3h & 70%
	Soft Core Papers						
	PH SCT 430	Solid State Physics III	4h & 4	100	15%	15%	3h & 70%
	PH SCT 431	Nuclear Physics III	4h & 4	100	15%	15%	3h & 70%
	PH SCT 440	Solid state Physics IV	4h & 4	100	15%	15%	3h & 70%
	PH SCT 441	Nuclear Physics IV	4h & 4	100	15%	15%	3h & 70%
	Practicals						
	PH HCP 450	Practical VI (Solid state physics Lab III)	4h & 4	100	15%	15%	3h & 70%
	PH HCP 451	Practical VI (Nuclear Lab III)	4h & 4	100	15%	15%	3h & 70%
	Project						
	PH HCP 460	Project	4h & 4	100	15%	15%	3h & 70%

VIJAYANAGARA SRI KRISHNADEVARAYA UNIVERSITY, BALLARI
Department of studies in Physics (PG)
(2019-20)
Choice Based Credit System, Continuous Assessment Patterned Semester Scheme.

The Board has framed and approved the Syllabus/Scheme of examination of Choice Based Credit System (CBCS) and recommended for implementation from the academic year 2019-2020. The following are the core papers and scheme of examination proposed by the Board.

1. M.Sc., Degree in Physics I & II Semester
2. M.Sc., Degree in Physics III and IV Semester.

The pattern of matrix for two year Master's Degree Program in Physics shall be as follows.

No.	COURSES	I SEM			II SEM			III SEM			IV SEM			TOTAL		
		C	P	M	C	P	M	C	P	M	C	P	M	C	P	M
1	HARD CORE (Theory)	12	3	300	8	2	200	8	2	200	8	2	200	36	9	900
2	HARD CORE (Practicals)	8	2	200	8	2	200	8	2	200	4	1	100	28	7	700
3	HARD CORE (Project)	-	-	-	-	-	-	-	-	-	4	1	100	04	1	100
4	SOFT CORE	4	1	100	8	2	200	8	2	200	8	2	200	28	7	700
5	OPEN ELECTIVE	-	-	-	4	1	100	4	1	100	-	-	-	08	2	200
TOTAL		**24**	**6**	**600**	**28**	**7**	**700**	**28**	**7**	**700**	**24**	**6**	**600**	**104**	**26**	**2600**

III and IV semesters will have two specialization, Viz 1) Solid state Physics
2) Nuclear Physics

Note:

1. All hard core theory/Practical papers (HCT/HCP) are **compulsory** for all the students (M.Sc. Physics).
2. The students of M.Sc. Physics in Semester III (including Semester IV) have to choose a specialization (either **Nuclear Physics/Solid State Physics**) and have to select **one** specialization containing two soft core papers (SCT).
3. Open elective theory (OET) papers are for other than Physics students. Students need to opt open elective paper in semester II and III respectively. However the operation of such paper starts with a minimum of **ten** students.

Theory question paper format for CBCS Semester Examinations

Time: 3 Hours **Maximum Marks: 70**

Instructions: **1) Answer all the questions.**

2) Question no. 1 to 8 carry 15 marks each.

3) Question no. 9 to 12 carry 5 marks each.

1. a)
b) **(5+10)**

OR

2. a)
b)
c)
(4+6+5)

3. a)
b)

OR

4. **(15)**

5. a)
b) **(8+7)**

OR

6. **(15)**

7. **(15)**

OR

8. **(15)**

9. **(5)**

10. **(5)**

11. **(5)**

12. **(5)**

Note: Equal weightage is given to each unit while preparing the question paper. From question number 1 to 8, two main questions will be drawn from each unit and student has to answer one. Question no. 1 to 8 can be subdivided as per the paper setter discretion for sub-questions a, b or c. Four questions are drawn from each unit from question number 9 to 12 and student has to answer any two.

PH HCP 460: Project work

Every student has to compulsorily carryout a Project course in the semester IV. The Project may be a theoretical or an experimental work in the respective specialization subject. More than one student may be required to work on an assigned project. Project course carries 100 marks, of which 30 marks for Internal Assessment and 70 marks for semester end examination; out of which 50 marks for dissertation and 20 marks for via-voce.

Scheme of examination for project work:

Thesis evaluation: 50 Marks; Viva-Voce: 20 Marks

Scheme for Practical examination:

Viva-voce: 10 Marks; Record Book: 10 Marks; Experiment: 50 Marks

Practical Internal Assessment: 30 Marks

Course Code: **PH HCT 110** Dept. Code: **9111**
Total Hours: **56 hrs** Workload: **4 hours per week**
Evaluation: Continuous Internal Assessment - **30 marks** Credit Points: **4**
Semester End Examination - **70 marks**

M.Sc. Physics (Semester I) (CBCS)

COURSE: MATHEMATICAL PHYSICS I (PH HCT 110)

Unit 1 **Complex analysis** 14 hrs

Properties of analytic functions, Cauchy's integral theorem, singularities, Cauchy's residue theorem, evaluation of definite integrals.

Vector analysis

Cartesian and curvilinear coordinate systems; Review of vector algebra; Vector differentiation and integration; Line, surface and volume integrations, some examples; Gauss and Stock theorems, some physical applications.

Unit 2 **Group theory** 14 hrs

Groups, subgroups, classes. Homomorphism and isomorphism. Group representation. Reducible and irreducible representations. Character of a representation, character tables. Construction of representations. Representations of groups and quantum mechanics. Lie groups. The three dimensional rotation group SO(3). The special unitary groups SU(2) and SU(3). The irreducible representations of SU(2). Representations of SO(3) from those of SU(2). Some applications of group theory in physics.

Unit 3 **Differential equations** 14 hrs

Ordinary differential equations: First order homogeneous and non-homogeneous equations with variable coefficients. Second order homogeneous and non-homogeneous equations with constant and variable coefficients.

Partial differential equations: Classification, systems of surfaces and characteristics, examples of hyperbolic, parabola and elliptic equations, method of direct integration, method of separation of variables.

Unit 4 **Special functions** 14 hrs

Legendre functions: Legendre polynomials, Rodrigue's formula generating function and recurrence relations, orthogonality and normalization, associated Legendre function and spherical harmonics.

Bessel functions: Bessel functions of the first kind representation relations orthogonality.

Hermite functions: Hermite polynomials, generating five recursion relations, orthogonality

Laguerre functions: Laguerre and associated Laguerre polynomials, recursion relations, orthogonality

Applications of special functions to problems in physics.

References:

1. Mathematical Physics by P K Chattopadhyay, Wiley Eastern Lit., Mumbai
2. Introduction to Mathematical Physics by C Harper, PHI
3. Mathematical Physics by Satya Prakash, S Chand and Sons, New Delhi
4. Advanced Engineering Mathematics by H.K. Dass, S Chand and Company Ltd.
5. Mathematical Physics by B. D. Gupta, 3rd Ed, Vikas publishing house Pvt. Ltd (2004)
6. Mathematical Methods for Physicist, George Arfken and Hans J Academic press San Diego, 1995.

Course Code: **PH HCT 120** Dept. Code: **9111**
Total Hours: **56 hrs** Workload: **4 hours per week**
Evaluation: Continuous Internal Assessment - **30 marks** Credit Points: **4**
Semester End Examination - **70 marks**

M.Sc. Physics (Semester I) CBCS

COURSE: CLASSICAL MECHANICS (PH HCT 120)

Unit 1 **Newtonian mechanics** 14 hrs

Single and many particle systems-Conservation laws of linear momentum, angular momentum and energy. Application of Newtonian mechanics: Two-body central force field motion. Kepler's laws of planetary motion. Scattering in a central force field, scattering cross section, The Rutherford scattering problems

Unit 2 **Lagrangian formalism** 14 hrs

Constrains in motion, generalised co-ordinates, virtual work and D'Alembert's principle. Lagrangian equation of motion. Symmetry and cyclic co-ordinates. Hamilton variational principle; Lagrangian equation of motion from variational priniciple. Simple applications.

Unit 3 **Motion of Rigid body** 14 hrs

Fixed and moving co-ordinate systems. Coriolis force, Coriolis force acting on falling body Euler theorem. Euler angle, angular momentum and kinetic energy of a rigid body.

Inertia tensor, Euler's equations of motion. Torque free motion. Motion of symmetric top –

Nutational motion, Problems.

Unit 4 **Hamiltonian Mechanics** 14 hrs

Legendre transformation and Hamilton equations of motion: Conservation theorem and physical significance of Hamiltonian. Derivation of Hamilton's equation from a variation principle: principle of least action. Lagrange and Poisson brackets, Equation of motion in Poisson bracket notation.

Hamilton-Jacobi Theory:

Hamilton-Jacobi equation of motion for Hamilton's principle and Characteristic functions, Harmonic oscillator problem as example of Hamilton-Jacobi method.

Problems

References

1. Classical Mechanics: H Goldstein, (Addision-Wesley, 1950)
2. Introduction to Classical Mechanics: R G Takwale and P S Puranik (TMH, 1979)
3. Classical Mechanics: N C Rana and P S Joag (Tata McGraw, 1991)
4. Mechanics: Landau L D and Lifshitz E M (Addition-Wesley, 1960)

Course Code: **PH HCT 130** Dept. Code: **9111**
Total Hours: **56 hrs** Workload: **4 hours per week**
Evaluation: Continuous Internal Assessment - **30 marks** Credit Points: **4**
Semester End Examination - **70 marks**

M.Sc. Physics (Semester I) (CBCS)

COURSE: ATOMIC, MOLECULAR AND OPTICAL PHYSICS (PH HCT 130)

Unit 1 **Atomic spectra and structure** 14 hrs

Overview of the salient features of optical spectra due to alkalis, Boron group and IIA and IIB group of elements (as in Periodic Table). Spin-orbit interaction due to single-valence electron atoms and its doublet spectra. Vector model for two-valence electron atoms: Determination of spectral terms (singlets, doublets, triplets, etc); derivation of interaction energies in LS and jj coupling schemes; the Lande interval rule; singlet and triplet splitting. Normal and anomalous Zeeman Effect of singlet and doublet states (qualitative). Stark effect in hydrogen (qualitative).

Unit 2 **Diatomic rotational spectra and structure** 14 hrs

General features of observed spectra of typical diatomic molecules in Far-IR (microwave) and due to Raman scattering; empirical series for the observed wave numbers in both IR and Raman spectra. Diatomic molecule as rigid and non-rigid rotator models: energy levels, eigenfunctions, selection rules, IR spectra and correlation with empirical series and illustrations. Raman scattering and spectra due to the rigid and non-rigid rotator: energy levels, eigenfunctions, selection rules, spectra and correlation with empirical series and illustrations

Unit 3 **Diatomic vibrational spectra and structure** 14 hrs

General features of observed spectra of typical diatomic molecules in Near-IR and due to Raman scattering; empirical series for the observed wave numbers in both IR and Raman spectra. Diatomic molecule as Harmonic and Anharmonic oscillator models: energy levels, eigenfunctions, selection rules, IR spectra and correlation with empirical series and illustrations. Raman scattering and spectra due to Harmonic and Anharmonic oscillator models: energy levels, eigenfunctions, selection rules, spectra and correlation with empirical series and illustrations. The vibrating rotator model: energy levels, selection rules, IR and Raman spectra, IR fine-structure spectrum of a rotation-vibration band and correlation with empirical series.

Unit 4 **Laser physics and Fibre optics** 14 hrs

Laser principles: Einstein coefficients, optical pumping, population inversion, the threshold condition-the Schawlow-Townes condition for laser oscillations. Three-level and four-level laser systems. The Ruby laser and He-Ne Laser: energy level diagrams, excitation mechanism, construction and working.
Fibre optics: Mechanism of light propagation in a fiber wave guide, numerical aperture, types of optical fibers, transmission characteristics of optical fibers-attenuation and dispersion, optical fiber communication system (qualitative).

References

1. Introduction to Atomic Spectra : H.E. White, McGraw – Hill, Tokyo (1934)
2. Atomic Spectra: H.G.Kuhn, Longmans, Green & Co.Ltd, London & Harlow (1962)
3. Molecular Spectra & Molecular Structure(Vol I; 2nd ed): G.Herzberg, D. Van Nostrand Inc. N.Y. (1950) [Free soft copy available on Net]
4. Spectroscopy (Vol. 3):S. Walker & B. P. Strauhghan, Chapman & Hall, London (1976)
5. Fundamentals of Molecular Spectroscopy: C. N. Banwell and E.M. McCash, Tata Mc Graw-Hill Co., (4th revsd Ed; 9th reprint, 2000)
6. Lasers and Non-Linear Optics : B. B. Laud, Wiley Eastern Ltd., New Delhi (1991).
7. Laser Fundamentals: William T. Silfvast, Cambridge Univ Press, 1999.
8. Fundamentals of Spectroscopy (2nd ed): B. Narayan, Allied Publishers Ltd., New Delhi (1999).
9. Physics of Atoms and Molecules – 2nd Ed., Bransden B.H. and Joachain C.J., Pearson Education, India (2006).
10. Modern Spectroscopy (4th Ed): J.M. Hollas, John Wiley & Sons Ltd. UK 2004 [Free soft copy available on Net]
11. Laser Electronics: Joseph T. Verdeyen, Prentice-Hall of India Pvt. Ltd. New Delhi (1989).
12. Lasers: Theory & Applications: K. Thyagarajan & A. Ghatak, MacMillan India, New Delhi (1981).
13. Optical Electronics, Ghatak and Tyagarajan, Cambridge Press, 2004

Course Code: **PH SCT 140** Dept. Code: **9111**
Total Hours: **56 hrs** Workload: **4 hours per week**
Evaluation: Continuous Internal Assessment - **30 marks** Credit Points: **4**
Semester End Examination - **70 marks**

M.Sc. Physics (Semester I) (CBCS)

COURSE: ELECTRONICS (PH SCT 140)

Unit 1 **Bipolar junction transistor** 14 hrs

Transistor operation, transistor amplification action and CB, CE, CC configuration. BJT hybrid equivalent circuits and low frequency analysis; small signal analysis for input output impedances, voltage gain, current gain and power gain. Biasing techniques for BJT and design consideration for CE and CC. Concept of feedback criteria for oscillation.

Unit 2 **Analog electronics** 14 hrs

Op-Amp

Ideal characteristics, offset voltage, current, CMMR, Skew rate, negative feedback in Op-amp of feedback on gain and bandwidth. Current amplifier, summing amplifier, difference amplifier, integrator and differentiator.

Active filters

Types and specifications, filter transfer function, first order and second order filter functions, low-pass, high-pass band-pass and band-reject filters, Butterworth filter.

Signal generators

Basic principles. Wein-bridge oscillator, phase-shift oscillator, triangular wave generator.

Unit 3 **Integrated circuits (ICs)** 14 hrs

Microelectronics technology; integrated circuits package relevant to BJT and MOS

Digital electronics

Boolean operations and expressions, Boolean analysis of logic gates, simplification of Boolean expression. Karnaugh map: two, three and four variable map, product of sums (POS) and sum of products (SOP) simplification.

Digital logic gates

AND, OR, NAND and NOR gates, AND-OR and NAND-NOR implementation of Boolean expressions. Logic gate operation with pulse waveforms.

Combinational logic circuits

Adder, parallel binary adder, subtractor, comparators, decoders, BCD to seven segment decoder, encoders, code conversion, multiplexers, demultiplexers, parity generators and checkers.

Unit 4 **Sequential circuits** 14 hrs

Latches, flip-flops, edge triggered flip-flops, SR, JK, Master-Slave JK, D, T flip-flops, counters, synchronous counters, ripple counters, registers, shift registers.

A/D and D/A conversion circuits

Introduction, filtering and sampling, quantization, quantization error, flash converter and dual slop converter, conversion errors. Binary weighted converter, R-2R ladder converter, characteristic properties.

References

1. Microelectronics, J Millman and Arvin Grabel.
2. Introduction to electronics, K J M. Rao.
3. Integrated electronics, Millman and Halkias.
2. Electronic Fundamentals and Application, J D Ryder.
3. Basic Electronics, M N Farugui and S L Maskara.
4. Operational Amplifiers and Linear IC's, F Robert Coughlin and F Frederick, PHI Publications (1994).
5. Op-Amps and Linear Integrated Circuits, R Gayakwad, PHI Publications, New Delhi (2000).
6. Digital Principles and Applications, A P Malvino and D Leach, TMH Publications (1991).
7. Digital fundamentals, Thomas L Floyd, 8th edition, Pearson Education (2003).

Course Code: **PH HCT 141** Dept. Code: **9111**
Total Hours: **56 hrs** Workload: **4 hours per week**
Evaluation: Continuous Internal Assessment - **30 marks** Credit Points: **4**
Semester End Examination - **70 marks**

M.Sc. Physics (Semester I) (CBCS)
COURSE: ASTROPHYSICS (PH SCT 141)

Unit 1 **Basic concepts** 14 hrs

Coordinate systems, time systems, trigonometric parallaxes, parsec, apparent and absolute magnitudes, atmospheric extinction, angular radii of stars, Michelson's stellar interferometer, binary stars and their masses, radial and transverse velocities, types of optical telescopes and their characteristics, modern telescopes like Gemini, KECT etc.

Unit 2 **Properties of stars** 14 hrs

Spectra of stars, spectral sequence-temperature and luminosity classifications, H-R diagram, Saha's ionization formula and application to stellar spectra, Virial theorem, stellar structure equations, star formation and main sequence evolution, mass luminosity relation, white dwarfs, pulsars, magnetars, neutron stars and black holes, variable stars.

Unit 3 **The solar system** 14 hrs

The surface of the sun, solar interior structure, solar rotation, sun spots, the active sun, properties of interior planets and exterior planets, satellites of planets, comets, asteroids, meteorites, Kuiper belt object and Oort cloud, theories of formation of solar system.

Unit 4 **Star clusters, galaxies and the universe** 14 hrs

Open and global clusters, the structure and contents of milky way galaxy, Hubble's classification of galaxies, Galactic structure and dark matter, galactic motions, Hubble's law, Olber's paradox, big bang theory and the origin of the early universe, nucleosynthesis, cosmic microwave background radiation and evolution of the universe.

References

1. Introduction to Stellar Astrophysics, E. Bohm-Vitense, 3rd Volume, CUP, 1989
2. Astrophysics and Stellar Astronomy, T.L. Swihart, Wiley 1968
3. Introduction to Cosmology, J.V. Narlikar, CUP, 1993
4. Priciples of Physical Cosmology, P.J.E. Peebles, Princeton U.P. 1993
5. Galaxies; their Structure and Evolution, R.J. Taylor, CUP, 1993
6. Solar System Astrophysics, J.C. Brandt and Hodge, McGraw-Hill, 1964
7. Introduction to Modern Astrophysics, Ostlie and Carroll, Addison Wesley, 1997
8. An Introduction to Astrophysics Baidyanath Basu, PHI
9. A Text book of Astrophysics and Cosmology, V.B.Bhatia, New Age
10. Stars and Galaxies, K.D. Abhyankar, University Press
11. Pulsar Astronomy, A.G. Lyne and G. Smith, Cambridge Univ.

Course Code: **PH HCP 150** Dept. Code: **9111**
Total Hours: **40 hrs** Workload: **4 hours per week**
Evaluation: Continuous Internal Assessment - **30 marks** Credit Points: **4**
Semester End Examination - **70 marks**

M.Sc. Physics (Semester I) CBCS
Practical I: ELECTRONICS LAB I (PH HCP 150)

LIST OF EXPERIMENTS:

1. Studies on Cathode Ray Oscilloscope
   DC/AC voltages and frequencies of sine and square signals,
   Unknown frequencies using Lissageous figures.
2. Study of RC/RL/LCR circuits
   Time constants of RC and RL circuits, resonance frequencies and quality factors of LCR series and parallel circuits.
3. Astable multivibrator using transistors
   Frequency studies
4. Full-wave bridge rectifier using diodes
   Design and study the performance of CR, L and π type filters
5. Clipping and clamping circuits
   Design circuits using diodes and resistors and study their performance
6. Operational Amplifier characteristics
   Set up a circuit and study offset voltage and currents, CNRR and slew rate
7. Op-Amp: configurations
   Voltage and current follower, Inverting and non-inverting
8. Op-Amp: Mathematical operations
   Addition, subtraction, integration and differentiation
9. Wein bridge Oscillator using Op-Amp
   Design and study frequency response.
10. Comparator using Op-Amp
    Design simple voltage and regenerative comparators and study performance.
    With the permission of BOS, new experiments may be added to the list whenever they are developed.

Note: Minimum of eight experiments must be carried out.

Experiments shall be added as and when developed.

References

1. Electronic devices and circuits by R.Boylstead and Nashalsky
2. Electronics principles by A.P.Malvino
3. Operational amplifiers and linear IC’s by F.Robert Coughlin and Frederick F Driscoll
4. Any other book suggested by the course teacher

Course Code: **PH HCP 160** Dept. Code: **9111**
Total Hours: **40 hrs** Workload: **4 hours per week**
Evaluation: Continuous Internal Assessment - **30 marks** Credit Points: **4**
Semester End Examination - **70 marks**

M.Sc. Physics (Semester I) CBCS

PRACTICAL II: GENERAL AND COMPUTATIONAL LAB I (PH HCP 160)

LIST OF EXPERIMENTS:

1. Error Analysis: computations
2. Ultrasonic velocity studies in liquids
3. Verification of Fresnel's laws
4. Blackbody radiation-Stefan's constant determination (electrical method)
5. Excitation and Ionization potentials
6. Determination of h/e by photocell method
7. Constant Deviation spectrometer
8. Study of Beer's law
9. Production and measurement of vacuum
10. Verification of Binomial and Gaussian distributions
    (Do experiment with identical coins for BD and lengths of nails for GD)
11. Solution of quadratic equation : Computer programming
12. Newton's forward and backward interpolations: Computer programming
13. Linear least square fitting: Computer programming
    (Provide x and y data and ask to write program for determining slope and intercept)
    With the permission of BOS, new experiments may be added to the list whenever they are developed.

Note: Minimum of six experiments and three computations must be carried out.

Experiments shall be added as and when developed.

References

1. Advanced practical physics by Worsnop and Flint, 9^{th} Edition
2. Experiments in modern Physics by A.C. Melissinos
3. Taylor manual of advanced laboratory experiments in Physics by Ed. T. Brown
4. Optics by A.K. Ghatak
5. Instrumental methods of analysis by HH Willard, LL Merritt, FA Settle, JK Jain
6. Any other book suggested by the course teacher.

Course Code: **PH HCT 210** Dept. Code: **9111**
Total Hours: **56 hrs** Workload: **4 hours per week**
Evaluation: Continuous Internal Assessment - **30 marks** Credit Points: **4**
Semester End Examination - **70 marks**

M.Sc. Physics (Semester II) (CBCS)

COURSE: MATHEMATICAL PHYSICS II (PH HCT 210)

Unit 1 **Fourier series** 14 hrs

Fourier's theorem. Cosine and Sine series. Change of interval. Complex form of Fourier series. Fourier integral. Extension to many variables.

Integral transforms

Fourier transforms: Transform of impulse function. Constant unit step function and periodic function. Some physical applications.
Laplace transforms: Transform of Dirac delta function, periodic function and derivatives. Solution of linear differential equations with constant coefficients Physical applications.

Unit 2 **Matrices** 14 hrs

Orthogonal, Hermitian and unitary matrices; eigenvalues and eigenvectors, diagonalization of matrices, Matrix representation of linear operators, eigenvalues and eigenvectors of operators, simultaneous eigenvectors and commutativity.

Tensors

Coordinate transformation in linear spaces, definition and type of tensors, Contravariant and Covariant tensors, symmetric and antisymmetric tensors. Tensor algebra: Equality, addition and subtraction, tensor multiplication, outer product; contraction of indices, inner product, quotient theorem, Kronecker delta, metric tensor, Christoffel symbols. Tensors in physics.

Unit 3 **Numerical techniques** 14 hrs

Numerical methods. Solutions of algebraic and transcendental equations: Bisection, iterative and Newton-Raphson methods. Interpolation: Newton's and Lagrange's methods. Curve fitting: Method of least squares. Differentiation: Newton's formula. Integration: Trapezoidal rule, Simpson's 1/3 and 3/8 rules. Eigen values and eigenvectors of a matrix. Solutions of ordinary differential equations: Euler's modified method and Runge-Kutta methods. Some applications of Numerical techniques in physics.

Unit 4 **Computational Physics** 14 hrs

Tokens, keywords, identifier and constants, basic data types, user defined data types, derived data types, arithmetic operators, relational operators, logical operators, assignment operators, increment and decrement operators, conditional operators, bit wise operators, special operators, expressions and evaluation of expressions. Decision making, branching and looping: if, if-else, else-if, switch statement,

break, continue and go to statement, for, while and do-while. Arrays, strings, Functions-Defining function, function arguments and passing, returning values from functions.
Numerical methods using C-programming.

References

1. Mathematical Physics by P K Chattopadhyay, Wiley Eastern Ltd., Mumbai.
2. Introduction to Mathematical Physics by C Harper, PHI.
3. Mathematical Physics by Satya Prakash, S Chand and Sons, New Delhi
4. Introductory Methods of Numerical Analyes: S. S. Sastry, PHI, 1995
5. Fundamentals of Computers by V. Rajaraman, PHI
6. Programming in Basic by Balagurswamy TMH
7. Programming with C by Venugopal and Prasad, TMH
8. Numerical Methods: E. Balagurswamy (TMH, 2001)
9. Instrumentation measurement analysis, Nakra and Chaudhury
10. Programming in ANSI-C by E Balaguruswamy Tata McGraw Hill New Delhi (1992).
11. Matrices and Tensors in Physics by A W Joshi
12. Advanced Engineering Mathematics by H.K. Dass, S Chand and Company Ltd.
13. Mathematical Physics by B. D. Gupta, 3rd Ed, Vikas publishing ho Pvt. Ltd (2004)

Course Code: **PH HCT 220** Dept. Code: **9111**
Total Hours: **56 hrs** Workload: **4 hours per week**
Evaluation: Continuous Internal Assessment **- 30 marks** Credit Points: **4**
Semester End Examination **- 70 marks**

M.Sc. Physics (Semester II) (CBCS)
COURSE: QUANTUM MECHANICS I (PH HCT 220)

Unit 1	**Basic Principles:** Hermitian operators, observables; Eigenfunctions, eigenvalues and orthonormalization of eigenfunctions, completeness. State functions as probability amplitude and the principle of superposition. Momentum, Hamiltonian and energy operators, Schrodinger equation. Probability density and probability current density, expectation value, Ehrenfest's theorem; basic postulates of quantum mechanics. **Simple Applications:** Eigenvalues and eigenfunctions of free particle, particle in infinite square well and of simple harmonic oscillator by polynomial method, barrier transmission: leakage of free particle through a thick rectangular potential barrier and transmission and reflection coefficients.	14 hrs
Unit 2	**Hydrogen atom:** Particle in spherically symmetric potential, Reduction of two-body problem to a single particle problem. Center-of-mass and relative motions; eigenvalues and eigenfunctions. Hydrogen-like atom, eigenvalues of energy and eigenfunctions. **Angular momentum:** The expression for the three Cartesian components and the square of the angular momentum, their commutation relations, expression for the operators in polar coordinates, eigenvalues and eigenfunctions in terms of polar coordinates; eigenvalues and eigenfunctions of the square and z-component of angular momentum.	14 hrs
Unit 3	**Time-Independent Perturbation Theory:** Eigenvalue of energy and eigenfunction in the first-order approximation (the case of a system with non-degenerate energy levels). Application to anharmonic oscillator and to the ground state of Helium atom. **Time-Dependent Perturbation Theory:** Concept of the theory, transition from one discrete level to the other, to a continuum states: Fermi's Golden rule. The harmonic perturbation, resonance transitions. Semi-classical theory of Einstein's A & B coefficients. Interaction of radiations with a system of atoms, transition dipole moment, selection rules.	14 hrs
Unit 4	**Elastic Scattering:** Differential and total cross-section, phase analysis. Significance of the partial waves and phase shifts, S-wave scattering from a square well potential. The Born approximation, derivation of the expression for differential scattering cross-section, condition for validity of the approximation: application to square well potential and screened coulomb potential.	14 hrs

References:

1. Quantum Mechanics – Theory & Applications (3rd Ed): A.K. Ghatak & S. Loknathan, MacMillan India Ltd. (1984)
2. A Text of Quantum Mechanics: P.M. Mathews &K. Venkatesan, Tata McGraw-Hill, New Delhi (1982)
3. Quantum Mechanics (2nd ed): G. Aruldhas, Prentice-Hall India Pvt. Ltd., New Delhi (2009)
4. Quantum Physics (3rd ed): S. Gasiorowicz, Wiley India (P) Ltd., New Delhi (2007)
5. Introduction to Quantum Mechanics: L. Pauling & E. Bright Wilson, McGraw-Hill, N.Y.(1935)
6. Quantum Mechanics (3rd ed): L.I. Schiff, McGraw-Hill, N.Y.(1968)
7. Quantum Mechanics: E. Merzbacher, 2nd ed., Wiley, N.Y.(1970)
8. Quantum Mechanics (2nd Ed): V.K. Thankappan, New Age International (P) Ltd. (1993)
9. Quantum Mechanics (2nd ed): B.H. Bransdon, C. J. Joachain. Prentice Hall, 2000.

Course Code: **PH SCT 230** Dept. Code: **9111**
Total Hours: **56 hrs** Workload: **4 hours per week**
Evaluation: Continuous Internal Assessment - **30 marks** Credit Points: **4**
Semester End Examination - **70 marks**

M.Sc. Physics (Semester II) (CBCS)

COURSE: ELEMENTS OF SOLID STATE PHYSICS (PH SCT 230)

Unit 1 **Crystal structure** 14 hrs

Crystal systems, crystal classes, Bravais lattice. Unit cell: Wigner-Seitz cell. Notations of planes and directions. Atomic packing: packing fraction, Co-ordination number. Examples of simple crystal structures: NaCl, ZnS and diamond. Symmetry operations, point groups and space groups.

X-ray diffraction

X-ray diffraction, Bragg law. Laue equations, Atomic form factor and structure factor. Concept of reciprocal lattice and Ewald construction. Experimental diffraction methods: Laue rotating crystal method and powder method.

Unit 2 **Crystal binding** 14 hrs

Types of binding. Van der Waals-London interaction, repulsive interaction. Modelung constant. Born’s theory for lattice energy in ionic crystals and comparison with experimental results. Ideas of metallic binding, Hydrogen bonded crystals.

Lattice vibrations

Vibrations of monoatomic and diatomic lattices. Optical and acoustical branches, Quantization of lattice vibration-Concept of phonon, phonon momentum. Specific heat of lattice (qualitative).

Unit 3 **Energy bands in solids** 14 hrs

Formation of energy bands. Free electron model: free electron in one and three dimensional potential wells, electrical conductivity, heat capacity, paramagnetism, Fermi-Dirac distribution, density of states, concept of Fermi energy. Kroning-Penny model.

Defects in solids

Point defects: Schottky and Frenkel defects and their equilibrium concentrations. Line defects: Dislocations, multiplication of dislocations (Frank-Read mechanism). Plane defects: grain boundary and stacking faults.

Unit 4 **Semiconductors** 14 hrs

Intrinsic and extrinsic semiconductors: concept of majority and minority carriers. Statistics of electrons and holes, electrical conductivity, Hall effect in both intrinsic and extrinsic semiconductors, Experimental determination of energy gap of a semiconductor

Superconductors

Superconductivity, zero resistance, Meissner effect, critical field, classification into Type I and Type II, thermodynamics of superconducting transition, electrodynamics of superconductors.

References

1. Elementary Solid State Physics: Principles and applications, M. A. Omar, Addison-Wesley
2. Introduction to Solid State Physics, C. Kittel, Wiley Eastern
3. Solid State Physics: Structure and Properties of Materials by M A Wahab, Narosa Publishing
4. Solid State Physics, A. J. Dekkar, Prentice Hall Inc.
5. Semiconductor Physics, P. S. Kireev, MIR Publishers

Course Code: **PH SCT 240** Dept. Code: **9111**
Total Hours: **56 hrs** Workload: **4 hours per week**
Evaluation: Continuous Internal Assessment - **30 marks** Credit Points: **4**
Semester End Examination - **70 marks**

M.Sc. Physics (Semester II) (CBCS)

COURSE: ELEMENTS OF NUCLEAR PHYSICS (PH SCT 240)

Unit 1 **Basic properties of nucleus** 14 hrs

Nuclear constitution. The notion of nuclear radius and its estimation from Rutherford's scattering experiment; the coulomb potential inside the nucleus and the mirror nuclei. The nomenclature of nuclei and nucleon quantum numbers. Nuclear spin and magnetic dipole moment. Nuclear electric moments and shape of the nucleus.

Nuclear forces

General features of nuclear forces. Bound state of deuteron with square well potential, binding energy and size of deuteron. Deuteron electric and magnetic moments-evidence for non-central nature of nuclear forces. Yukawa's meson theory of nuclear forces.

Unit 2 **Nuclear reactions** 14 hrs

Reaction scheme, types of reactions and conservation laws. Reaction kinematics, threshold energy and Q-value of nuclear reaction. Energetics of exoergic and endoergic reactions.

Nuclear models

The shell model; Evidence for magic numbers, energy level, scheme for nuclei with infinite square well potential and the ground state spins. The liquid drop model: Nuclear binding energy, Bethe-Weizsacker's semi empirical mass formula.

Unit 3 **Nuclear decays** 14 hrs

Alpha decay: Quantum mechanical barrier penetration, Gammow's theory of alpha, half-life systematics. Beta decay: Continuous beta spectrum, neutrino hypothesis and Fermi's theory of beta decay, beta comparative half-life systematics. Gamma decay: Qualitative consideration of multipole character of gamma radiation and systematics of mean lives for gamma multipole transitions.

Interaction of radiation with matter

Interaction of charged particles with matter, ionization energy loss, stopping power and range energy relations for charged particles. Interaction of gamma rays; Photoelectric, Compton and Pair production processes. Nuclear radiation detectors- G M counter and scintillation detector.

Unit 4 **Nuclear energy** 14 hrs

Fission process, fission chain reaction, four factor formula and controlled fission chain reactions, energetics of fission reactions, fission reactor. Fusion process, energetics of fusion reactions; Controlled thermonuclear reactions; Fusion reactor. Stellar nucleosynthesis.

Fundamental interactions and elementary particles

Basic interactions and their characteristic features. Elementary particles, classification; Conservation laws in elementary particle decays. Quark model of elementary particles.

References

1. The Atomic Nucleus: R D Evans (TMH)
2. Nuclear and Particle Physics: W.E. Burcham and M. Jobes (Addison Wesley, 1998, ISE)
3. Nuclear Physics: R R Roy and B P Nigam (Wiley Eastern)
4. Physics of Nuclei and Particles: P Mermier and E Sheldon (Academic Press)
5. Subatomic Physics-Nuclei and Particles: L Valantin
6. Nuclei and Particles: E Serge (Benjamin)
7. Nuclear Physics: D C Tayal (Himalaya)
8. Nuclear Physics: R C Sharma (Khanna)
9. Introduction to Nuclear Physics: S B Patel (Wiley Eastern)
10. Introductory Nuclear Physics: Kenneth S Krane (Wiley)
11. Atomic and Nuclear Physics: S N Ghoshal (S. Chand)

Course Code: **PH SCT 241** Dept. Code: **9111**
Total Hours: **56 hrs** Workload: **4 hours per week**
Evaluation: Continuous Internal Assessment - **30 marks** Credit Points: **4**
Semester End Examination - **70 marks**

M.Sc. Physics (Semester II) (CBCS)

COURSE: ATMOSPHERIC AND SPACE SCIENCE (PH SCT 241)

Unit 1	**Physical Meteorology and atmospheric pollution** Scope of atmospheric science terminology and definitions: weather and climate, composition of the atmosphere: fixed and variable gases, VMR, mechanism of production and destruction of atmospheric constituents, structure of atmosphere, temperature variation in the boundary layer and free atmosphere, Chapman cycle, laws of thermodynamics of the atmosphere: Equation of state for dry air and moist air, virtual temperature. Role of meteorology on atmospheric pollution, atmospheric boundary layer-solar radiation, terrestrial radiation, soil temperature; Air stability, Local wind structure, aerosols.	14 hrs
Unit 2	**Optics of the atmosphere and atmospheric instrumentation systems** Scattering – role of scattering, elements of radiometry and photometry-geometric considerations, radiometric quantities, response of eye, photometric quantities, Characteristic of scattering – types and nature of scattering processes, scattering in the atmosphere – angular scattering and polarization, total scattering and attenuation, transmittance and optical thickness, ground based instruments for the measurement of temperature – mechanical thermometers, electrical thermometers, wet and dry bulb thermometers, maximum and minimum thermometers; Humidity – relative humidity and absolute humidity, hygrometers; Pressure – barometer, wind – anemometers and rainfall rate – rain gauges.	14 hrs
Unit 3	**Orbital motion and space dynamics** Coordinate and time systems, elements of orbits in space, motion, elements of reduction of observational data, review of two body problem: Kepler's law of orbital motion, Newton's laws of motion and gravitation, solution to two body problem: Elliptical, parabolic and hyperbolic orbits, orbit in space: f and g series, many body problem: Equations of motion, Lagrange's solutions, Lagrange's planetary equations (qualitative), artificial satellites, types of orbits-geostationary and geosynchronous orbits, sun synchronous orbits and satellites, weightlessness and artificial gravity. Forces acting on artificial satellites, atmospheric drag. Rocket motion: Motion of a rocket in a gravitational field and in atmosphere.	14 hrs
Unit 4	**Remote sensing** Concepts of remote sensing, electromagnetic spectrum, source of electromagnetic radiation for remote sensing, fundamentals of radiometry and radiometric measurements, energy interaction with earth's surface, signatures of vegetation, soil and water bodies of	14 hrs

the earth's surface (general discussion), classification of remote sensors, spectral, spatial and temporal resolution, IR and microwave sensors (qualitative), data reception and products (qualitative), application of remote sensing for earth's resource management (general discussion). Indian remote sensing programme.

References

1. Fundamentals of Atmospheric Modeling: Mark Z Jacobson, Cambridge University, 1999/2000
2. Optics of the Atomosphere: Earl J McCartney, John Wiley and Sons, 1976
3. Radar Meteorology by S Raghavan, Kulwer Academic Publishers, 2003
4. Dynamic Meteorology by Holton, J.R., 3rd edition, Academic Press N.Y. 1992
5. Meteorology for Scientists and Engineers: Roland B. Stull, Brookes/Cole (Thomson Learning), 2000
6. Atomospheric Physics: J.V. Iribrine and H.R. Cho, D. Reidel Publishing Co. 1980
7. The Physics of Atmosphere: John Hougton Cambridge University Press, 1976
8. Orbital Motion: A.E. Roy, Adam Hinglar Ltd. 2002
9. Fundamentals of Remote Sensing: George Joseph, University Press Pvt. Ltd. Hyderabad, 2002
10. Introduction to Remote Sensing: Singh and Sharma, Rawath Publications, New Delhi, 2004.
11. Basic Space Plasma Physics: W. Baumjohann and R.A. Treumann, Imperial College Press, 1997
12. Introduction to Ionosheric Physics: H. Rishberth and O.K. Garriot, Academic Press, 1969
13. Physics of Space Plasma, 2nd Edn.: G.K. Parks, Addison-Wesley, 1991

Course Code: **PH OET 250** Dept. Code: **9111**
Total Hours: **56 hrs** Workload: **4 hours per week**
Evaluation: Continuous Internal Assessment - **30 marks** Credit Points: **4**
Semester End Examination - **70 marks**

M.Sc. Physics (Semester II) (CBCS)

COURSE: MODERN PHYSICS (PH OET 250)

Unit 1 **Electronics** 14 hrs

AC, DC, resistance, capacitance, inductance fundamentals and applications. rectifiers, power supply and amplifiers. Microphones and speakers. Mobile communication (qualitative)

Unit 2 **Basic nuclear physics** 14hrs

Nucleus and its constitution, Basics of radioactivity, alpha, beta and gamma particles and their properties.

Astronomy

Solar system, evolution of stars, star birth, white dwarfs, neutron stars and holes. Newton's laws of gravitation, Kepler's laws of planetary motion. Basics of satellite.

Unit 3 **Basics of condensed matter physics** 14 hrs

Crystalline and non-crystalline solids, thin films and nano structures. X-rays production and detection, applications. conductors, semiconductors and superconductors.

Thermodynamics

Thermodynamic system. Laws of thermodynamics, entropy, carnot's cycles, non-reaching of 0 K.

14hrs

Unit 4 **Basics of optics**

Electromagnetic spectrum, reflection, refraction, diffraction, interference and polarization of light. Optical fibers and its structure.

Lasers

Lasers, characteristics of laser, laser applications.

References

1. Electronic Devices and Circuit Theory, R Boylestad and L Nashelsky, VIIIth Edi. (PHI, 2002)
2. Elements of X-ray Diffraction, B D Cullity and S R Stock, IIIrd Edi. (Prentice Hall, 2001)
3. Introduction to Solid State Physics, C Kittel, IVth Edi. (Wiley Eastern, 1974)
4. Thermal Physics, C Kittel and H Kroemer, IInd Edi. (CBS Publ., 1980)
5. Atomic and Nuclear Physics, S N Ghoshal, Vol. I and II (S Chand and Company, 1994).
6. Text book on spherical Astronomy by Smart W.M.
7. Observational Astronomy by Binney Scott D.
8. Optics by A.Ghatak

Course Code: **PH OET 251** Dept. Code: **9111**
Total Hours: **56 hrs** Workload: **4 hours per week**
Evaluation: Continuous Internal Assessment **- 30 marks** Credit Points: **4**
Semester End Examination **- 70 marks**

M.Sc. Physics (Semester II) (CBCS)
COURSE: GENERAL PHYSICS (PH OET 251)

Unit 1 **Mechanics** 14 hrs

Newton's laws of motion and their applications, energy and its conservation, rockets and satellites.

Heat

Definitions of heat and temperature, thermometers, different scales of temperature, specific heat, some common effects of heat.

Unit 2 **Electricity and magnetism** 14 hrs

Electrical charges, Coulomb's law, electrical current, electrical resistance, Ohm's law, magnetic field, electromagnetic induction, Faraday's law, electric generator, motors, transformers, some common applications pf electricity.

Unit 3 **Light** 14hrs

concept of light, reflection, refraction and dispersion of light, refractive index, plane concave and convex mirrors, dispersion by a prism, lenses and their properties, telescopes.

Unit 4 **Atomic and nuclear physics** 14hrs

Atomic size and structure, Bohr's theory of hydrogen atom (qualitative), atomic spectra, nuclear size and contents, binding energy of nuclei, nuclear fission, nuclear fusion, nuclear reactors.

References

1. Blackwood and Kelly, General Physics, John Wiley, 1955
2. T A Ashford, The Physical Sciences, Holt, Rinehart and Winston, 1967
3. Isaac Asimov, Understanding Physics, Bracket Books, 1966
4. Albert J Read, Physics-a descriptive analysis, Addison Wesley
5. J B Marion, Physics and the Physical Universe, John Wiley, 1971
6. George Gamow and John. M. Cleveland, Physics: Foundations and Frontiers,

Course Code: **PH HCP 260** Dept. Code: **9111**
Total Hours: **40 hrs** Workload: **4 hours per week**
Evaluation: Continuous Internal Assessment - **30 marks** Credit Points: **4**
Semester End Examination - **70 marks**

M.Sc. Physics (Semester II) CBCS

PRACTICAL III: Optics lab (PH HCP 260)

LIST OF EXPERIMENTS:

1. Wavelength of Laser light by single slit diffraction method.
2. Wavelength of Laser light by double slit interference method
3. Talbot bands
4. Diffraction halos (Lycopodium powder particle size determination)
5. Wavelength of sodium light using Michelson's Interferometer
6. Ultrasonic Interferometer
7. Constant deviation Spectrometer
8. Study of interference and diffraction by means of He-Ne Laser
9. Fresnel's laws of reflection
10. Assignment-I: Analysis of constant deviation spectrographs through Hartman formula.

Note: Minimum of eight experiments must be carried out.

Experiments shall be added as and when developed.

References

1. Electronic devices and circuits by R. Boylstead and Nashalsky
2. Electronics principles by A.P. Malvino
3. Microelectronics circuits by Adel S. Sedra and Kenneth C Smith
4. Digital principles and applications by A.P. Malvino and D.Leach
5. Any other book suggested by the course teacher

Course Code: **PH HCP 270** Dept. Code: **9111**
Total Hours: **40 hrs** Workload: **4 hours per week**
Evaluation: Continuous Internal Assessment **- 30 marks** Credit Points: **4**
Semester End Examination **- 70 marks**

M.Sc. Physics (Semester II) CBCS

PRACTICAL IV: GENERAL AND COMPUTATIONAL LAB II (PH HCP 270)

LIST OF EXPERIMENTS:

1. Modes of vibration of a fixed bar
2. Material constant of a semiconductor
3. Determination of doublet separation by using Michelson's Interferometer
4. Verification of Hartman's formula
5. Cornu's method for elastic constants
6. Thermionic emission
7. Calibration of thermocouple
8 Refractive Index and thickness of reflecting surface using Laser source
9. Velocity of light by Kerr cell method
10. Study of Zeeman effect: determination of (e/m) of electron
11. Euler's method of interpolation: Computer programming
12. Numerical integration by Simpson's 1/3 and 3/8 rules: Computer programming.
13 Numerical integration by Trapezoidal rule: Computer programming.
14. Least square fit : Computer programming
(Provide data from the experiments and ask to work out fit coefficients)

Note: Minimum of six experiments and three computations must be carried out.

Experiments shall be added as and when developed.

References

1. Advanced practical physics by Worsnop and Flint, 9th Edition
2. Experiments in modern Physics by A.C. Melissons
3. Taylor manual of advanced laboratory experiments in Physics by Ed.T. Brown
4. Optics by A.K. Ghatak
5. Instrumental methods of analysis by HH Willard, LL Merritt, FA Settle, J Jain
6. Any other book suggested by the course teacher.

Course Code: **PH HCT 310** Dept. Code: **9111**
Total Hours: **56 hrs** Workload: **4 hours per week**
Evaluation: Continuous Internal Assessment - **30 marks** Credit Points: **4**
Semester End Examination - **70 marks**

M.Sc. Physics (Semester III) (CBCS)

COURSE: QUANTUM MECHANICS-II (PH HCT 310)

Unit 1 **Linear Vector Algebra** 14 hrs

Linear Vectors space, Orthonormality, linear independence. Operators -Eigenvalues, eigenvectors; Hermitian, Unitary and Projection operators. Bra and Ket notation for vectors. The elements of Representation Theory. Idea of Measurements, Observables and generalized uncertainty relation. Coordinate and momentum representations. Quantum Poisson Bracket.

Quantum Dynamics: Schrödinger and Heisenberg pictures; Interaction picture; the Heisenberg equation of motion. Linear harmonic oscillator problem by matrix method.

Unit 2 **Angular Momentum** 14 hrs

Introduction, angular momentum operator and its representation, Eigen values and eigen functions of L^2, commutation relations, Angular momentum and rotations. Bra and Ket representation, Eigen values, ladder operators, Eigenvectors of $\mathbf{J}^2$and $\mathbf{J}_z$**.** Angular momentum matrices for j=1/2 and j=1. Pauli wavefunction and equation, Theory of addition of two angular momenta, Clebsch-Gordan coefficients, allowed values of j, singlet and triplet states (qualitative).

Unit 3 **Approximation Methods** 14 hrs

First-order stationary perturbation theory for a degenerate case; the secular equation; applications: particle in a infinitely deep potential well subject to perturbing potential and, Stark effect in hydrogen atom; Second order perturbation theory and its application to a linear harmonic oscillator subject to a potential. W.K.B. approximation: Connection formulas; application to a potential well and alpha decay. The Variation method and its application to the ground state of hydrogen atom and helium atom.

Unit 4 **Relativistic Quantum Mechanics** 14 hrs

Klein-Gordon equation. Dirac's relativistic equation for a free particle: commutation relations and matrices for α and β; free-particle solutions; probability charge and current densities; positive and negative energy states; the spin of the Dirac particle, Zitterbewegung. Dirac equation in electromagnetic potentials and magnetic moment. Dirac equation for a central field; the hydrogen atom: energy levels and fine structure (without derivation).

References:

1. Quantum Mechanics (2nd Edition) : L. I. Schiff, McGraw – Hill Co, New York (1955)
2. Quantum Mechanics (Vol. I) : A. Messiah, North Holland Pub Co, Amsterdam (1962)
3. Quantum Mechanics – Theory and Applications (3rd Edition): A. Ghatak and S. Lokanathan, MacMillan India Ltd. New Delhi (1984)
4. A Text book of quantum Mechanics: P. M. Mathews and K. Venkatesan, Tata Mc Graw – Hill, New Delhi (1987).
5. The Principles of Quantum Mechanics (4th Edition) : P.A.M. Dirac, Oxford Univ Press, New York (1958)
6. Quantum Mechanics (1st Edition): V. K. Thankappan, New Age Intl. Pvt. Ltd., New Delhi (1985)
7. Quantum Mechanics : E. Merzbacher., John Wiley, New York (1970)
8. Modern Quantum Mechanics : J. J. Sakurai, Addison Wesley, Massachusetts (1994)
9. Applied Quantum Mechanics: A.F.J Levi, Cambridge Univ Press, 2003.

Course Code: **PH HCT 320** Dept. Code: **9111**
Total Hours: **56 hrs** Workload: **4 hours per week**
Evaluation: Continuous Internal Assessment - **30 marks** Credit Points: **4**
Semester End Examination - **70 marks**

M.Sc. Physics (Semester III) (CBCS)

COURSE: STATISTICAL MECHANICS (PH HCT 320)

Unit 1 **Basic thermodynamic and statistical concepts** 14 hrs

The laws of thermodynamics and their implications. Thermodynamic potentials, Maxwell's relations and their applications. phase space, ensembles, Ergodic hypothesis and Liouville's theorem. Probability, probability distribution and the most probable distribution. The probability distribution and partition function. Microcanonical, canonical and grand canonical ensembles, thermodynamic potentials and the partition function.

Unit 2 **Classical statistics** 14 hrs

Partition function of a system of particles. The translation partition function, Gibbs paradox and Boltzmann equipartition theorem. Rotational and vibrational partition function. Einstein relation and electronic partition function. Various other partition functions and the corresponding thermodynamic potentials. Maxwell-Boltzmann distribution and its physical applications.

Unit 3 **Quantum statistics** 14 hrs

The symmetry and anti symmetry of the wave functions, Bosons and Fermions, Bose-Einstein and Fermi-Dirac distributions. Ideal Bose and Fermi gases-their properties at high and low temperatures and densities. Bose-Einstein condensation. Blackbody radiation and photons. The phonons and specific heat of solids-Einstein and Debye's theories.

Unit 4 **Fluctuations** 14 hrs

Fluctuations in canonical, grand canonical and microcanonical ensembles. The Brownian motion and Langevin equation. Random walk, diffusion and the Einstein relation for mobility. Fockker-Plank equation. Johnson noise and shot noise.

Irreversible thermodynamics

Onsager reciprocity relations. Thermoelectric phenomena. Non-equilibrium phenomenon in liquid helium-fountain effect. Gibbs entropy for non-equilibrium states. The entropy and information.

References

1. Statistical Mechanics: K Huang (Wiley Eastern)
2. Statistical Mechanics and Properties of matter: E S R Gopal (Macmillan)
3. Elementary Statistical Physics: C Kittel (John Wiley)
4. Fundamentals of Statistical and Thermal Physics: F Reif (McGraw Hill)
5. Statistical Mechanics: Satya Prakash
6. Thermodynamics of irreversible Processes: S R de Groot
7. Statistical Physics: L D Landau and E M Lifshitz (Pergamon)

Course Code: **PH SCT 330** Dept. Code: **9111**
Total Hours: **56 hrs** Workload: **4 hours per week**
Evaluation: Continuous Internal Assessment - **30 marks** Credit Points: **4**
Semester End Examination - **70 marks**

M.Sc. Physics (Semester III) (CBCS)

COURSE: SOLID STATE PHYSICS I (PH SCT 330)

Unit 1 **Periodic structures** 14 hrs

Reciprocal lattice and its properties. Periodic potential and Bloch theorem, reduction to Brillouin zone, Born-von Karman boundary conditions. Counting of states.

Electron states

Nearly free electron model, discontinuity at zone boundary, energy gap and Bragg reflection. Tight binding model, band width and effective mass in linear lattice and cubic lattices. APW and k.p methods of band structure calculations.

Unit 2 **Quantization of lattice vibrations** 14 hrs

Potential and kinetic energies in terms of generalized coordinates and momenta, Hamilton's equations of motion, quantization of normal modes.

Lattice waves

Lattice dynamics, properties of lattice waves using mono and diatomic lattices, lattice spectrum and Van Hove singularity, diffraction by crystal with and without lattice vibrations, phonons and Debye-Waller factor.

Unit 3 **Thermal properties** 14 hrs

Density of states, thermal energy of harmonic oscillator. Lattice heat capacity: Dulong-Petit's classical theory, Einstein and Debye's theories, comparison of theory with experimental results. Anharmonicity and thermal expansion, phonon-phonon interaction.

Elastic properties of solids

Stress and strain tensors, elastic constants and Hooke's law, strain energy, reduction of elastic constants from symmetry, isotropy for cubic crystals, technical moduli and elastic constants. Propagation of long wavelength vibrations. Experimental determination of elastic constants by ultrasonic interference method.

Unit 4 **Fermi surface studies** 14 hrs

Extended, reduced and periodic zone schemes. Construction of Fermi surface in square lattice, Harrison construction, slope of band at zone boundary, electron orbits, hole orbits and open orbits. Experimental methods: Electron dynamics in a magnetic field, cyclotron frequency and mass, cyclotron resonance. Quantization of orbits in a magnetic field, Landau quantization, degeneracy of Landau levels, quantization of area of orbits in k-space, de Has-van Alphen effect, extremal orbits.

References

1. Principle of the theory of solids: J.M. Ziman (Cambridge University Press)
2. Introduction to Solid State Physics: C. Kittel (Wiley Eastern)
3. Solid State Physics: A.J. Dekkar (Prentice Hall Inc)
4. Solid State Physics: N.W. Ashcroft and N.D. Mermin (Saunders College Publishing)
5. Elementary Solid State Physics: Principles and applications, M.A. Omar (Addison-Wesley)
6. Physics of Solids: F.C. Brown (Benjamin Inc. Amsterdam)
7. Introduction to Theory of Solid State Physics: J.D. Patterson (Addison-Wesley)

Course Code: **PH SCT 331** Dept. Code: **9111**
Total Hours: **56 hrs** Workload: **4 hours per week**
Evaluation: Continuous Internal Assessment - **30 marks** Credit Points: **4**
Semester End Examination - **70 marks**

M.Sc. Physics (Semester III) (CBCS)

COURSE: NUCLEAR PHYSICS I (PH SCT 331)

Unit I **General Properties of Nucleus** 14 hrs

Properties of the nucleus: Nuclear size and shapes- estimation of nuclear radii by different methods, charge distribution in nuclei and nucleons by electron scattering experiment, nuclear shapes - nuclear moments - Magnetic dipole moment - molecular beam experiments for determination of nuclear moments.

Electric quadrupole moment: Expression for axial quadrupole moment, moment of spheroidal nucleus, quadrupole moment due to a single nucleon in a state j.

Beta decay: selection rules - classification of beta transitions into allowed and forbidden types - the shape factor – universal Fermi interaction.

Elementary theory of internal conversion and discussion of experimental results.

14 hrs

Unit 2 **Interaction of radiation with matter**

Interaction - stopping power - energy loss characteristics, particle range - energy loss in thin absorbers. Scaling laws. Interaction of fast electrons - specific energy loss. Electron range and transmission curves.

Interaction of gamma rays - interaction mechanisms - photoelectric absorption, Compton scattering and pair-production. Gamma ray attenuation - attenuation coefficients, absorber mass thickness, cross sections.

Interactions of neutrons - general properties - slow down interaction, fast neutron interaction, neutron cross sections. Radiation exposure and dose – dose equivalent.

14 hrs

Unit 3 **Nuclear detectors**

Gas filled counters (qualitative), Scintillation detectors - different types of scintillators - photomultiplier tubes, measurement with scintillation detectors - NaI(Tl), plastic scintillator - Scintillation spectrometer. Spectrum analysis.

Semiconductor detectors - semiconductor properties - physics of semiconductor detectors - diffused junction, surface barrier and ion-implanted detectors. Si(Li), Ge(Li) and HPGe detectors - semiconductor detector spectrometer. Pulse height analysis of spectrum, SSNTD, TLD, Superheated drop detectors.

14 hrs

Unit 4 **Nuclear electronics**

Preamplifier circuits, linear and pulse amplifier, pulse shaping, pulse stretching. Wilkinson type analog to digital converter. Pulse discriminators - coincidence and anticoincidence circuits - memories, single and multichannel analysers – on-line data processing - time to amplitude converter - charge sensitive amplifier. Basic principles of measurement techniques such as collimation, shielding, geometry and calibration.

References

1. Physics of Nuclei and Particles: P Mermier and E Sheldon (Academic Press)
2. Nuclear Physics: R R Roy and B P Nigam (Wiley Eastern)
3. Subatomic Physics-Nuclei and Particles: L Valantin
4. The Structure of Nucleus: M A. Preston and R K Bahaduri
5. Emilio Segre: Nuclei and Particles, II Edn. (Benjamin, 1977)
6. Nuclear and Particle Physics: W.E. Burcham and M. Jobes (Addison Wesley, 1998, ISE)
7. Nuclear Physics: D C Tayal (Himalaya)
8. Atomic and Nuclear Physics: S N Ghoshal (S. Chand)
9. Kenneth S Krane: Introductory Nuclear Physics (John Wiley, 1986)
10. Knoll G F: Radiation Detection and Measurement, II Edn. (John Wiley, 1989)
11. Evans R D: Atomic Nucleus (Tata McGraw Hill, 1972)
12. Delaney: Electronics for Physicists.

Course Code: **PH SCT 340** Dept. Code: **9111**
Total Hours: **56 hrs** Workload: **4 hours per week**
Evaluation: Continuous Internal Assessment - **30 marks** Credit Points: **4**
Semester End Examination - **70 marks**

M.Sc. Physics (Semester III) (CBCS)
COURSE: SOLID STATE PHYSICS II (PH SCT 340)

Unit 1 **Transport properties of metals** 14 hrs

Boltzmann equation, electrical conductivity, calculation of relaxation time. Impurity scattering, ideal resistance. General transport coefficients, thermal conductivity, thermoelectric effects, lattice conduction, phonon drag.

Transport properties of semiconductors

Thermal conductivity. Thermoelectric and magnetic effects. Hot electron and energy relaxation times. High frequency conductivity. Acoustic (deformation and piezoelectric) and optical (polar and non polar) scattering by electrons.

Unit 2 **Dielectric properties** 14 hrs

Macroscopic description of static dielectric constant, electronic, ionic and orientational polarization, Lorentz field, dielectric constant of solids, complex dielectric constant and dielectric losses. Theory of electronic polarization and optical absorption.

Ferroelectricity

General properties, classification, dipole theory and its drawbacks, thermodynamics of ferroelectric transitions, ferroelectric domains.

Unit 3 **Magnetic properties** 14 hrs

Classification, Langevin theory of diamagnetism, quantum theory of paramagnetism.

Ferromagnetism: concept of domains, thermodynamics, thickness of Bloch wall, molecular field concept, Weiss theory, Heisenberg exchange interaction, Ising model, spin waves dispersion relation (one dimensional case), quantization of spin waves, concept of magnons and thermal excitation of magnons, Bloch $T^{3/2}$ law for magnetization.

Antiferromagnetism: Two sublattice model. Ferrimagnetism in the context of iron garnets.

Unit 4 **Superconductivity** 14 hrs

Review of basic properties, classification into type I and type II. Energy gap and its temperature dependence. Super current and critical currents.

London's phenomenological equations, penetration depth. Cooper pairs, coherence length. Instability of Fermi surface and cooper pairs. BCS theory and comparison with experimental results. Ground state energy of superconductor. Quantization of magnetic flux. Josephson effects (AC and DC) and applications.

High T_c materials: Structure and properties, some applications.

References

1. Principle of the theory of solids: J.M. Ziman (Cambridge University Press)
2. Introduction to Solid State Physics: C. Kittel (Wiley Eastern)
3. Solid State Physics: A.J. Dekkar (Prentice Hall Inc)
4. The physical principles of solids: A.H. Morish
5. Introduction to Superconductivity: M. Tinkham (McGraw-Hill, International Edition)
6. Semiconductor Physics: P.S. Kireev (MIR Publishers)
7. Semiconductor Physics-An Introduction: K. Seeger (Solid State Science-Springer Verlag Telog)

Course Code: **PH SCT 341** Dept. Code: **9111**
Total Hours: **56 hrs** Workload: **4 hours per week**
Evaluation: Continuous Internal Assessment - **30 marks** Credit Points: **4**
Semester End Examination - **70 marks**

M.Sc. Physics (Semester III) (CBCS)

COURSE: NUCLEAR PHYSICS II (PH SCT 341)

Unit 1	**Nuclear spectroscopy** Experimental determination of beta interaction. The shape of beta spectra. The rest mass of neutrino - neutrino recoil experiment. Inverse beta decay. Double beta decay. **Gamma ray spectroscopy:** gamma-gamma, beta-gamma angular correlation studies, decay schemes, angular distribution of gamma rays from oriented nuclei, polarization of gamma rays.	14 hrs
Unit 2	**Nuclear techniques:** Basic principles, instrumentation and application of X-ray fluorescence (XRF), Neutron activation analysis- Principle, Instrumentation and application, Proton induced X-ray emission (PIXE)- Principle, Experimental details and applications, Positron annihilation-Principle, Sources, Experimental details, angular correlation of annihilation radiation and Fermi momentum of conduction electron in metals, Positron lifetime and lattice defects in metals, Ion beam analysis- Rutherford back scattering, Channeling, Nuclear reaction analysis.	14 hrs
Unit 3	**Review of deuteron problem and nuclear forces** Review of ground state properties of deuteron, Deuteron as mixture of S and D states - admixture in the deuteron wave function - magnetic and electric quadrupole moment of deuteron from S and D mixture. Ground state wave function of deuteron. Expression for Pd. **Review of nuclear forces** - charge independence, Symmetry, spin-dependence, tensor character, exchange character. Pseudoscalar meson theory. General survey of non-central forces. Two body potential, three body and many body potentials.	14 hrs
Unit 4	**Nucleon-nucleon scattering** **n-p scattering:** n-p scattering formalism - partial wave analysis - theory of S wave neutron scattering by free protons - scattering length - spin dependence of n-p scattering. Effective range theory of n-p scattering - significance of sign of scattering length - coherent and incoherent scattering. Coherent scattering from hydrogen molecules and sign of scattering lengths. Cross sections for ortho and para hydrogen - comparison with experiment. The optical theorem. **p-p scattering:** Low energy scattering of protons by protons. Mott's modification of Rutherford formula. Experimental results. Effective range theory for p-p scattering. Analysis of n-p and p-p scattering at low energy. High energy n-p and p-p scattering and experimental results.	14 hrs

References

1. Roy R R and Nigam B P: Nuclear Physics – Theory and Experiment (Wiley Eastern Ltd., 1993)
2. Emilio Segre: Nuclei and Particles, II Edn. (Benjamin, 1977)
3. Ghoshal S N: Atomic and Nuclear Physics, Vol. II (S Chand & Company, 1994)
4. Singru R M: Experimental Nuclear Physics' (Wiley Eastern, 1972)
5. Curtis L F, 'Introduction to Neutron Physics'
6. Wong, `Introduction to Nuclear Physics' (Prentice Hall, 1997)
7. Poenaru D N and Greiner W (ed) 'Experimental Techniques in Nuclear Physics' (Berlin: De Gruyter, 1997).
8. Glasstone S, 'Introduction to Thermonuclear Reactions'
9. Kenneth S Krane, 'Introductory Nuclear Physics' (John Wiley, 1986)
10. Enge H, 'Introduction to Nuclear Physics' (Addison Wesley, 1988)
11. Paul E B, 'Nuclear and Particle Physics' (North Holland, 1969)
12. Evans R D, 'Atomic Nucleus' (Tata McGraw Hill, 1972)
13. Kapoor S S and Ramamoorthy V S, 'Radiation Detectors' (Wiley Eastern, 1986)
14. Burcham W E, Nuclear Physics, II Edn. (Longman, 1963)
15. Siegbahn Kai, Alpha, Beta & Gamma Ray Spectroscopy, Vol. I, II (North Holland, 1979)
16. Marmier D and Sheldon E, 'Nuclear Physics', Vol. I, II (Academic Press, 1969)

Course Code: **PH HCP 350** Dept. Code: **9111**
Total Hours: **40 hrs** Workload: **4 hours per week**
Evaluation: Continuous Internal Assessment - **30 marks** Credit Points: **4**
Semester End Examination - **70 marks**

M.Sc. Physics (Semester III) CBCS

PRACTICAL V: SOLID STATE PHYSICS LAB I (PH HCP 350)

LIST OF EXPERIMENTS:

1. Determination of interplanar spacing using X-ray powder pattern
2. Magnetic Susceptibility of liquid by Quinke's method
3. Measurement of resistivity of a semiconductor by four probe method (fixed temperature)
4. Determination of Debye's temperature of Lead or Tin
5. Structure factor determination: Computations
6. Specific heat of metals
7. Ultrasonic velocity in solids
8. Activation energy of point defects in metals: Experiment/Computation
9. Fermi energy of metals: Experiment/Computation
10. Thermal expansion coefficient in solids
11. Thermoelectric power of Ferrites
12. Energy gap of a pn-junction diode/LED
13. Thermistor characteristics

Note: Minimum of eight experiments must be carried out.

Experiments shall be added as and when developed.

References

1. Introduction to Solid State Physics by C. Kittel
2. X-Ray diffraction by B.D. Cullity
3. Physics of Solids by F.C. Brown
4. Interpretation of X-ray powder diffraction pattern by H.P. Lipson and H. Steeple
5. Any book suggested by the course teacher

Course Code: **PH HCP 351** Dept. Code: **9111**
Total Hours: **40 hrs** Workload: **4 hours per week**
Evaluation: Continuous Internal Assessment - **30 marks** Credit Points: **4**
Semester End Examination - **70 marks**

M.Sc. Physics (Semester III) CBCS

PRACTICAL V: NUCLEAR LAB I (PH HCP 351)

LIST OF EXPERIMENTS:

1. Nuclear counting statistics: Verification of Poisson Distribution
2. GM counter characteristics: Operation voltage determination
3. Determination of dead time of GM counter-single source
4. Verification of inverse square law for nuclear radiation
5. Attenuation of β-rays in aluminium
6. Attenuation of γ-rays
7. Half life of K-40
8. Coincidence circuit
9. Analysis of stopping power and energy loss
10. Nuclear radius calculation
11. Semi-empirical mass formula and binding energy analysis
12. Analysis of β-spectrum and half life systematic
    With the permission of BOS, new experiments may be added to the list whenever they are developed.

Note: Minimum of eight experiments must be carried out.

Experiments shall be added as and when developed.

References

1. Experiments in Nuclear Science, ORTEC Applications Note. ORTEC (1971)
2. Practical Nucleonics by F.J.Pearson and R.R.Osborne
3. Experimental Nucleonics by E. Bleuler and G.J. Goldsmith, Rinehart
4. The Atomic Nucleus by R.D.Evans
5. Any other book suggested by the course teacher

Course Code: **PH HCP 360** Dept. Code: **9111**
Total Hours: **40 hrs** Workload: **4 hours per week**
Evaluation: Continuous Internal Assessment **- 30 marks** Credit Points: **4**
Semester End Examination **- 70 marks**

M.Sc. Physics (Semester III) CBCS

PRACTICAL VI: SOLID STATE PHYSICS LAB II (PH HCP 360)

LIST OF EXPERIMENTS:

1. Magnetic susceptibility by Gouy's method
2. Temperature variation of resistivity of a semiconductor: four probe method
3. Curie temperature of a ferromagnetic material
4. Hall effect in semiconductors
5. Electron spin resonance: g factor determination
6. Dielectric studies in some solids
7. Ionic conductivity of an alkali halide crystal
8. Temperature variation of conductivity in a glass
9. Study of creep
10. Determination of yield point and yield strength
11. Determination of elastic constants
12. Intensity calculations of X-ray powder pattern

Note: Minimum of eight experiments must be carried out.

Experiments shall be added as and when developed.

References

1. Introduction to Solid State Physics by C. Kittel
2. X-ray diffraction by B.D. Cullity
3. Physics of Solids by F.C. Brown
4. Interpretation of X-ray powder diffraction pattern by H.P. Lipson and H. Steeple
5. Any book suggested by the course teacher

Course Code: **PH HCP 361** Dept. Code: **9111**
Total Hours: **40 hrs** Workload: **4 hours per week**
Evaluation: Continuous Internal Assessment - **30 marks** Credit Points: **4**
Semester End Examination - **70 marks**

M.Sc. Physics (Semester III) CBCS

PRACTICAL VI: NUCLEAR LAB II (PH HCP 361)

LIST OF EXPERIMENTS:

1. Dead time of GM counter by double source method
2. Nuclear electronics: linear amplifier, single channel analyzer, coincidence circuits
3. Study of scintillation detector (NaI)
4. Γ-ray spectrum using scintillation detector: multi channel analysis
5. Β-ray spectrum using scintillation detector
6. Half life of Indium-116
7. Study of Bremsstrahlung radiation
8. Positron annihilation
9. Study of solar cells
10. Study of solar panels
11. Energy transfer efficiency in liquid scintillators
12. Nuclear models and nuclear structure analysis

Note: Minimum of eight experiments must be carried out.

Experiments shall be added as and when developed.

References

1. Experiments in Nuclear Science, ORTEC Applications Note. ORTEC (1971)
2. Practical Nucleonics by F.J. Pearson and R.R. Osborne
3. Experimental Nucleonics by E. Bleuler and G.J. Goldsmith, Rinehart
4. The Atomic Nucleus by R.D. Evans
5. Any other book suggested by the course teacher

Course Code: **PH OET 370** Dept. Code: **9111**
Total Hours: **56 hrs** Workload: **4 hours per week**
Evaluation: Continuous Internal Assessment **- 30 marks** Credit Points: **4**
Semester End Examination **- 70 marks**

M.Sc. Physics (Semester III) (CBCS)

COURSE: ENERGY SCIENCE (PH OET 370)

Unit 1 **Energy and thermodynamics** 14 hrs

Laws of thermodynamics, forms of energy, conservation of energy, heat capacity, thermodynamic cycles, Carnot diesel, Otto and Rankin cycle.

Unit 2 **Renewable energy resources** 14 hrs

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, extraterrestrial and terrestrial solar radiations, solar spectral irradiance, measurement techniques of solar radiations, estimation of average solar radiation.

Unit 3 **Biomass energy** 14 hrs

Nature of biomass as a fuel, biomass energy conversion processes, direct combustion: heat of combustion, combustion with improved Chulha and cyclone furnace.

Unit 4 **Biogas technology** 14 hrs

Dry chemical conversion processes: pyrolysis, gasification, types of gasification importance of biogas technology, anaerobic decomposition of biodegradable materials, factors affecting bio-digestion, types of biogas plants, applications of biogas.

References

1. Advances in energy systems and technology: A. Peter, Academic Press, USA, 1986
2. Solar energy conversion: C.R. Neville, Elsevier North-Holland, 1986
3. Solar energy conversion: A.E. Dixon and J.D. Leslie, Pergamon Press, New York, 1978
4. Biomass, energy and environment: N.H. Ravindranath, Oxford University Press, 1995

Course Code: **PH OET 371** Dept. Code: **9111**
Total Hours: **56 hrs** Workload: **4 hours per week**
Evaluation: Continuous Internal Assessment - **30 marks** Credit Points: **4**
Semester End Examination - **70 marks**

M.Sc. Physics (Semester III) (CBCS)
COURSE: RADIATION PHYSICS (PH OET 371)

Unit 1 **Nuclear radiation** 14 hrs
Natural radioactivity, half life, alpha, beta and gamma radiations, induced nuclear transformations; Interaction of gamma rays and x-rays with matter.

Unit 2 **Biological effect of radiation** 14 hrs
Basic human physiology, cell biology, interaction of radiation with cells, somatic effects of radiation, hereditary effect of radiation.

Unit 3 **Radiation protection in medicine** 14 hrs
Protection against sealed sources, diagnostic radiography, diagnostic fluoroscopy radiotherapy. Protection against unsealed sources, control and disposal of radioactive materials.

Unit 4 **Lasers** 14 hrs
Definition, principle of lasing action, pumping techniques, different lasers and their characteristics, applications: defense, medical and industry.

References

1. Nuclear Radiation Physics, R E Lapp, Prentice hall, 1963
2. Principles of Nuclear Science and Reactors, Jacobs, Kline, Remik, Van Nostrand, 1966
3. Radiation- What it is and how it affects you, J Schubert and R E Lapp, Viking, 1957
4. An introduction to radiation protection, A. Martin, S. A. Harbison,
   Chapman and Hall, 1982
5. Introduction to High energy Physics, Hughes
6. Lasers and Non-linear Optics, B.B. Laud
7. Optics, Ajay Ghatak

Course Code: **PH HCT 410**	Dept. Code: **9111**
Total Hours: **56 hrs**	Workload: **4 hours per week**
Evaluation: Continuous Internal Assessment - **30 marks**	Credit Points: **4**
Semester End Examination - **70 marks**	

M.Sc. Physics (Semester IV) (CBCS)

COURSE: CLASSICAL ELECTRODYNAMICS (PH HCT 410)

Unit 1	**Electrostatics:** Divergence and curl of electrostatic field, Gauss law in integral and differential forms, Poisson and Laplace equations, Boundary conditions and uniqueness theorem, electrostatic potential energy and energy density of a continuous charge distribution. Multipole expansion of the potential and energy of a localized charge distribution, monopole and dipole terms, electric field of a dipole, dipole-dipole interaction. Electrostatic fields in matter, polarization, macroscopic field equations, electrostatic energy in dielectric media.	14 hrs
Unit 2	**Magnetostatics:** Current density, continuity equation, magnetic field of a steady current, the divergence and curl of B, Ampere's law, magnetic vector potential, multipole expansion of vector potential of a localized current distribution, magnetic moment. Torques and forces on magnetic dipoles, effect of a magnetic field on atomic orbits. Magnetic fields in matter, macroscopic equations, magnetostatic boundary conditions, magnetic scalar potential. Energy in the magnetic field.	14 hrs
Unit 3	**Electrodynamics:** Faraday's law of induction, displacement current, Maxwell's equations. Vector and scalar potentials. Gauge transformations, Lorentz gauge, Coulomb gauge. Continuity equation, Poynting's theorem, momentum, Maxwell's stress tensor, conservation of energy and momentum in electromagnetic fields. **Electromagnetic Waves:** Propagation of waves in linear media, reflection and transmission at normal and oblique incidence, Electromagnetic waves in non-conducting and conducting medium, skin depth, reflection at conducting surface. **Wave guides:** Fields at the surface and within a conductor, modes in rectangular wave guide, TE waves in a rectangular wave guide, Co-axial transmission line and cylindrical cavities.	14 hrs
Unit 4	**Electromagnetic radiation:** Retarded Potentials, Lienard-Wiechert potentials, fields of a moving point charge. Electric dipole radiation, Magnetic dipole radiation, Power radiated by a point charge, Larmor formula, Power radiated by a point charge with collinear velocity and acceleration, Bremsstrahlung radiation, radiation from a charged particle moving in a circular orbit, cyclotron and synchrotron radiation.	14 hrs

References:

1. Classical Electrodynamics: J.D. Jackson , Wiley Eastern Ltd., Bangalore (1978)
2. Introduction to Electrodynamics: D.J. Griffiths, Prentice Hall of India, Ltd., New Delhi (1995).
3. Electromagnetics: B.B. Laud. Wiley Eastern Ltd., Bangalore (1987)
4. Classical Electromagnetic Radiation: J.B. Marion, Academic press, New York (1968).
5. Classical Electrodynamics; S P Puri, Tata McGraw-Hill Publishing Company Ltd., New Delhi, (1990).

Course Code: **PH HCT 420** Dept. Code: **9111**
Total Hours: **56 hrs** Workload: **4 hours per week**
Evaluation: Continuous Internal Assessment - **30 marks** Credit Points: **4**
Semester End Examination - **70 marks**

M.Sc. Physics (Semester IV) (CBCS)

COURSE: ANALYTICAL TECHNIQUES AND INSTRUMENTATION
(PH HCT 420)

Unit 1 **Spectrophotometry** 14 hrs

Ultra-violet, Visible, Infrared, Raman, Fluorescence and Atomic Absorption Spectrophotometry.

Thermal analyses

Differential Thermal Analysis (DTA); Differential Scanning Calorimetry (DSC); Thermo Gravimetric Analyses (TGA).

X-ray spectrometry

X-ray Diffraction (XRD) techniques and associated instrumentation.

Unit 2 **Electron and ion spectroscopy** 14 hrs

Auger Electron Spectroscopy (AES), Scanning Electron Microscopy (SEM); Transmission Electron Microscopy (TEM). Scanning Tunneling Electron Microscopy (STEM). Ion Spectroscopy, Secondary Ion Mass Spectroscopy (SIMS), Ion Scattering Spectroscopy (ISS).

Unit 3 **Optical techniques** 14 hrs

Refractometry, polarimetry.

Electric and dielectric techniques

Impedance, dielectric constant and dielectric loss measurements using impedance analyzers.

Magnetic resonance spectroscopy

Nuclear Magnetic Resonance (NMR), Electron Paramagnetic Resonance (EPR), Electron Spin Resonance (ESR).

Unit 4 **Nuclear techniques** 14 hrs

Nuclear activation analysis, isotope tracer methods, Mossbauer spectroscopy, neutron diffraction, positron annihilation.

Low temperature techniques

Production and measurement of low temperatures: liquification of gases (H_2, N_2 and O_2), cryostats, refrigerators.

Vacuum techniques

Production and measurement of vacuum.

References

1. Handbook of Analytical Instruments, R.S. Khandpur, Tata McGraw-Hill.
2. Instrumental method of analysis, Willard, Merritt, Dean and Settle, CBS Publishers and Distributors, Delhi.
3. Instruments methods of Chemical analysis, Chatwal and Anand, Himalaya Publishing House.
4. Methods of Experimental Physics Vol. 14 A and B, edited by Dudley.
5. Experimental Spectroscopy by Sawyer.

Course Code: **PH SCT 430** Dept. Code: **9111**
Total Hours: **56 hrs** Workload: **4 hours per week**
Evaluation: Continuous Internal Assessment - **30 marks** Credit Points: **4**
Semester End Examination - **70 marks**

M.Sc. Physics (Semester IV) (CBCS)
COURSE: SOLID STATE PHYSICS III (PH SCT 430)

Unit 1	**Magnetic Resonance** Basic principles of paramagnetic resonance, spin-spin and spin-lattice relaxation, susceptibility in a.c. magnetic field power absorption, equations of Bloch, steady state solutions, determination of g-factor, line width and spin-lattice relaxation time, paramagnetic resonance and nuclear magnetic resonance. Effect of crystal field on energy levels of magnetic ions (qualitative). Spin-Hamiltonian, zero field splitting.	14 hrs
Unit 2	**Optical Properties of Semiconductors:** Interband and intraband absorption, fundamental absorption, absorption edge, exciton absorption, free carrier absorption, impurity involved absorption. Photoconductivity, luminescence. **Low-dimensional semiconductor structures:** Inversion layer, quantum well. Modulation doping, quantum well wire, quantum dot and superlattice. Two-dimensional electron gas, energy levels and density of states. **Amorphous Semiconductors:** Classification, band structure, electronic conduction, optical absorption, switching.	14 hrs
Unit 3	**Elastic properties:** Elastic, anelastic and viscoelastic behaviours; Fracture of materials: ductile and brittle fracture, fatigue fracture, fracture toughness, ductile-brittle transition, methods of protection against fracture; Plastic deformation: tensile stress-strain curve, plastic deformation by slip, shear strength of perfect and real crystals, mechanism of creep. **Liquid crystals:** Classification. Structure and texture. Orientational and translational order. Mechanical, optical, magnetic and electrical properties. Liquid crystal displays.	14 hrs
Unit 4	**Properties of Ferrites**: Intrinsic and Extrinsic properties of Ferrites Magnetic Properties under consideration, mixed ferrites for Property Optimization, Temperature Dependence of Initial Permeability, Time Dependence Initial Permeability (Disaccomodation), Chemistry Dependence Low Field Losses (Loss Factor), Chemistry Considerations for Hard Ferrites Saturation Induction Microwave Ferrites and Garnets Ferrites for Memory and Recording Applications. **AC Properties of Ferrites:** Introduction AC Hysteresis Loops Eddy Current Losses Permeability Disaccomodation Core Loss Microwave Properties Microwave Precessional Modes Logic and Switching Properties of Ferrites.	14 hrs

References:

1. Structure Determination from Powder Diffraction Data Ed By W.I.F. David, Shankland, L.B. McCusker and Ch. Baerlocher.
2. Electron beam analysis of materials, M.H. Loretto.
3. Science of Engineering materials, Srivastava and Srinivasan.
4. The Science and Engineering of materials, D.R. Askeland.
5. The Physics of Low Dimensional Semiconductors: J. H. Davies. Cambridge University press, (1998).
6. The Physical Principles of Magnetism: A. H. Morrish, John Wiley & sons, New York (1965).
7. Introduction to Magnetic Resonance: A. Carrington and A. D. McLachlan, Harper & Row, New York, (1967).
8. Elements of Solid State Physics (2nd Ed): J.P. Srivastava, PHI Learning Pvt. Ltd., New Delhi (2009) .
9. Amorphous Semiconductors: D. Adler, CRC, London, (1972).
10. Solid State and Semiconductor Physics : J. P. McKelvey, Harper and Row, New York (1966)

Course Code: **PH SCT 431** Dept. Code: **9111**
Total Hours: **56 hrs** Workload: **4 hours per week**
Evaluation: Continuous Internal Assessment - **30 marks** Credit Points: **4**
Semester End Examination - **70 marks**

M.Sc. Physics (Semester IV) (CBCS)

COURSE: NUCLEAR PHYSICS III (PH SCT 431)

Unit 1 **Nuclear models** 14 hrs

Fermi gas model: kinetic energy for the ground state-asymmetry energy – nuclear evaporation.

Shell model: Evidences for shell structure, motion in mean potential, energy levels according to harmonic oscillator potential and infinite square well potential - effect of spin-orbit interaction.

Shell model prediction of ground state spin, parity of odd-A nuclei and odd-odd nuclei - Nordheim's rules, magnetic moments of odd-A nuclei Schmidt limits and quadrupole moment.

Unit 2 **Nuclear shell model** 14 hrs

Shell model for one nucleon outside the core-configurations for the excited states. Model for two nucleons outside the core. Residual interaction - ^{18}O Spectrum (qualitative) for two particles in $d_{5/2}$ orbit and in $d_{5/2}$ - $s_{1/2}$ orbits.

Collective model: Nuclear deformations and collective motions of nucleons. Vibrational model- Vibrational excitation and vibrational energy levels for even-even nuclei, β and ϒ vibrations for permanently quadrupole deformed nuclei, rotational model- Nuclear rotational motion and rotational energy spectra for even-even and odd A nuclei. Nuclear quadrupole moments. Nilsson model - calculation of energy levels - prediction of ground state spin. Nuclear moments.

Unit 3 **Nuclear Reactions I** 14 hrs

Background information for nuclear reaction - reaction mechanisms, features of compound nucleus model and direct reaction model. Theory of stripping and pickup reactions.

Partial wave approach: partial wave analysis of nuclear reactions-expressions for scattering and reaction cross sections and their interpretations - shadow scattering. Resonance theory of scattering and absorption. Breit-Wigner formulae. Shape of cross section curve near a resonance.

Unit 4 **Nuclear Reactions II** 14 hrs

Nuclear reaction cross section - its behavior near threshold - inverse reactions - principle of detailed balance.

Optical model – forms and features of optical potential, Kapur-Peierls dispersion formula for potential scattering and experimental results.

Transfer reactions - semiclassical description. Plane wave Born approximation (PWBA) - its predictions of angular distributions - modifications - distorted wave Born approximation (DWBA) -

spectroscopic factors and their significance.

Heavy ion physics: Special features of heavy ion reactions. Qualitative treatment of remote electromagnetic interaction Coulomb excitations; close encounters, grazing collisions and particle transfer. Direct and head on collision, compound nucleus and quasi molecule formation.

References

1. Segre E, 'Nuclei and Particles', II Edn. (Benjamin, 1977)
2. Preston M A and Bhaduri R K, 'Structure of the Nucleus' (Addison Wesley, 1975)
3. Ghoshal S N, 'Atomic and Nuclear Physics', Vol. I & II (S Chand & Company, 1996)
4. Roy R K and Nigam P P, 'Nuclear Physics - Theory and Experiment' (Wiley Eastern Ltd., 1993)
5. Enge H, 'Introduction to Nuclear Physics' (Addison Wesley, 1988)
6. Sachler G R, 'Introduction to Nuclear Reactions', II Edn. (Macmillan Press, 1990)
7. Marmier D and Sheldon E, 'Physics of Nuclei and Particle', Vol. I & II (Academic Press, 1969)
8. Blatt J M and Weisskopf V F, 'Theoretical Nuclear Physics' (John Wiley, 1952)
9. Krane K S, 'Introductory Nuclear Physics' (John Wiley, 1987)
10. Perkins D H, 'Introduction to High Energy Physics', II Edn. (Addison Wesley, 1982)
11. Soodak H and Campbell B C, 'Elementary Pile Theory' (John Wiley, 1950)

Course Code: **PH SCT 440** Dept. Code: **9111**
Total Hours: **56 hrs** Workload: **4 hours per week**
Evaluation: Continuous Internal Assessment - **30 marks** Credit Points: **4**
Semester End Examination - **70 marks**

M.Sc. Physics (Semester IV) (CBCS)

COURSE: SOLID STATE PHYSICS IV (PH SCT 440)

Unit 1	**Semiconductors:** General properties of semiconductors, Elemental and compound semiconductors, band structure of real semiconductors. Intrinsic semiconductors: Carrier concentration, Fermi energy, extrinsic semiconductors: Binding energy of impurity, impurity levels, Population of impurity levels, carrier concentration, Fermi energy and its dependence on impurity concentration and temperature.	14 hrs
Unit 2	**Transport in Semiconductors:** Electrical conductivity and mobility, their dependence on temperature and scattering mechanisms, energy gap determination. Diffusion, Einstein relation, diffusion equation and diffusion length. **Magnetic Field Effects:** Hall effect, Hall resistance, magnetoresistance (qualitative), cyclotron resonance and effective mass determination.	14 hrs
Unit 3	**Semiconductor devices:** introduction, p-n junction, the junction transistors, tunnel diode, MIS Tunnel diode. IMPATT diode. Gunn diode semiconductor lasers, field effect transistor, the semiconductor lamp and other devices, integrated circuits and microelectronics (qualitative), MODFET, quantum Hall effect, heterojunctions, quantum wells and super lattices (qualitative)	14 hrs
Unit 4	**Physics of Nanomaterials**, Different form of nanostructures, idea of 2-d, 1-d and 0-d nanostructures; density of states, surface electron density; exciton, quantum size effect, electron confinement strong and weak limit, spherical well, effect of confinement. **Different methods of preparation of nanomaterials** Top down: UV and electron beam lithography, Ball milling; Bottom up: Dip pen nanolithography, Cluster beam evaporation, Sol-gel Method; **Characterization techniques:** X-ray diffraction, scanning electron and transmission electron microscopies. The basic concepts of scanning tunneling and atomic force microscopies. Some properties of nano materials: mechanical, structural, melting point depression, electrical conductivity and optical properties.	14 hrs

References:

1. Charles Kittel, Introduction to Solid State Physics (V edition), Wiley, 1976.
2. A.J. Dekker, Solid State Physics, Prentice Hall, (1957).
3. N.W.Ashcroft and N.D.Mermin, Solid State Physics, Saunders College publishing (1976).

4. J.S. Blakemore, Solid State Physics,(II edition), Cambridge University Press,(1974).
5. Harald bath and Hans Luth ,Solid State Physics, Springer International Student editon, Narosa Publishing House, (1991).
6. M.A. Omar, Elementary Solid State Physics, Addison Wesley, New Delhi,(2000).
7. S.O. Pillai, Solid State Physics, New Age International Publication,(2002).
8. M.A.Wahab, Solid State Physics, Narosa Publishing House, New Delhi,(1999).
9. H.C.Gupta, Solid State Physics, Vikas Publishing House, New Delhi,(2002).
10. J.H. Fendler: Nanoparticles and Nanostructure Films: Preparation,Characterization and Applications 1998 WILEY-VCH Verlag GmbH 15 Dec 2007
11. S. Raimes: Many Electron Theory. Published by North-Holland Pub. Co (1972)
12. O. Madelung: Introduction to Solid State Theory. Springer Series in Solid-State Sciences Softcover reprint of the original 1st ed. 1978.
13. H. Ibach and H. Luth: "Solid State Physics: An Introduction to Theory and experiments: Edition: 4th ed. 2009
14. J.M. Ziman: Principles of the Theory of Solids. Cambridge University Press second edition 1972
15. Puri and Jaganathan, Material science Nova Science Publishers, 2001
16. A.S Edestein, R.C. Cammarata: Nano materials application and synthesis. Edited by *A. S. Edelstein* and *R. C. Cammarata*, Institute of Physics Publishing, Bristol, UK 1996
17. Dieter-Vollath Nano materials an introduction to synthesis properties and applications. 2 ed Wiley.VCH
18. Charles.P. Pole jr, Frank. J. Owens: introduction Nano technology. John Wiley & Sons, 30-May-2003
19. S.M. Lindsay: Introduction to Nano science, Oxford Univ. press, 2009
20. A.K. Bandyopadhyay, Nano Materials :New age International (P) limited publishers), 2008
21. Juh Tzeng Lue, Encyclopedia of Nanoscience and Tech.; Physical properties of Nano materials: Ed: H.S. Nalva, Vol. X, Page: 1-46. 2007.
22. Ryan Richards and Helmut Bonnemann, Nanofabrication towards biomedical applications: Synthetic approach to metallic Nanomaterials: Editors: Challa. S.S.R, Kumar, J. Hormes, WILEY: VCH, 2005.

Course Code: **PH SCT 441** Dept. Code: **9111**
Total Hours: **56 hrs** Workload: **4 hours per week**
Evaluation: Continuous Internal Assessment - **30 marks** Credit Points: **4**
Semester End Examination - **70 marks**

M.Sc. Physics (Semester IV) (CBCS)
COURSE: NUCLEAR PHYSICS IV (PH SCT 441)

Unit 1 **Neutron physics** 14 hrs

Classification of neutrons according to their energy - neutron sources. Ultrafast neutrons, Neutron detectors, Neutron detection from nuclear reactions. BF_3 counters, ^{3}He counters, fission detectors, activation method for neutron flux measurement. Recoil counters, neutron time of flight technique. Slow neutron detection through nuclear reaction and induced radio activity, slow neutron cross section measurements, neutron monochromators.

Nuclear fusion, basic fusion processes, characteristics of fusion, fusion in stars. Controlled thermonuclear reactions. Hydromagnetic equations. Magnetic pressure, pinch effect, magnetic confinement systems for controlled thermonuclear fusion.

Unit 2 **Reactor physics** 14 hrs

Fundamentals of nuclear fission – fission fuels. chain reaction , multiplication factor. Condition for criticality-Breeding phenomena. Different types of reactors, Slowing down of neutrons by elastic collisions - logarithmic decrement in energy - number of collisions for thermalisation.

Elementary theory of diffusion of neutrons - spatial distribution of neutron flux (1) in an infinite slab with a plane source at one end and (2) in an infinite medium with point source at the centre. Reflection of neutrons - Albedo.

Slowing down density - Fermi age equation. Corrections for absorption - resonance escape probability. The pile equations - Buckling. Critical size for spherical and rectangular piles.

Condition for chain reaction - the Four-factor formula. Thermal neutron reactor - Fast breeder reactor.

Unit 3 **Particle physics** 14 hrs

Conservation laws and symmetry principles

Conservation laws and basic interactions relating to elementary particles - particles and antiparticles.

symmetry principles; Space-time symmetries, internal and gauge symmetries; Time reversal symmetry

Leptons - neutrinos, muon production and decay - muon capture, spin and magnetic moments of muons.

Pions - the Yukawa interaction, spin of pions - intrinsic parity - isotopic spin of pions. Pion-nucleon scattering and resonance. Nuclear collision, production and photo production of Pions. Rho, Omega and Eta mesons.

Unit 4 **Strange particles and unified model** 14 hrs

Strange particles: associated production – strangeness quantum number; GellMann Nishijima formula – Kaons and Lambda, Sigma, Xi and Omega hyperons.

The Quark model – quark composition of particles.
Weak interactions: neutral Kaons. The K° - K° systems. Regeneration of the short lived component of neutral Kaons. CP violation – the CPT theorem Verification of electromagnetic and weak interactions – intermediate vector bosons.
Standard model, GUTs and proton decay; Super symmetry.

References

1. Goshal S N, `Atomic & Nuclear Physics', Vol. II (S Chand & Company, 1994)
2. Wong, `Introduction to Nuclear Physics' (Prentice Hall, 1997)
3. Marmier D and Sheldon E, 'Physics of Nuclei and Particles', Vol. I, II (Academic Press, 1969)
4. Zweifel P F, 'Reactor Physics', International student Edn. (McGraw Hill, 1973)
5. Emilio Segre, 'Nuclei and Particles', II Edn. (Benjamin, 1977)
6. Kenneth S Krane, 'Introductory Nuclear Physics' (John Wiley, 1986)
7. Glasstone S and Sesonske A, 'Nuclear Reactor Engineering' (CBS, Delhi, 1986)
8. Littlefield T A and Thorley N 'Atomic and Nuclear Physics', II Edn. (Nostrand Co., 1988)

Course Code: **PH HCP 450** Dept. Code: **9111**
Total Hours: **40 hrs** Workload: **4 hours per week**
Evaluation: Continuous Internal Assessment - **30 marks** Credit Points: **4**
Semester End Examination - **70 marks**

M.Sc. Physics (Semester IV) CBCS

PRACTICAL VII: SOLID STATE PHYSICS LAB III (PH HCP 450)

LIST OF EXPERIMENTS:

1. Hall Effect and Hall mobility
2. Determination of e/k_B
3. Susceptibility of paramagnetic substance by Gouy's method
4. Specific heat of metals
5. Magnetoresistance of semiconductors
6. Determination of Curie temperature of a ferromagnet
7. Electron spin resonance
8. Resistivity by four probe method
9. Determination of elastic constants
10. Thermoluminescence studies of alkali halides by X-ray irradiations
11. Size estimation of nanocrystals

Note: Minimum of eight experiments must be carried out.

Experiments shall be added as and when developed.

References

1. X-ray diffraction: B.D. Cullity, Addison-Wesley, New York (1972).
2. X-ray diffraction procedures: H.P. Klug and L.E. Alexander, John-Wiley and sons, New York.
3. Interpretation of X-ray powder diffraction pattern: H.P. Lipson and H. Steeple, Macmillan, London (1968).
4. Introduction to Solid State Physics: 5th Edn C. Kittel, Wiley Eastern Ltd., Bangalore (1976)
5. Elementary Solid State Physics: M. A. Omar, Addison-Wesley Pvt. Ltd., New Delhi (2000)
6. Introduction to Magnetochemistry: A. Earnshaw, Academic press, London (1968).
7. Lab manuals.

Course Code: **PH HCP 451** Dept. Code: **9111**
Total Hours: **40 hrs** Workload: **4 hours per week**
Evaluation: Continuous Internal Assessment - **30 marks** Credit Points: **4**
Semester End Examination - **70 marks**

M.Sc. Physics (Semester IV) CBCS

PRACTICAL VII: NUCLEAR PHYSICS PRACTICAL III (PH HCP 451)

LIST OF EXPERIMENTS:

1. Z dependence of external bremsstrahlung
2. Anthracene crystal beta ray spectrometer
3. Electron capture transition energy using internal bremsstrahlung
4. Coincidence circuit
5. Si (Li) beta ray spectrometer
6. Digital to analog converter circuits
7. Half life of ^{40}K
8. Gamma-gamma angular correlation
9. Nuclear reaction analysis
10. Schmidt trigger circuit using transistors and IC-555
11. Charge sensitive pre-amplifier using LF-357
12. Function generator using IC-741

Note: Minimum of eight experiments must be carried out.

Experiments shall be added as and when developed.

References:

1. Experiments in Modern Physics: A.C. Melissions, Academic Press (NY) (1966).
2. Experiments in Nuclear Science, ORTEC Application Note. ORTEC, (1971)
3. (Available in Nuclear Physics Laboratory).
4. Practical Nucleonics: F. J. Pearson., and R. R. Osborne, E & F. N. Spon Ltd., London (1960).
5. The Atomic Nucleus: R. D. Evans, Tata McGraw Hill Pub. Comp. Ltd. (1960).
6. Nuclear Radiation Detectors: R. D. Kapoor and V. S. Ramamurthy, Wiley Eastern Limited (1986).
7. Experimental Nucleonics: E. Bleuler and G. J. Goldsmith, Rinehart & Co. Inc. (NY) (1958)
8. A manual of experiments in reactor physics: Frank A. Valente the Macmillan company (1963).
9. A practical introduction to electronic circuits: Martin Harthley Jones Cambridge University Press (1977).
10. Integrated Circuit Projects: R. M. Marston Newnes Technical Books (1978).
11. Semiconductor Projects: R. M. Marston A Newnes Technical Books (1978).
12. Linear Integrated Circuits: D. Roy Choudhary and Shail Jain, New Age International (1995).
13. Op-Amps and Linear Integrated Circuits: Ramakanth A Gayakawad, Prentice-Hall of India (1995).
14. Op-Amps and Linear Integrated Circuits: Ramakanth A Gayakawad, Prentice Hall of India (1995).

Course Code: **PH HCP 460** Dept. Code: **9111**
Total Hours: **40 hrs** Workload: **4 hours per week**
Evaluation: Continuous Internal Assessment **- 30 marks** Credit Points: **4**
Semester End Examination **- 70 marks**

M.Sc. Physics (Semester IV) CBCS

COURSE: PROJECT (PH HCP 460)

Course: Project in Solid State Physics

Topic(s) for the project may be selected in consultation with the project supervisor.

Reference/Text books to be recommended by the Course Teacher.

Course: Project in Nuclear and Particle Physics

Topic(s) for the project may be selected in consultation with the project supervisor.

Reference/Text books to be recommended by the Course Teacher.

Note:

Every student has to compulsorily carryout a Project course in the IV-semester. The Project may be a theoretical or an experimental work in the respective specialization subject. More than one student may be required to work on an assigned project. Project course carries 100 marks, of which 30 marks for Internal Assessment and 70 marks for semester end examination out of which 50 marks for dissertation and 20 marks for via-voce.

Both project report and viva-voce examinations must be assessed by two examiners drawn from the panel of examiners prepared by the BOS.