## UNIVERSITY OF KERALA

# DRAFT

# Syllabus for
# M.Sc Degree Program in Physics

**(With effect from 2020 admissions)**

Submitted by Board of Studies in Physics [ PG ]

# UNIVERSITY OF KERALA

## M. Sc Degree Program in Physics

**Objectives:** Major objective of the M. Sc Physics program of University of Kerala is to equip the students for pursuing higher studies and employment in any branches of Physics and related areas. The program also envisages developing thorough and in-depth knowledge in Mathematical Physics, Classical Mechanics, Quantum Mechanics, Statistical Physics, Electromagnetic Theory, Nuclear Physics, Atomic and Molecular Spectroscopy and Electronics. The program also aims to enhance problem solving skills of students so that they will be well equipped to tackle national level competitive exams. The program also acts as a bridge between theoretical knowhow and its implementation in experimental scenario. The program also introduces the students to the scientific research approach in defining problems, execution through analytical methods, systematic presentation of results keeping in line with the research ethics through M. Sc dissertations.

## Program Outcome

(i) Define and explain fundamental ideas and mathematical formalism of theoretical and applied physics.

(ii) Identify, classify and extrapolate the physical concepts and related mathematical methods to formulate and solve real physical problems.

(iii) Identify and solve interdisciplinary problems that require simultaneous implementation of concepts from different branches of physics and other related areas.

(iv) To define a research problem, translate ideas into working models, interpret the data collected draw the conclusions and report scientific data in the form of dissertation.

(v) To disseminate scientific knowledge and scientific temper in the society to contribute towards greater human cause.

**UNIVERSITY OF KERALA**

**M.Sc Degree Program (effective from 2018 - 19)**

**A: COURSE STRUCTURE & MARK DISTRIBUTION**

| Semester | Paper Code | Title of Paper | Contact hours per week | | | UE duration (h) | Maximum marks | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | L | T | P | | IA | UE | Total |
| I | PH 211 | Classical Mechanics | 6 | 1 | … | 3 | 25 | 75 | 100 |
| | PH 212 | Mathematical Physics | 6 | 1 | … | 3 | 25 | 75 | 100 |
| | PH 213 | Basic Electronics | 6 | 1 | … | 3 | 25 | 75 | 100 |
| | PH 251 | General Physics Practicals | … | 1 | 3 | … | … | … | … |
| | PH 252 | Electronics & Computer Science Practicals | … | 1 | 4 | … | … | … | … |
| | Total for Semester I (S1) | | 18 | 5 | 7 | … | 75 | 225 | 300 |
| II | PH 221 | Modern Optics & Electromagnetic theory | 6 | 1 | … | 3 | 25 | 75 | 100 |
| | PH 222 | Thermodynamics, Statistical Physics & Basic Quantum Mechanics | 6 | 1 | … | 3 | 25 | 75 | 100 |
| | PH 223 | Computer Science & Numerical Techniques | 6 | 1 | … | 3 | 25 | 75 | 100 |
| | PH 251 | General Physics Practicals | … | 1 | 3 | 6 | 25 | 75* | 100 |
| | PH 252 | Electronics & Computer Science Practicals | … | 1 | 4 | 6 | 25 | 75* | 100 |
| | Total for Semester II (S2) | | 18 | 5 | 7 | … | 125 | 375 | 500 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| III | PH 231 | Advanced Quantum Mechanics | 6 | 1 | … | 3 | 25 | 75 | 100 |
| | PH 232 | Atomic and Molecular Spectroscopy | 6 | 1 | … | 3 | 25 | 75 | 100 |
| | PH 233 X | Special Paper I | 6 | 1 | … | 3 | 25 | 75 | 100 |
| | PH 261 | Advanced Physics Practicals | … | 1 | 4 | … | | | |
| | PH 261 | Advanced Electronics Practicals | … | 1 | 3 | … | | | |
| | Total for Semester III (S3) | | 18 | 5 | 7 | | 75 | 225 | 300 |
| IV | PH 241 | Condensed Matter Physics | 6 | 1 | … | 3 | 25 | 75 | 100 |
| | PH 242 | Nuclear & Particle Physics | 6 | 1 | … | 3 | 25 | 75 | 100 |
| | PH 243 X | Special Paper II | 6 | 1 | … | | 25 | 75 | 100 |
| | PH 261 | Advanced Physics Practicals | … | 1 | 3 | 6 | 25 | 75* | 100 |
| | PH 262 | Advanced Electronics Practicals | … | … | 4 | 6 | 25 | 75* | 100 |
| | PH 201 | Project | … | … | … | … | 25 | 75 | 100 |
| | PH 202 | Viva voce | … | … | … | … | … | 100 | 100 |
| | Total for Semester IV (S4) | | 18 | 5 | 7 | … | 150 | 550 | 700 |
| **Grand Total** | | | **72** | **20** | **28** | **…** | **425** | **1375** | **1800** |

* 10 marks for records

L - Lecture IA - Internal Assessment

T - Tutorial UE - University Exam

P - Practical

X: E (Electronics), M (Materials Science) N (Nuclear Physics), S (Space Physics) T (Theoretical Physics)

**B: SPECIAL PAPERS FOR THIRD AND FOURTH SEMESTERS**

| Sl. No | Special paper Category | Code Nos of Special Papers | Name of Special Papers |
|---|---|---|---|
| 1 | ELECTRONICS | PH 233 E<br>PH 243 E | Advanced Electronics-I<br>Advanced Electronics-II |
| 2 | MATERIALS SCIENCE | PH 233 M<br>PH 243 M | Materials Science-I<br>Materials Science-II |
| 3 | NUCLEAR PHYSICS | PH 233 N<br>PH 243 N | Advanced Nuclear Physics<br>Radiation Physics |
| 4 | SPACE PHYSICS | PH 233 S<br>PH 243 S | Space Physics and Plasma Physics<br>Advanced Astrophysics |
| 5 | THEORETICAL PHYSICS | PH 233 T<br>PH 243 T | Theoretical Physics-1<br>Theoretical Physics-2 |

**C: GENERAL GUIDELINES**

C-1 **Theory papers**

Books of study and corresponding chapters are given for most of the theory papers in the syllabus to define the scope of the syllabus.

For internal evaluation of theory papers at least one Viva must be conducted for each paper

For assignments and seminars current developments in the areas of the syllabus may be chosen for improving the general awareness of the student

In tutorial sessions of theory papers problem solving in different topics of the syllabus may be discussed.

C-2 **Lab Courses**

Rough records may be properly maintained for each practical paper and should be produced during the University Practical Examinations along with original record book.

Each student is encouraged to include critical comments on each experiment done in the original records including sources and estimates of errors, limitations in the experiments done and scope for improvements/additions in the experimental work.

In performing Electronics Practicals: Bread Board Practice is recommended in addition to soldering of electronic circuits.

## C-3 Special papers

Depending on the expertise and facilities available in a College (with approval of the University and Government as per rules) one of the five Specialisations (Special paper Category) may be chosen by a student for the third and fourth semesters of the M.Sc Programme in Physics. At present for all specialisations, practical courses are common.

## C4-Project work and Project Evaluation

The Project may be started during the second semester of the M.Sc programme.

25 marks of the project are to be awarded on the basis of internal assessment carried out in the College for each student concerned. A Project rough record may be maintained by each student to help to evaluate the progress of the project. Each student is required to present the completed project along with experimental demonstration if any in the college before the final University examinations in the Fourth Semester of the MSc (Physics) Programme.

For University Examinations for the Project: 50 marks is allotted for Project report evaluation and 25 marks allotted for Project based Viva Voce to be conducted along with General Viva Voce examination by the University.

## D Pattern of University Question Papers

### D-1 Theory Papers

Each question Paper has three parts: Part A, Part B and Part C

Part A: Eight short answer questions covering the entire syllabus. *One of the questions from this section may be used to test the CURRENT AWARENESS (general knowledge) of the students the areas of syllabus covered for this paper.* Each question carries 3 marks.

Part B: contains three compulsory questions with internal choice. Questions cover all the three units in the syllabus. Each question carries 15 marks.

Part C: contains six problems covering the entire syllabus. The student needs to answer any three. Each question carries five marks.

The question paper pattern for the theory papers is given separately.

## D-2 PRACTICALS

Each practical paper carries a total of 75 marks. 10 marks are allotted for practical records. PH 252: Electronics and Computer Science: Unit A-Electronics practical (4h, 45 marks)

Unit B- Computer Science (2h, 20 marks)

PH261: Advanced Physics has two parts: Physics Experiment (5h, 45 marks) Data Analysis of given scientific data (1 h, 20 marks)

PH 262: Advanced Electronics has two parts: (i) Electronics Practicals (4h, 45 marks)

(ii) Microprocessor Practicals (2h, 20 marks)

**PH 201 Project** : Internal Evaluation for project is 25 marks

For University Examinations: 50 marks for Project Dissertation/report evaluation and 25 marks for Project based Viva Voce

**PH 202 General Viva Voce** : For General Viva Voce covering the entire MSc Syllabus,

University Examinations: 100 marks

**(University Question Paper pattern given separately)**

## Question paper pattern

**MSc Degree Examination**

**Branch II PHYSICS**

PH 2xy…………………………………………

**Duration: 3 hours** **Maximum marks: 75**

Instructions to question paper setter

1. Each question paper has three parts - Part A, Part B and Part C
2. Part A contains eight short answer questions spanning the entire syllabus, of which the candidate has to answer any *five* question carries *three* marks.
3. Part B contains *three* compulsory questions with internal choice. Each question shall be drawn from each unit of the syllabus. Each question carries 15 marks
4. Part C contains six problems spanning the entire syllabus. The candidate has to answer any *three* Each question carries *five* marks

**PART A**

(Answer any five questions. Each question carries three marks)

1.

2.

3.

4

5.

6.

7.

8.

(5 x 3 = 15 marks)

## PART B

**Answer three questions each question carries 15 marks**

9 (a)

(b)

OR

10 a) (15 marks)

(b)

11 a)

(b)

OR

12 a) (15 marks)

b)

13 a
b

OR

14 a)

b)

## Part C

(Answer any three questions. Each question carries five marks)

16
17
18
19
20
21

(3 x 5= 15 marks)

## PH 211: CLASSICAL MECHANICS (6L, 1T)

**Objectives:** This course is aimed to provide basic and advanced concepts in classical mechanics. The course discusses Lagrangian and Hamiltonian formalisms, central force problems, theory of small oscillations, Hamilton -Jacobi equations, Kepler's problem, Rigid body dynamics and Euler's equations, Concepts of special and general theory of relativity, Non linear dynamical systems and chaos.

### Unit I

#### Lagrangian Mechanics (12 hours)

Mechanics of a particle and system of particles- constraints- D'Alemberts principle and Lagrange's equations-simple applications of Lagrangian formulation-Hamilton's principle-techniques of calculus of variations-derivation of Lagrange's equations from Hamilton's principle-conservation theorems and symmetry properties

#### Two body central force problem (14 hours)

Reduction to one body problem-equations of motion-equivalent one dimensional problem-differential equation for the orbit in the case of integrable power law potentials- Virial theorem- Kepler's problem-inverse square law of force-scattering in central force field-transformation of the scattering problem to laboratory coordinates

#### Theory of small oscillations (10 hours)

Equillibrium and potential energy-theory of small oscillations-normal modes- two coupled pendula- longitudinal vibrations of carbon dioxide molecule

### Unit II

#### Hamiltonian Mechanics (12 hours)

Generalised momentum and cyclic coordinates-conservation theorems-Hamilton's equations-examples in Hamiltonian dynamics (harmonic oscillator, motion of a particle in a central force field, charged particle in an electromagnetic field, compound pendulum)- canonical transformations-generating functions- poisson brackets- Liouoville's theorem

#### Hamilton-Jacobi equations (10 hours)

Hamilton-Jacobi equation-harmonic oscillator as an example-separation of variables in Hamilton-Jacobi equation-action angle variables-Kepler's problem

## Rigid body dynamics (14 hours)

Generalised coordinates of rigid body-Euler's angles- infinitesimal rotations as vectors-angular momentum and intertia tensor- Euler's equations of motion of a rigid body-force free motion of symmetrical top-motion of heavy symmetrical top.

## Unit III

## Special and General Theory of Relativity (16 hours)

Postulates of special theory- four-vectors and tensors- relativistic particle dynamics- Lorentz transformations -relativistic Lagrangian- mass-energy equivalence- covariant Lagrangian, Relativistic Langrangian, Mass energy equivalence.

General theory of relativity principle of equivalence applications - ideas of Riemannian geometry-space time curvature geodesics –Einstein's equations of General theory of relativity, Observational evidence to general theory of relativity.

## Introduction to non-linear dynamics (12 hours)

Linear and nonlinear systems-integration of second order non-linear differential equations-pendulum equation-phase plane analysis of dynamical systems-linear stability analysis-limit cycles

## Elements of classical chaos (10 hours)

Bifurcation- logistic map-strange attractors- Lyapunov exponent and Chaos-ideas of fractals- solitary waves- Kdv equations and solutions

## Course Outcome

(i) Students are able to learn the concepts of Lagrangian and Hamiltonian mechanics and use them to solve problems in mechanics. Able to learn concepts of generating functions, Poisson brackets Hamilton Jacobi equations and action angle variables.

(ii) To equip the students to deal with central force problem and analyzing Kepler's laws.

(iii) To inculcate the students the concepts of special and general theory of relativity and related problems.

(iv) To acquaint the students about the theory of small oscillations and Euler's equations of motions of rigid bodies.

(v) To analyze nonlinear dynamical systems and to explain the concepts of classical chaos.

### Books for study


a. H. Goldstein, C.Pooleabd S. Safko, *Classical Mechanics*, 3rd Edn, Pearson Education Inc (2008 Print)

b. V.B. Bhatia, *Classical Mechanics with introduction to nonlinear oscillations and chaos*, Narosa Publishing House (1997)

c. J.C. Upadyaya, *Classical Mechanics*, Revised Edition, Himalaya Publishing Company (2005)

d. G. Aruldas, *Classica lMechanics*, Prentice Hall of India Pvt Ltd ( 2008 Print)

e. K.D.Krori, *Fundamentals of Special and General Relativity*, PHI Learning Pvt Ltd (2010)

f. S.K. Srivastava, *General Relativity and Cosmology*, PHI Learning Pvt Ltd (2008)

g. P.G Drazin and R.S Johnson, *Solitons – an Introduction*, Cambridge University Press (1989)


### References


1. N.C. Rana and B.S. Joag, ClassicalMechanics,TataMcGrawHill (1991)
2. M. Tabor Chaos and integrability in nonlinear dynamics,Johnwiley& Sons (1989)
3. R.K. Pathria, The Theory of Relativity, Second Edition, Over Publications (2003)

## PH 212: Mathematical Physics (6L, 1T)

**Objectives:** This course is aimed to equip the students with the mathematical techniques used for developing strong back ground in the basic and advanced level problems. The course describes about curvilinear coordinates, Fourier series and transforms, probability distributions, partial differential equations and different integral transforms, special functions, tensors and group theory.

### Unit I

#### Vector analysis and matrices (8 hours)

Review of vector analysis-vector calculus operators-orthogonal curvilinear coordinates-gradient, divergence, curl, Laplacian in cylindrical and spherical polar coordinates-orthogonal and unitary matrices- Hermitian matrices- diagonalization of matrices- normal matrices- Cayley-Hamilton theorem

#### Complex analysis (8 hours)

Cauchy-Riemann conditions-Cauchy's integral theorem and formula-singularities and mapping-calculus of residues-dispersion relations

#### Fourier series and applications (8 hours)

General principles of Fourier series, Complex representation, Parseval's identity, Fourier's Integrals, Fourier transforms and its properties.

#### Probability (12 hours)

Definitions and simple properties of probability-random variables- Chebychev inequality and moment generating function-discrete and continuous probability distributions-binomial distributions- poisson distributions- Gauss Normal distribution-error analysis and least square fitting-chi-square and student 't' distributions

### Unit II

#### Differential equations (16 hours)

Partial differential equations-first order equations-separation of variables-singular points-series solutions and Frobenius method- non-homogeneuous partial differential equations-Green's functions-Laplace transforms and inverse Laplace transforms-applications to solution of simple differential equations

#### Special functions (20 hours)

Bessel functions of the first kind-orthogonality-Neumann functions-Hankelfuctions-modified Bessel functions-spherical Bessel functions-Legendre functions-generating function-recurrence relations and orthogonality-associated Legendrefunctions-spherical harmonics-Hermite functions-Lagurerre functions-Chebyshev polynomials-hypergeometric functions

**Unit III**

**Tensor analysis (18 hours)**

Notations and conventions in tensor analysis-Einstein's summation convention-covariant and contravariant and mixed tensors-algebraic operations in tensors-symmetric and skew symmetric tensors-tensor calculus- Christoffel symbols-kinematics in Riemann space-Riemann- Christoffel tensor.

**Group theory (18 hours)**

Definitions of a group-elementary properties-sub groups-homomorphism and isomorphism of groups-representation of groups-reducible and irreducible representations-simple applications in crystallography and molecular symmetry- Lie groups- SU(2) groups and their representations

**Course Outcome**

(i) To apply and analyze the various vector and matrix operations and to perform complex analysis for solving physical problems.

(ii) To demonstrate and utilize the concepts of Fourier series and its transforms.

(iii) To explain and differentiate different probabilistic distributions.

(iv) To apply partial differential equations and special functions for solving mathematical problems.

(v) To illustrate and apply concepts of group theoretical operations and tensors.

**Books for study**


1. G.B. Arfken and H.J. Weber, *Mathematical methods for Physicists*, 6th Edition,Elsavier (2005).
2. H.K. Dass and R. Verma, *Mathematical Physics*, S.Chand & Co Pvt Ltd ( 1997)
3. A.W. Joshi, *Matrices and Tensors in Physics*, 3rd Edition,New Age International Pub ( 1995)
4. B.D. Gupta, *Mathematical Physics*, 4th Edition, Vikas Publishing House (2004)
5. A.W. Joshi, *Elements of Group Theory for Physicists*, Fourth Edition, New Age International Pub (1997).
6. S.C. Bagchi, S.Madan, A, Sitaram,V.B Tewari, *A first course in representation theory andlinear Lie groups*, Universities Press (India) Pvt Ltd (2000).
7. C. Harper, Introduction to Mathematical Physics, Prentice Hall (1986)

**References**

1. Harry Lass, Vector and Tensor Analysis, McGraw Hill Pub (1950)
2. M.L.Jain,Vector Spaces and Matrices in Physics, Alpha Science International (2001)
3. W.W.Bell, Special Functions for Scientists and Engineers, Dover Publications (2004)
4. W.K.Tung, Group theory in Physics, World Scientific Pub Co (1999)
5. A.K. Ghatak, I.C. Goyalamd S.T. Chua, Mathematical Physics, Macmillan India (1985)

## PH 213: BASIC ELECTRONICS (6L,1T)

**Objectives:** This course is aimed to introduce the students with the basic knowledge of analog and digital circuits. The course illustrates the concepts of various amplifier circuits, solid state electronic devices, sequential digital circuits, optoelectronics devices and measurements using electronic instruments.

### Unit I

**Selections from electronic circuits (10 hours)**

Frequency response of an amplifier circuits-power and voltage gain- impedance matching- Bode plots- Miller effects- rise time bandwidth relations- frequency analysis of BJT and FET amplifier stages

**Operational amplifier and its applications (18 hours)**

Opamp - frequency response, poles and zeroes, transfer functions (derivation not required), expression for phase angle- Active filters-first order and second order Butterworth transfer function-first order and second order active filters- low pass, high pass and band pass filters- comparators-OP Amp as a voltage comparator-zero crossing detectors-Schmitt trigger-voltage regulators- square, triangular and saw tooth wave form generators-Weinberg oscillator- monostable and astable multivibrator circuits using IC 555 timer- Phase Locked Loop circuits (PLL)

**Microwave solid state electronic devices (8 hours)**

Tunnel diode-varacter diode-IMPATT diode- QWITT diode- TRAPATT diode- Gunn diode

### Unit II

**Digital electronics**

**Arithmetic and data processing digital circuits (16 hours)**

Binary adder and subtractor- arithmetic logic unit- binary multiplication and division- arithmetic circuits using HDL- multiplexers- demultiplexers- BCD to decimal decoder- seven segment decoder- parity generators and checkers- magnitude comparator- programmable logic arrays

**Sequential digital circuits (20 hours)**

Flip flops- edge triggered- SR flip flops- JK flip flop- D- flip flop- JK master-slave flip flop- different types of registers (SISO, SIPO, PISO, PIPO)- universal shift registers- applications- counter asynchronous and synchronous electronic counters- decade counters-digital clock

## Unit III

### Optoelectronics (22 hours)

Optical fibre as a wave guide-mode theory of circular wave guide- -modes in step index fibres- signal distortion in optical fibres- group delay, material dispersion, wave guide dispersion- sources of attenuation- absorption, scattering, bending loss, core and cladding loss- optical sources- LED's- structure, quantum efficiency and power- laser diodes- modes and threshold conditions, rate equations, efficiency and resonant frequency- photo detector- pin and avalanche photodiodes- principles- optical amplifier- basic applications and types, semiconductor optical amplifiers, erbium doped fibre amplifiers.

### Electronic Instrumentation (14 hours)

Electronic measurements and instruments-comparison between analog and digital instruments- performance and dynamic characteristics-ideas of errors and measurement standards- voltmeters-ammeters- CRO- Block diagram, CRT, CRT circuits, vertical deflection system- delay line, multiple trace, horizontal deflection system, oscilloscope probes and transducers, oscilloscope techniques, storage oscilloscope, digital storage oscilloscope- classification of transducers-active and passive transducers-force and displacement transducers-strain gauges- temperature measurements-thermistors- thermocouples-flow measurements.

## Course Outcome

(i) To equip the students design and analyze different analogue and digital circuits.
(ii) To summarize the knowledge of basic arithmetic and data processing circuits and memory devices.
(iii) To equip the students to explain various components in optical communications systems and microwave devices.
(iv) To measure and analyze the different electronic signals.

## Books for study


1. A. Malvino and D.J.Bates, *Electrinics Prinicples*, 7th Edition,Tata McGraw Hill (2007)
2. R.A. Gayakwad, *Operational Amplifiers and Linear integrated Circuits*, Prentice Hall of India (2000)
3. M.S. Tyagi, *Introduction to semiconductior materials and devices*, Wiley India (2005)
4. B.G. Streetman, S.K. Banerjee, *Solid state electronic devices*, Pearsoninc (2010)
5. J. Millman, C. Halkias and C.D. Parikh, *Integrated Electronics*, Tata McGraw Hill (2010)
6. D.P. Leach,A.P. Malvino, and G. Saha , *Digital principles and applications*, Tata Mc Graw Hill (2011)

7. G.Keiser, *Optical Fibre Communication*, 3rd edition, McGraw Pub (2000)
8. Lal Kishore, *Electronic measurements and Instrumentation*, Dorling Kindersley (India) Pvt Ltd (2010)
9. W.D. Cooper, A.O. Helfrik and H. Albert, *Electronic Instrumentation and measurement Techniques*, PHI (1997)
10. Electronic Devices and Circuits Theory, Robert L. Boylestad, Louis Nashelsky, Pearson 10th edition (2009).

**References**

1. T.F. Bogart Jr, J.S. Beasley and G. Reid, Electronic devices and circuits, Sixth Edition, Pearson Inc (2004)
2. Thomas. L. Floyd, Digital Fundamentals, 10th edition, Dorling Kindersley (India) Pvt Ltd (2011)
3. Joachion Piprek, Semiconductor Optoelectronic Devices, Academic Press (2003)

## PH 221: MODERN OPTICS AND ELECTROMAGNETIC THEORY (6L, 1T)

**Objectives:** This course covers linear and non-linear optical phenomenon, propagation of electromagnetic waves, relativistic electrodynamics, radiation and antenna theory.

### Unit I

#### Modern optics (24 hours)

Multiple beam interference-Fabry-Perot interferometer- theory of multilayer films-antireflection films and high reflectance films -Fresnel- Kirchoff integral theorem and formula- Fraunhofer and Fresnel diffraction patterns and theory-applications of Fourier transforms to diffraction- acoustic- optic modulation- basic ideas of Raman-Nath diffraction and Bragg diffraction- holography as wavefront reconstruction-propagation of light in crystals-optical activity and Faraday rotation

#### Non-linear optics (12 hours)

Harmonic generation- second harmonic generation- phase matching- third harmonic generation- optical mixing- paramagnetization of light- self focusing- multiquantum photoelectric effect- two photon process and theory- multiphoton processes- three photon processes- second harmonic generation- parametric generation of light.

### Unit II

#### Electromagnetic waves (12 hours)

Electromagnetic wave equations-electromagnetic waves in non-conducting media-plane waves in vacuum-energy and momentum of electromagnetic waves-propagation through linear media- reflection and transmission at normal and oblique incidence-electromagnetic waves in conductors-modified wave equations and plane waves in conducting media-reflection and transmission at a conducting interface

#### Relativistic electrodynamics (14 hours)

Vector and scalar potential- gauge transformations- Coulomb gauge and Lorentz gauge-Magnetism as a relativistic phenomena- transformation of the field-electric field of a uniformly moving point charge-electrodynamics in tensor notation-electromagnetic field tensor-potential formulation of relativistic electrodynamics

**Radiation (10 hours)**

Dipole radiation- electric dipole radiation- magnetic dipole radiation- radiation from an arbitrary source- point charges- power radiated by a point charge- radiation reaction

**Unit III**

**Transmission lines (12 hours)**

Transmission line parameters and equations-input impedance-standing wave ratio and power- The Smith Chart-applications of transmission lines

**Waveguides (12 hours)**

Rectangular wave guides-transverse magnetic (TM) modes-Transverse electric (TE) modes- wave propagation in the wave guide-power transmission and attenuation

**Antennas (12 hours)**

Radiation from Hertzian dipole-half wave dipole antenna-quarter wave monopole antenna- antenna characteristics -antenna arrays-effective area and Friji's equations

**Course Outcome**

(i) To demonstrate the linear and nonlinear optical phenomena.

(ii) To explain and discuss propagation of electromagnetic waves through different media.

(iii) To restate formulations and relativistic effects in electrodynamics.

(iv) To analyse the propagation of electromagnetic waves through waveguides.

(v) To use radiation theory in developing different antennas.

**Books for study**

1. G.R. Fowles,, *Introduction to Modern Optics*, Second Edition, Dover Publications (1989).
2. A. Yariv, *Introduction to Optical electronics*, Holt, Reinhart and Winston (1976).
3. A. Ghatak and K. Thyagarajan, *Optical Electronics*, Cambridge University Press (1998)
4. D. Roody and J. Coolen, *Electronic Communications*, Fourth Edition, Dorling Kindersley (India) Pvt Ltd (2008)
5. D.J. Griffiths , *Introduction to Electrodynamics*, PHI Learning India Pvt Ltd (2007).
6. M.N.O. Sadiku, *Elements of electromagnetics*, Oxford University Press (2007).
7. B.B. Laud, *Lasers and Non-linear Optics*, Second Edition, Wiley-Eastern Limited (1991)

## References


1. J.R. Meyer-Arendt, Introduction to Classical and Modern Optics, Prentice Hall Intl (1995)
2. J.C. Palais, Fibre optic communications, Fifth Edition, Pearson Education Inc (2005)
3. E.C. Jordan and K.G. Balmain, Electromagnetic waves and radiating systems, Second Edition, Pearson Education (2002)
4. D.K.Cheng, Field and Wave electromagnetics , Second Edition ,Addison Wesley (1999).
5. L.Ganesan and S.S.Sreejamole,Transmission lines and wave guides, Second Edition, Tata McGraw Hill (2010)

## PH 222: THERMODYNAMICS, STATISTICAL PHYSICS AND BASIC QUANTUM MECHANICS (6L, 1T)

**Objectives:** This course is aimed to introduce the concepts of thermodynamic equations, foundations of classical and quantum statistics, theory of phase transitions and foundations quantum mechanics together with problems.

### Unit I

**Thermodynamic relations and consequences (20 hours)**

Thermodyanamic functions and Maxwells's equations-Clausius -Claepyrans equations-Properties of thermodyanamic potentials-Gibbs-Helmoltz relation-thermodynamic equilibrium-Nernst –heat theorem and its consequences-Gibb's phase rule-chemical potential-vapour pressure relation and chemical constants

**Foundations of classical statistical physics (16 hours)**

Phase space-ensembles-Lioville's theorem-statistical equilibrium-microcanonical ensemble-partition functions and thermodynamic quantities-Gibb's paradox-Maxwell-Boltzmann distribution laws-grand canonical ensemble

### Unit II

**Quantum statistics (26 hours)**

Quantum statistics of classical particles-density matrix in microcaonical, canonical and grand canonical ensembles-Bose Einstein statistics and Bose Einstein distribution law-Maxwell Boltzmann statistics and Maxwell Boltzmann distribution law—Fermi Dirac statistics and Fermi Dirac distribution law-comparison of three types of statistics-applications of quantum statistics-Planck radiation laws-Bose Einstein gas and Bose Einstein condensation—Fermi Dirac gas-electron gas in metals-thermionic emission-statistical theory of white dwarfs

**Phase transitions (10 hours)**

Triple point-Vanderwal's equation and phase transitions-first and second order phase transitions- Ehrenfest's equations- Ising model

**Unit III**

**Foundations of quantum mechanics (14 hours)**

Basic postulates if quantum mechanics- Hilberts space- observables- Hermitian operators- general statistical interpretation-Uncertainty principle-minimum uncertainty wave packet- energy time uncertainty principle-Dirac notation-Matrix representation of state vectors and operators-change of representations- eigenvalue problem in matrix mechanics-energy and momentum representations-unitary transformations involving time- Schrodinger, Heisenberg and interaction pictures.

**Exactly solvable problems in quantum mechanics (22 hours)**

One dimensional eigen value problems-square well potential-potential barrier-alpha particle emission-Bloch waves in periodic potential-linear harmonic oscillator problem using wave mechanics and operator methods-free particle wave functions and solutions-three dimensional eigen value problems-particle moving in spherical symmetric potential-rigid rotator-hydrogen atom problem-three dimensional potential well- Deuteron

**Course Outcome**

(i) To explain the basic thermodynamic relations, Maxwell's equations and its consequences.
(ii) To equip the students to demonstrate and apply classical and quantum statistics in different physical phenomena.
(iii) To distinguish the different phase transitions using Ising model.
(iv) Outline and apply foundations of quantum mechanics.

**Books for study**


1. R. K. Pathria, *Statistical Mechanics*, Pergamon Press (1991)
2. Satya Prakash, *Statistical Mechanics*, Kedarnath Ram Nath Publishers,Meerut and Delhi (2009)
3. B.K. Agarwal and HariPrakash, *Quantum Mechanics*, Prentice Hall of India (2002)
4. S. Devanarayanan, *Quanrtum Mechanics*, Sci Tech Publications (India) Pvt Ltd (2005)
5. D.J. Griffiths, *Introduction to Quantum Mechanics*, Second Edition, Pearson Education Inc ((2005)
6. G. Aruldas, *Quantum Mechanics*, Second Edition, PHI learning Pvt Ltd (2009).
7. J. J Sakurai , Modern Quantum Mechanics, Second edition, Pearson (2010).
8. N. Zettili, Quantum Mechanics concepts and Applications, Second edition, Wiley (2009).


**References**


1. R.K. Srivastava and J. Asok , Statistical Mechanics, Wiley Easter Ltd ( 2005)

2. S.K. Sinha, Statistical Mechanics-Theory and Applications, Tata Mc Graw Hill
3. P.M. Mathews and K.Venkitesan, A Text Book of Quantum Mechanics, Tata Mc Graw Hill (2010)
4. A. Ghatak and S. Lokanathan ,Quantum Mechanics Theory and Applications, Kluewer Academic Publishers (2004).
5. V.K. Thankappan, Quantum Mechanics, Second Edition, New Age International Pvt Ltd (2003).

## PH 223: COMPUTER SCIENCE AND NUMERICAL TECHNIQUES (6L, 1T)

**Objectives:** This course provides introduction to computer architecture, microprocessors, programming in python and C++ and computational numerical methods.

### Unit I

**Foundations of computer science (12 hours)**

Introduction to computers-computer architecture-memory (RAM and ROM, cache) and storage- I/O devices- operating systems-data communications, computer networks and topology

**Introduction to microprocessors (12 hours)**

Evolution of microprocessors-microcontrollers and digital signal processors- Intel 8085 8 bit microprocessor- pin description-functional description- 8085 instruction format-addressing modes of 8085- interrupts of 8085- memory interfacing- 8085 machine cycles and Bus timings- assembly language programming of 8085

**Introduction to Python Programming (12 hours)**

Python - Python shell, number, variables, comparisons and logic, Python objects - strings, lists, tuples, loops; control flow, file input and output functions

### Unit II

**Programming with C++ (36 hours)**

C++- flow control-conditional statements-iterative statements-switch statements-conditional operators as an alternative to IF-nested loops-break statements-ext( ) functions-structured data types-arrays-storage classes-multidimensional arrays-sorting of strings-functions-built in and user defined- accessing function and passing arguments to functions-calling functions with arrays-scope rule for functions and variables-structures in C++-classes abd objects – definition- class declaration-class function definitions-creating objects-use of pointers in the place of arrays-file handling in C++-basic file operations-serial and sequential files-reading and writing on to disks.

### Unit III

**Numerical Techniques (36 hours)**

Solution of simultaneous linear algebraic equations-Gauss elimination method-Gauss

Jordan method-inverse of a matric using Gauss elimination method-Finite differences-forward and backward differences-central differences-difference of a polynomial-error propagation in difference table-Interpolation with equal intervals-Gregory Newton forward and backward formula- error in polynomial interpolation-central difference interpolation formula-Gauss's forward and backward formula- Striling's formula-Lagrange interpolation formula-numerical differentiation-numerical integration using general quadrature formula-Trapezoidal rile- Simsons 1/3 and 1/8 rules-numerical solutions to ordinary differential equations-Euler and modified Euler methods-Runge Kutta methods-numerical solution to partial differential equations-solutions to Poisson and Laplace equations.

**Course Outcome**

(i) To summarize computer hardware and its operating systems
(ii) Explain internal architecture of microprocessors 8085 and create assembly language programing.
(iii) To develop and compile programs in python and C++.
(iv) Apply numerical methods to solve physical problems.

**Books for study**

1. ITL Education Solutions Ltd, *Introduction to Computer Science*, Second Edition, Dorling Kindersley (India) Pvt Ltd (2011)
2. V.N. Vedamurty and N. Iyengar, *Numerical Methods*, Vikas Publishing Pvt Ltd (1998)
3. K. Udayakumar, and B.S. Umasankar, *The 8085 microprocessor*, Dorling Kindersley (India) Pvt Ltd (2008)
4. Christian Hill, *Learning Scientific Programming with Python*, Cambridge University Press (2015)
5. V. Carl Hamacher, Z.G.Vranesic and S.G. Zaky, *Computer Organization*, Fourth Edition, McGraw Hill International Edition (1996)
6. Peter Norton etal., *Beginning Python*, Wiley Publishing (2005)
7. Abishek Yadav, *Microprocessor 8085 8086*, University Science Press, New Delhi (2008)
8. D.Ravichandran, *Programming in C++*, Tata McGraw Hill (2011)
9. M.T.Somasekhara, *Programming in C++*, PHI Pvt Publishing (2005).
10. B. Ram, Fundamentals of Microprocessors and Microcontrollers, Dhanpat Rai Publications (2008).
11. S. S. Sastry, Introductory method of Numerical analysis, Fifth Edition, PHI (2012).

**References**

1. V. Rajaraman, Fundamentals of Computers, Fifth Edition, PHI (2010)
2. R.S.Gaonkar, Microprocessor-Architecture, Programming and Applications with 8085
3. S.S. Sastry, Introductory method of Numerical analysis, Fifth Edition, PHI
4. P. Ghosh, Numerical Methods with computer programs in C++,PHI learning Pvt Ltd
5. Bjorne Stroustrup, The C++ Programming Language ,Fourth Edition, Addison Wesley

**PH231: ADVANCED QUANTUM MECHANICS (6 L, 1 T)**

**Objectives:** This course describes a thorough conceptual understanding of advanced quantum mechanics covering variation method, WKB approximation, perturbation theory, symmetry and conservation laws, theory of scattering, system of identical particles, angular momentum and relativistic quantum mechanics.

**Unit I**

**Variation method (6 hours)**

The variational principle-Rayleigh Ritz method-variation method for excited states-ground state of Helium and Deutron.

**WKB approximation (8 hours)**

WKB method-connection formulas-barrier potential-penetration-alpha particle emission-bound states in a potential well

**Time dependent and time-independent perturbation theory (22 hours)**

Time independent perturbation- basic concepts- non-degenerate energy levels- anharmonic oscillator-ground state of helium- effect of electric field on the ground state of hydrogen- degenerate energy levels- effect of electric field on the n=2 state of hydrogen- spin-orbit interaction.
Time dependent perturbation- first order, harmonic, transition to continuous states, absorption and emission of radiation- Einstein's coefficients- selection rules.

**Unit II**

**Symmetry and conservation laws (10 hours)**

Symmetry transformations-space translation and conservation of angular momentum-time translation and conservation of energy-rotation in space and conservation of angular momentum-space inversion-time reversal

**Quantum theory of scattering (12 hours)**

Scattering cross section and scattering amplitude-partial wave analysis and scattering by a central potential-scattering by attractive square well potential-scatteriing length-expression for phase shifts-Born approximation-scattering by Coulomb potential-Laboratory and centre of mass coordinate transformations.

**System of identical particles (14 hours)**

Identical particles- Pauli's exclusion principle-inclusion of spin-spin function for a two electron system-Helium atom-central field approximation-Thomas Fermi model of an atom-Hartree and Hartree-Fock equations.

**Unit III**

**Angular momentum (12 hours)**

Angular momentum in operators and commutation relations-eigen values and eigen functions of $L^2$ and $L_z$ –general angular momentum-eigen values of $J^2$ and $J_z$-angular momentum matrices-spin angular momentum –spin vectors for a spin ½ system-addition of angular momentum-Clebsch-Gordan coefficients.

## Relativistic quantum mechanics (24 hours)

Klein-Gordon equations and its relevance-particle in a Coulomb's field-Dirac's relativistic theory-Dirac's equation for a free particle-Dirac matrices-covariant form of Dirac's equations-probability density-plane wave solutions-negative energy starts-spin in Dirac's theory-magnetic moment of an electron-relativistic corrections of Hydrogen atom spectrum-spin orbit correction-Lamb shift

## Course Outcome

(i) To extend the use of approximation methods viz variation, WKB, time dependent and time independent perturbations.

(ii) To summarize different types of symmetry, conservation laws and quantum theory of scattering.

(iii) To distinguish different approximation methods, to study the structure and properties of many electron systems.

(iv) To compute eigen values of angular momentum and evaluation of CG coefficients.

(v) Infer the requirements of relativistic quantum mechanics.

## Book for study

1. G.Aruldas, *QuantumMechanics*,SecondEdition,PHI learning Pvt Ltd (2009)
2. D.J.Griffiths, *Indroducion to Quanum Mechanics*, Second Edition, Pearson Education Inc (2005)
3. J.J.Sakurai,Advamced Quantum Mechanics, Pearson Education Inc (2009)

## References


1. P.M.Mathews and K.Venkitesan,A Text Book of Quantum Mechanics,TataMcGraw Hill (2010)
2. A.Ghatak and S.Lokanathan ,QuantumMechancis Theory and Applications, Kluwer Academic Publishers (2004)
3. V.K.Thankappan,QuantumMechancics, Second Edition, New Age International Pvt Ltd (2003)
4. S.Devanarayanan,QuanrtumMechanics, Sci Tech Publications ( India) Pvt Ltd ( 2005)
5. L.H.Ryder,Quantum Field TheorySecondEdition,Cambridge University Presss (1996)
6. Steven Weinberg,Quantum Theory of Fields( in Three Volumes), Cambridge University Presss (2002)

## PH 232: ATOMIC AND MOLECULAR SPECTROSCOPY (6L, 1T)

**Objectives:** This course provides an overview of symmetry of molecules, concepts of atomic spectra, Photoelectron and photo acoustic spectroscopy, Rotational, vibrational, electronic, Raman, Mossbauer, nuclear and electron spin resonance spectroscopic techniques.

### Unit I

### Atomic Spectroscopy (14 hours)

Spectra of Atoms - Spectroscopic terms– selection rules– exchange symmetry of wave functions- Pauli's exclusion principle. Many electron atoms- Building principle- the spectra of Li and hydrogen like elements, The L-S and j-j coupling schemes- total angular momentum – term symbols- The spectra of Helium-Zeeman effect – The magnetic moment of atom, Lande's g factor- The normal Zeeman effect- Emitted frequencies in anomalous Zeeman transitions- Nuclear spin and Hyperfine structure, Stark Effect, Paschen Bach effect

### Molecular symmetry (10 hours)

Symmetry operations-symmetry elements-algebra of symmetry operations-multiplication tables-matrix representation of symmetry operators-molecular point groups-reducible and irreducible representations-great orthogonality theorem-character tables for $C_{2V}$ and $C_{3V}$ point groups, symmetry species of point groups-IR and Raman activity

### Photoelectron and Photo-acoustic spectroscopy (12 hours)

Photoelectron spectroscopy-experimental methods-photoelectron spectra and their interpretation-Auger electron and X ray Fluorescence spectroscopy-Photo-acoustic effect-basic theory-experimental arrangement-applications.

### Unit II

### Molecular rotational spectroscopy (12 hours)

Classification of molecules-rotational spectra of diatomic molecules-isotope effect and intensity of rotational lines-non rigid rotator-linear polyatomic molecules-symmetric and asymmetric top molecules-microwave spectrometer-analysis of rotational spectra.

### IR spectroscopy (12 hours)

Vibrational spectra of diatomic molecules-characteristic IR spectra-vibrations of polyatomic molecules- anharmonicity- Fermi resonance-hydrogen bonding-normal modes of vibration in a crystal- interpretation of vibrational spectra- IR spectrometer- Fourier transform IR spectroscopy

**Electronic spectra of molecules (12 hours)**

Vibrational coarse structure and analysis of bound systems- Deslanders table-Frank-Condon principle-vibrational electronic spectra-rotational fine structure- Fortrat parabola-electronic angular momentum in diatomic molecules

**Unit III**

**Raman spectroscopy (12 hours)**

Theory of Raman scattering-rotational and vibrational Raman spectra-Raman spectrometer-structure determination using Raman and IR spectroscopy-nonlinear Raman effects-Hyper Raman effect-stimulated Raman scattering- coherent anti-stokes Raman scattering

**ESR and NMR spectroscopy (16 hours)**

Principle of NMR-ESR spectrometer-Hyperfine structure-ESR spectra of Free radicals-Magnetic properties of nuclei-resonance condition-NMR instrumentation-chemical shift-NMR spectra of solids-NMR imaging-interpretation of NMR spectra

**Mossbauer spectroscopy (8 hours)**

Recoilless emission and absorption-Mossbauer spectrometer-experimental techniques-isomer shift- quadrupole interaction-magnetic hyperfine interaction

**Course Outcome**

(i) Explain different symmetry operations and deduction of molecular structure.
(ii) Distinguish and classify the different spectra shown by atoms and molecules
(iii) Illustrate the various spectroscopic experimental techniques.

**Books for study**


1. J.M. Hollas, *Modern Spectroscopy*, Fourth Edition, John Wiley &Sons (2004)
2. G. Aruldas, *Molecular Structure and Spectroscopy*, PHI Learning Pvt Ltd (2007)
3. Suresh Chandra, *Molecular Spectroscopy*, Narosa Publishing Co (2009)
4. H E White, Introduction to Atomic Spectroscopy McGraw-Hill Inc. 1st Edition. (1934).


**References**


1. C.N. Banwell and E.M. McCash, Fundamentals of Molecular Spectroscopy, Fourth edition, Tata McGraw Hill (1995).
2. D.N. Satyanarayana, Vibrational spectroscopy-Theory and applications, New Age International Pvt Ltd (2004)
3. J.L.McHale, Molecular Spectroscopy, Pearson education Inc (2008).

## SYLLABUS FOR SPECIAL PAPERS (SPECIAL PAPER I)

### PH 233 E: ADVANCED ELECTRONICS -I (6L, 1T)

**Objectives:** To impart knowledge in advanced digital and analog communications systems and familiarize the concepts of digital signal processing.

**Unit I**

**Analog radio frequency communications (16 hours)**

Different types of analog continuous wave modulation-analog baseband signal transmission-signal distortions and equilization-linear continuous wave modulation schemes-amplitude modulation-DSB and SSB schemes-frequency conversion-angle modulation-spectra of angle modulated signals-power and bandwidth of FM signals-generation and demodulation of FM signals-commercial radio broadcasting techniques-AM and FM radio broadcasting and reception.

**Microwave radio communications (10 hours)**

Advantages and disadvantages of microwave radio communications-digital and analog systems-frequency and amplitude modulation techniques-FM microwave radio system-FM microwave repeaters-FM microwave radio stations-line of sight path characteristics

**Pulse modulation (10 hours)**

Different types of pulse modulation-pulse amplitude modulation (PAM)-PAM spectrum-pulse code modulation (PCM)-sampling and quantization of analog signals-quantization error-signal to noise ratio-differential PCM delta modulation-other pulse modulation schemes-applications of pulse modulation.

**Unit II**

**Digital communications (16 hours)**

Basics of information theory-ideas of digital codes –noise in information carrying channel-Digital carrier modulation -binary ASK,PSK and FSK schemes-bandwidth and power requirements-synchronization methods-ideas of error control coding and error corrections-digital transmission of analog signals-transmission using PCM – frequency and time division multiplexing ( TDM) –TDM in PCM telephone system.

**Optical fiber communications (20 hours)**

Overview of the optical communication system and its components-optical communication receiver and its equivalent circuit-direct and coherent detection systems- digital modulation and demodulation schemes for coherent optical communication receivers-heterodyne and homodyne detection – principles of wavelength division and code division multiplexing in optical communication-optical solitons- soliton based optical communication systems

## Unit III

### Mobile cellular communications (10 hours)

Mobile telephone services-cellular telephone-frequency reuse-cell splitting-sectoring, segmentation and dualisation-cellular system topology-roaming and handoffs-cellular telephone network components and call processing-first and second generation cellular telephone services-digital cellular telephone system-global system for mobile communication-personal satellite communication system

### Basics of signals and systems (6 hours)

Classification of signals-amplitude and phase spectra-classification of system-simple manipulations of discrete time signals-representation of systems-analog to digital conversion of signals

### Fourier analysis of signals and systems (12 hours)

Trigonometric Fourier series-exponential form-Parseval's identity-power spectrum of a period function-Fourier transform-properties of Fourier transform-Fourier transform of important signals-Fourier transform of power and energy signals-Discrete time fourier transform - Fast Fourier transform (FFT).

### Z-transforms (8 hours)

Definition of z transform-properties of z-transform-evaluation of the inverse z-transform

## Course Outcome

(i) To summarize various techniques of digital and analog communication systems.
(ii) Generalize the idea of information theory
(iii) Illustrate various techniques for digital signal processing based Fourier and Z transform.

## Books for study


1. K. Sam Shanmugam, *Digital and Analog communication systems*, John Wiley & Sons (2006).
2. W. Tomasi, *Electronic communications systems: Fundamentals through Advanced*, Dorling Kinderley (India) Pvt. Ltd (2009).
3. G. Kennedy and B. Davis, *Electronic communication systems*, Fourth Ediion, Tata McGraw Hill (2003)
4. G. Keiser, *Optical Fibre Communication*, 3rd edition, McGraw Pub (2000).
5. G. P. Agrawal, *Fibre optic communication systems*, John Wiley& Sons (1993)
6. S. Salivahanan and G. Ganapriya, *Digital Signal Processing*, Tata McGraw Hill (2011).

## References

1 H. Taub ,D. Schilling and G. Saha, Principle of Communication systems, 3rd Edition, Tata McGraw Hill (2008).

2 W.C.Y. Lee, Mobile Communications- design, Fundamentals, Second Edition, John Wiley & Sons (1993).

3 .J.S. Chitode, Digital Communications, Technical Publications Pune (2008)

4 J.M. Senior, Optical Fibre Communications-Principles and Practice, Second Edition, Pearson Education (2006).

5 J.J. Carr, Microwave and Wireless communications Technology, Butterworth-Heinemann (1996).

## PH 233 M: MATERIALS SCIENCE –I

**Objectives:** To understand and familiarize fundamentals of materials, structure and its imperfections, growth techniques and associated nucleation theories.

### Unit I

**Classification of materials, Functional classification of materials (36 hrs)**

Size effects on the optical, electrical, magnetic and mechanical properties. Size effects on the optical properties of semiconductor nanostructures, weak excitonic confinement, strong excitonic confinement. Materials for Aerospace, Biomedical, Electronic, Energy technology, Environmental technology, Magnetic, Photonic and Structural Applications- Smart materials. Structural classification of Materials- Crystalline-Single crystals-polycrystalline materials-Grains and grain boundaries.

**Crystal structures of ionic** materials-Cesium chloride, Fluorite, Perovskite and Corundum type structures-Covalent structures.

**Imperfections in crystals**

Types of imperfections in crystals -Point defects-Interstitial defects-Substitutional defects-Frenkel and Schottky defects-Line Kronger-Vink notation for defect chemical reaction-Dislocations and Diffusion in crystals - Dislocations- Burgers vectors – edge and screw dislocations –slip-significance of dislocations- Schmid's law-Surface defects-Domain boundaries- Importance of defects –Diffusion - Applications of Diffusion-Stability of atoms and ions-Mechanism for diffusion-Activation energy for diffusion- Permeability of polymers-Composition profile-Diffusion and materials processing.

### Unit II

**Formation of crystalline materials (36 hrs)**

Ambient phase equilibrium – Super saturation – Equilibrium of finite phases - Equation of Thomson- Gibbs – Types of nucleation – Formation of critical nucleus – Classical theory of nucleation – Homo and heterogeneous formation of 3D nuclei – Rate of nucleation – Growth from vapor phase, solutions and melts – Epitaxial growth – Growth mechanism and classification – Kinetics of growth of epitaxial films – Mechanisms and controls for nanostructures in 0 and 1 dimensions.

**Crystallization Principles and Growth Techniques**

Classes of crystal system – Crystal symmetry – Solvents and solutions – Solubility diagram – Super solubility – Expression for super saturation – Metastable zone and induction period – Miers TC diagram – Solution growth – Low and high temperatures solution growth – Slow cooling and solvent evaporation methods – Constant temperature bath as a crystallizer.

**Gel, Melt and Vapor Growth Techniques**

Principle of gel technique – Various types of gel -- Structure and importance of gel – Methods of gel growth and advantages -- Melt technique – Czochralski growth – Floating zone – Bridgeman method – Horizontal gradient freeze – Flux growth – Hydrothermal growth – Vapor-phase growth – Physical vapor deposition – Chemical vapor deposition –

Stoichiometry.

**Unit III**
**Thin Film Physics (36 Hours)**

**Film Preparations**: Vacuum evaporation - Evaporation theory - Rate of evaporation - Hertz-Kundsen equation - Free evaporation and effusion - Evaporation mechanisms - Directionality of evaporating molecules - vapour sources - wire and metal foils - Electron bean gun - flash evaporation - sputtering - Glow discharge sputtering - Bias sputtering - Reactive sputtering - Triode sputtering - Magnetron sputtering - Ion beam sputtering – Pulsed laser deposition – Molecular beam epitaxy- Chemical methods – Thermal CVD – Plasma enhanced CVD – Spray Pyrolysis – Sol Gel method – Spin and Dip coating – Electro plating and Electroless plating – Deposition mechanisms.

**Nucleation Theories**: Condensation process - Theories of Nucleation – Capillarity theory – Atomistic theory – Comparison – stages of film growth – Incorporation of defects during growth - Film thickness measurements - Optical methods – Ellipsometry.

**Course Outcome**

(i) To identify and distinguish various crystal structures and the associated imperfections.

(ii) To prepare and demonstrate the synthesis of crystalline materials by different growth techniques.

(iii) To demonstrate different methods for growth of thin films.

(iv) To discuss various nucleation theories of film growth and analyze the synthesized thin films.

**Reference Books**


1. S.V. Gaponenko, Optical properties of semiconducting nanocrystals, Cambridge University Press (1997)
2. A. K. Bandhyopadhyay, Nanomaterials, New Age International Publishers (2007)
3. Solid State Physics, A.J.Dekker, Macmillan, (1967).
4. The Science and Engineering of Materials: Donald R Askeland and Pradeep P Phule 6 Edition- Thomson Brooks/Cole.
5. I.V. Markov, *Crystal Growth for Beginners: Fundamentals of Nucleation, Crystal Growth and Epitaxy*, (2004) 2nd edition.
6. P. Santhanaragavan and P. Ramasamy, *Crystal Growth Process and Methods*, (KRU Publications, Kumbakonam, 2001).
7. A. Goswami, *Thin Film Fundamentals*, (New Age, New Delhi, 2008).
8. Maissel and Glang, Hand Book of Thin Film Technology
9. K.L. Choppra, Thin Film Phenomena
10. Dupy and Kachard, Physics of Non-Metallic Thin Films
11. T. Pradeep: NANO: The Essentials: Understanding Nanoscience and Nanotechnology, McGraw- Hill Educatio

## PH 233N: ADVANCED NUCLEAR PHYSICS (6L, 1T)

**Objectives:** To understand fundamentals of nuclear structure and models, nuclear reactors, nuclear detectors and accelerators. To describe various types nuclear reactions and theory if elementary particles.

### Unit I

### Nuclear properties and structure (36 hours)

Nuclear structure – charge, mass, shape, and size of nucleus, spin, parity, electric and magnetic moments, isospin, binding energy, packing fraction, Experimental determination of nuclear mass, Aston's mass spectrograph, Measurement of nuclear spin (using Zeeman effect) and magnetic moment (using NMR), nature of nuclear forces, ground and excited states of deuteron, spin dependence, effective range theory, non-central force, n-p scattering and p-p scattering at low energies, nature of two nucleon potential, charge independence and saturation of nuclear force, exchange forces, meson theory of nuclear force.

Nuclear models - liquid drop model: Bethe-Weizsacker formula and its applications, shell model, evidence and limitations of shell model, single particle shell model, nuclear vibrations and rotations, optical model, collective model.

### Unit II

### Nuclear instrumentation (36 hours)

Gas filled detectors, Ionization Chamber, Proportional counter, GM Counter, Scintillation counter, Cerenkov counter, semiconductor detectors [Si(Li), Ge(Li), HPGe], Solid state nuclear track detectors, Nuclear emulsion, neutron detectors, scaling circuits. Classification of accelerators, cyclotron, synchro-cyclotron, Betatron, Tandem accelerators, linear accelerator (LINAC). Nuclear Reactor – self sustained reaction, four factor formula, reactor theory, critical size, reactor materials, reactor control, breeder reactor, thermonuclear fusion, fusion in plasma, fission reactor, conditions for sustained fusion, magnetic confinement, toroidal confinement: Tokomak.

### Unit III

### Nuclear reactions and Particle Physics (36 hours)

Types of nuclear reactions, conservation laws, energetics of nuclear reactions, nuclear transmutations, cross section of nuclear reaction, compound nucleus hypothesis, Breit-wigner one level formula, direct reactions, stripping and pick up reactions, heavy ion induced reactions, Nuclear fission, energetic of nuclear fission, Bohr-wheeler theory, nuclear fusion, stellar energy and nucleo-synthesis.

Neutrons, Kinematics in high energy collisions, particles in high energy reactions, classification of elementary particles, interactions among particles, states of particles in terms of quantum numbers, Yukawa hypothesis, properties of pi mesons, muons, K-mesons and hyperons, particle interactions and Feynman diagrams, symmetries and conservation laws, CPT invariance, Gellmann Nishijima Formula, Quark Model, Quantum Chromo Dynamics (QCD), symmetry classifications of elementary particles, weak interactions, Grand Unification Theory (GUT).

## Course Outcome

(i) To outline and analyze nuclear properties, structure, models and reactions.

(ii) To illustrate the mechanisms of nuclear fission and fusion.

(iii) Explain various nuclear detectors and particle accelerators.

(iv) To differentiate elementary particles and discuss their interactions

## Books for Study

1. S.N. Goshal. *Atomic and Nuclear Physics*, S Chand & Company Ltd. 1998
2. Kenneth S Krane. *Introductory Nuclear Physics*, John Wiley & Sons, 1987
3. Sathya Prakash. *Nuclear Physics & Particle Physics*, S Chand 2005
4. John S Liley. *Nuclear Physics*, Wiley India, 2007

## References

1. Irving Kaplan, "Nuclear Physics", Narosa Book Distributors, (2002).
2. R.D. Evans, "The atomic Nucleus", McGraw-Hill, (1955).
3. D.C.Tayal, Nuclear Physics, Himalayan Publication house, Bombay, ( 1980)
4. R.R. Roy & B P Nigam, Nuclear Physics Theory and Experiments, Wiley Eastern, (2000).
5. D.J. Griffiths, Harper & Row, Introduction to elementary particles, Wiley Eastern, (1987)

## PH 233 S: SPACE PHYSICS AND PLASMA PHYSICS (6L, 1T)

**Objectives:** To explore the different physical processes that occurs in space environment. The course will provide information about basic plasma phenomena, magnetohydrodynamics, solar physics, cosmic rays and solar energetic particles, physics of atmospheric layers and experimental techniques.

### Unit I

#### Basic Plasma Phenomena (6 hours)

Plasma Concepts – Debye shielding – plasma parameters – Plasma as a fluid - Fluid equations – Fluid drift perpendicular to B – Fluid drift parallel to B.

#### Waves in plasma (20 hours)

Plasma oscillations –Electron plasma waves – sound waves – ion waves – Electrostatic electron oscillations perpendicular to B - Electrostatic ion waves perpendicular to B – Lower hybrid frequency – Electromagnetic waves perpendicular to $B_0$ – cut offs and resonances - Electromagnetic waves parallel to $B_0$ – Hydromagnetic waves – Magnetosonic waves.
Diffusion and Resistivity- Decay of plasma by diffusion – steady state solutions – Recombinations – Diffusion across a magnetic field – Collisions in fully ionized plasma – Single fluid MHD equations.

#### Magnetohydrodynamics (10 hours)

Maxwell's equations in MHD – MHD Induction equation – Magnetic Reynold's number – Momentum equation, Pressure force – Magnetic tension force – Magnetic Buoyancy – Acoustic waves – Alfven waves – Internal gravity waves – MHD waves – Whistlers.

### UNIT II

#### Solar Physics (16 hours)

Solar interior and energy production – Neutrino problem – Helioseismology – solar activity – sunspot cycle - Sun's magnetic field – solar rotation - Photosphere – Chromosphere – Corona – Coronal heating – Solar flares – Solar wind – importance of solar terrestrial studies.

## Solar wind Physics (16 hours)

Coronal expansion – Parker's hydrodynamic theory – solar wind parameters – interplanetary magnetic field – sector structure – solar wind variations and its relationship with solar phenomena.

## Cosmic rays and energetic particles (4 hours)

Galactic cosmic rays – solar cycle modulation of galactic cosmic rays – solar energetic particles – Interstellar pick up ions – Anomalous cosmic rays – Cosmic ray detectors.

## UNIT III

## Neutral atmosphere (8 hours)

Neutral atmosphere – scale height – Variation of temperature with altitude – Troposphere – Stratosphere – Mesosphere – Thermosphere – Heat balance equation – Exosphere.

## Ionosphere and Magnetosphere (16 hours)

Ion composition and chemistry – D, E, $F_1$ and $F_2$ regions – Ionospheric conductivities and currents – Equatorial anomaly. Magnetosphere, intrinsic magnetic field – Interaction of solar wind with magnetosphere – Bow shock and magnetopause – Magnetospheric current systems – Magnetic diffusion – Magnetic reconnection – magnetic activity and substorms – magnetic storms – geomagnetic activity indices.

## Observational technique (12 hours)

Upper atmosphere sensing – direct, indirect and remote – Direct methods for neutral atmosphere – Direct methods for ionized component – Langmuir probe – Impedance and resonance probes – Mass spectrometers – Detectors for energetic particles and radiation environment – Satellite drag and related methods – Remote sensing of the neutral atmosphere – Remote sensing by radio propagation – Experimental technique for ionospheric studies – Ionosonde technique – Incoherent scatter technique.

## Course Outcome

(i) Explain fundamental properties of plasma and plasma waves.
(ii) Apply basic electromagnetism to derive the kinetic theory of plasmas.
(iii) Discuss Sun's interior structure and interpret the physics of solar activity.
(iv) Discuss the experimental technique for atmospheric studies.

## References


1. Chen F. F.: Introduction to Plasma Physics and Controlled Fusion, Plenum Press.
2. Dendy R. O.: Plasma Dynamics (Clarendon Press, 1990).
3. Tamas I. Gombosi: Physics of the Space Environment (Cambridge University Press, 1998)
4. Harra L. K. and Mason K. O.: Space Science (Imperial College Press)
5. Peter Foukal: Solar Astrophysics (Wiley, 1990)

6. Ratcliffe: Introduction to ionosphere and magnetosphere (CUP,1972)
7. Robert G. Fleagle and Joost A. Businger: An Introduction to Atmospheric Physics, Academic Press, London, 1971.
8. Banks P. M. and G. Kocharts: Aeronomy, Academic Press, London, 1973.
9. Savindra Singh: Climatology, Prayag Pustak Bhavan, 2005.
10. Michael D. Pappagiannis: Space Physics and Space Astronomy, Gordon and Breach Science Publishers Ltd., 1972.

## PH 233 T: THEORETICAL PHYSICS-I (6L, 1T)

**Objectives:** To familiarize with the concepts of advanced theoretical physics covering relativistic quantum mechanics, quantum field theory, stochastic processes and general theory of relativity.

## Unit I - Quantum Mechanics (36 hours)

### Formalism

Linear vector space, linear operators, normed spaces, Hilbert spaces, self- adjoint operators, representation of operators and states in suitable basis, spectral properties of self-adjoint operators - spectral theorem.

### Groups and Symmetry

Review of groups: Irreducible representations of groups, discrete and continuous groups, Lie groups, Lie algebra, how symmetries form a group, unitary and anti-unitary symmetry operators, Rotation and O(3) group, SU(2) group, angular momentum algebra, vector operators, Tensor operators, Wigner-Eckart theorem Discrete symmetries - space and time inversion symmetries.

### Relativistic quantum mechanics

Lorentz group - generators, representation of Lorentz group extended by parity and Dirac equation, hydrogen atom

### Field theory

Lagrangian formalism, Noether's theorem, Hamiltonian density, quantization of fields, second-quantization, quantization of EM field.

## Unit II

## Statistical Physics (36 hours)

### Stochastic processes

Review of probability and measure, equilibrium vs non-equilibrium, Brownian motion, Langevin equation, Ito vs Stratanovic, Markov processes, Fokker-Planck equation, Fluctuation-Dissipation theorem.

### Special topics in non-equilibrium systems

Einstein diffusion equation - derivation and boundary conditions, free diffusion in one-dimensional half-space, fluorescence micro photolysis.

## Unit III - General relativity (36 hrs)

### Differential geometry

Tensors, differentiable manifolds, geodesics, curvature, Riemannian tensor

### Relativity

Principle of equivalence, Einstein equations, centrally symmetric gravitational fields, Schwaarzchild solution, singularities.

## Course Outcome

(i) To discuss introductory level problems in relativistic quantum mechanics and field theory.
(ii) To describe the basic theory of Stochastic processes with emphasize on non-equilibrium systems.
(iii) To illustrate formalism of general theory of relativity.

## References


1. F. Scheck, Quantum Physics, Springer (2007).
2. G. Teschl, Mathematical Methods in Quantum Mechanics, American Mathematical Society (2009).
3. P. Szekeres, Modern Mathematical Physics, Cambridge University Press (2004).
4. M. T. Vaughn, Introduction to Mathematical Physics, Wiley - VCH Verlag (2007).
5. Arfken, Mathematical Physics for Physicists, Academic Press (2013).
6. J. J. Sakurai, Modern Quantum Mechanics, Addison-Wesley Publishing Company (1994).
7. L. I. Schiff, Quantum Mechanics, McGraw-Hill Book Co. (1968).
8. R. Shankar, Principles of Quantum Mechanics, Springer (1994).
9. L. E. Ballentine, Quantum Mechanics, World Scientific Publishing Co. (2000).
10. L. H. Ryder, Quantum Field Theory, Cambridge University Press (2008).
11. J. J. Sakurai, Advanced Quantum Mechanics, Addison-Wesley (1967).
12. M. Le Bellac, Quantum and Statistical Field Theory, Oxford University Press (2001).
13. K. Schulten and I. Kosztin, Lectures in Theoretical Biophysics, University of Illinois at Urbana- Champaign (2000).
14. R. Kubo, M. Toda and N. Hashitsume, Statistical Physics II: Non equilibrium Statistical Mechanics, Springer-Verlag (1985).
15. G. F. Mazenko, Non equilibrium Statistical Mechanics, Wiley-VCH Verlag (2006).
16. V. Balakrishnan, Elements of Non equilibrium Statistical Mechanics, CRC Press (2008).
17. B. F. Schutz, A First Course in General Relativity, Cambridge University Press (2009).
18. S. Caroll, Spacetime and Geometry: An Introduction to General Relativity, Addison-Wesley (2004).
19. A. Altland and B. Simons, Condensed Matter Field Theory, Cambridge University Press (2008).
20. J. W. Negele and H. Orland, Quantum Many-particle Systems, Levant Books (2006).
21. E. Fradkin, Field Theories of Condensed Matter Systems, Levant Books (2006).
22. P. M. Chaikin and T. C. Lubensky, Principles of Condensed Matter Physics, Cambridge University Press (2004).
23. A. M. Tsvelik, Quantum Field Theory in Condensed Matter Physics, Cambridge UniversityPress(2003).

## PH 241: CONDENSED MATTER PHYSICS (6L, 1T)

**Objectives:** To understand and familiarize fundamentals of crystals, lattice vibrations, band theory, dielectric, magnetic and superconducting properties of materials. To introduce the synthesis and characterization techniques of nanomaterials.

### Unit I

#### Crystal physics (10 hours)

Lattice points and space lattice-basis and crystal structure-unit cells and lattice parameters-symmetry elements in crystals –space groups-Bravais lattice-density and lattice constant relation-crystal directions, planes and Miller indices-reciprocal lattice-allotropy and polymorphism in crystals-imperfections in crystals.

#### Lattice vibrations and thermal properties (10 hours)

Dynamics of identical atoms in crystal lattice-dynamics of linear chain-experimental measurement of dispersion relation-anharmonicity and thermal expansion-specific heat of solids-classical model-Einstein's model-Debye model-thermal conductivity of solids-role of electrons and phonons-thermal resistance of solids.

#### Free electron and band theory (16 hours)

Electrons moving in one dimensional potential well-Fermi-Dirac statistics-effect of temparature on Fermi distribution-electronic specific heat-electrical conductivity of metals-Wiedmann- Franz- Lorentz law-electrical resistivity of metals-Hall effect-energy bands in solids-Kronig- Penny model-construction of Brillouin zones-nearly free electron model-conductors, semiconductors and insulators-elementary ideas of Fermi surfaces

### Unit II

#### Semiconductors (12 hours)

Free carrier concentration in semiconductors-mobility of charge carriers-temperature effects-electrical conductivity of semiconductors-Hall effect in semiconductors - semiconductor junction properties.

## Dielectric and magnetic properties of materials (24 hours)

Dipole moment-polarisation-local electric field in an atom-dielectric constant and its measurement-polarizability-classical theory-Peizo, Pyro and Ferro electric properties of Crystals-Ferreoelectric domains-classification of magnetic materials-atomic theory of magnetism- Langevin's theory-paramagnetism and quantum theory-Weiss molecular exchange field-ferromagnetic domains-anti ferromagnetism-Ferrites.

**Unit III**

## Superconductivity (20 hours)

Experimental attributes to superconductivity-critical temperature, critical current and critical magnetic field of superconductors-effects of magnetic field on superconductors-Type I and II superconductors-intermediate and vortex states-thermal conductivity, specific heat and energy gap in superconductors-microwave and IR properties-coherence length-Theories of superconductivity-London equations-Ginzberg-Landau theory-BCS theory-AC and DC Josephson effects in superconductors- Examples and properties of High Temperature Superconductors.

## Introduction to nano science and technology (16 hours)

Introduction to nanomaterials, properties, classification of nanomaterials, quantum confinement effects, Density of states-nano material preparation techniques-sputtering-chemical vapor deposition-pulsed laser deposition-sol-gel technique-characterization of nano materials-X-Ray diffraction- Scanning Probe Microscopy-atomic force microscopy-SEM and TEM techniques-carbon nano structures-elements of nano electronics.

## Course Outcome

(i) Discuss crystal physics, lattice vibrations, models of thermal properties and band theory of solids.

(ii) Explain the theoretical concepts of semiconductors, dielectric, magnetic and superconducting materials.

(iii) To describe the synthesis and characterization techniques of nanomaterials.

(iv) To apply the concepts in condensed matter physics to meet the challenges.

## Books for study


1. N.W. Ashcroft and N.D. Merwin, *Solid State Physics*, Cenage Learning India (2001)

2. Charles.C. Kittel, *Introduction to Solid State Physics*, Wiley Student Edition (2007)

3. M. Ali Omar, *Elementary Solid State Physics*, Pearson Education Inc (1999)

4. K.K. Chattopahyay, A.N. Banerjee, *Introduction to Nano Science and NanoTechnology*, Prentice Hall of India (2009)

5. Gabor L Hornyak, H F Tibbals and Joydeep Dutta, *Introduction to Nanoscience and Nanotechnology*, CRC press (2009)

## References


1 S.O. Pillai, *Solid State Physics*, Third Edition New Age International Pvt. Ltd (1999).

2. M.A. Wahab, *Solid State Physics*, Narosa Publishing House (1999).

3 R.J. Singh, Solid State Physics, Dorling Kindersley (India) Pvt Ltd (2012).

4 P. Phillips, Advanced Solid State Physics, Second Edn, Cambridge University Press (2012).

## PH 242 NUCLEAR AND PARTICLE PHYSICS (6L, 1T)

**Objectives:** To familiarize the fundamental properties of nucleus, its structure, models, nuclear reactions, nuclear detectors and accelerators. To introduce the concept of elementary particles and their interactions.

### Unit I

**Nuclear forces (10 hours)**

Deuteron-neutron –proton scattering and proton-proton scattering at low energies-non central forces- nuclear exchange force-meson theory of nuclear forces

**Nuclear models (12 hours)**

Detailed studies on liquid drop, shell and collective models of the nuclei.

**Nuclear reactions (14 hours)**

Conservation laws-energetic nuclear reactions-Q value equation-partial wave analysis of nuclear reaction cross section- compound nuclear hypothesis-resonance reactions-Brot-Wigner one level formula-optical model-theory of stripping reactions.

### Unit II

**Nuclear fission (20 hours)**

Mechanism of nuclear fission-calculation of critical energy based on liquid drop model-fission products and energy release-fission chain reactions-neutron cycle and four factor formula-general features and classification of nuclear fission reactors.

**Nuclear fusion (16 hours)**

Nuclear fusion in stellar interiors-proton-proton reactions-carbon-nitrogen cycle-thermo nuclear reactions in the laboratary-conditions for the construction of nuclear fusion reactor-critical ignition temperature-Lawson criterian-plasma confinement in fusion- principles of pinch, magnetic an inertial confinements.

**Unit III**

**Nuclear detectors and particle accelerators (20 hours)**

Gas filled detectors-ionization chamber and proportional counters-GM counter-scintillation detectors-semiconductor detectors- Cerenkov detector-bubble chamber. Particle accelerators-electrostatic accelerators-cyclotron accelerators-synchrotrons-linear accelerators-colliding beam accelerators.

**Elementary particle physics (16 hours)**

Elementary particle interactions-symmetries and conservation laws-quark model of elementary particles-colored quarks and gluons-ideas of charm, beauty and truth-quark dynamics-ideas of grand unified theories of fundamental forces

**Course Outcome**

(i) To describe and analyze nuclear structure, models and reactions.

(ii) To illustrate the mechanisms of nuclear fission and fusion reactions.

(iii) Discuss various nuclear detectors and particle accelerators.

(iv) To classify elementary particles and discuss their interactions.

**Books for study**

1 D.C. Tayal, *Nuclear Physics*, 5th Edition, Himalaya Publishing Co (2008)

2 J. Verma, R.C.Bhandari, D.R.S.Somayajulu, *Fundementals of Nuclear Physics*, CBS Publishers and Distributors (2005).

3. K.S. Krane, *Introductory Nuclear Physics*, Wiley India Pvt. Ltd (1988)

**References**

1 S.B. Patel, Nuclear Physics-An Introduction, New Age International Pvt. Ltd (1996).

2. B.R. Marhu, Nuclear and Particle Physics- an Introduction, Second Edition, Wiley (2012)

3. S.N. Ghoshal, Nuclear Physics, S. Chand Ltd (1997)

4. M.P. Khanna, Introduction to Particle Physics, PHI (2011)

5. J. Freidberg, Plasma Physics and Fusion Energy, Cambridge University Press (2007)

6. FF.Chen, Introduction to Plasma Physics, Springer, London (2002)

## SPECIAL PAPER SYLLABUS: SPECIAL PAPER

## 243 E: ADVANCED ELECTRONICS-II (6L, 1T)

**Objectives:** The course introduces microprocessors and interfacing devices, embedded systems, artificial intelligence and neural networks. It also provides fundamental data communication codes, RADAR and Satellite communications.

### Unit I

**Microprocessor 8086: Introduction and Programming (22 hours)**

Internal architecture of 8086-pin configuration of 8086-memory organization of 8086-addressing modes of 8086-minimum and maximum mode configurations-instructions set of 8086-data movement instructions-arithmetic and logic instructions-programming of 8086-flow charts and programming steps- Simple programs- One's complement of a 16-bit number - BCD to ASCII, ASCII to BCD - addition of 2-16 bit numbers – generation of Fibonacci series.

**Microprocessor interfacing devices and advanced microprocessors (14 hours)**

Programmed I/O –direct memory access-micro controllers-8251A USART-8257 DMA controller-8259A programmable interrupt controller-8279 programmable keyboard/display interface-analog to digital and digital to analog converters-advanced microprocessors-80186/80188 high integration 16-bit microprocessors-80386 and 80386 processors-RISC processors.

### Unit II

**Elements of embedded systems (6 hours)**

Example of an embedded system-processor chips for embedded applications-a simple micro controller using embedded systems-embedded processor families

**Introduction to artificial intelligence and expert systems (20 hours)**

Overview of artificial intelligence (AI)-knowledge representation in AI-problem solving in AI- search methods-predicate and propositional logic-Formal symbolic logic-LISP and PROLOG basics-network representations of knowledge-natural language study in AI-Fuzzy sets and Fuzzy logic- Expert systems-rule based expert systems-nonproduction system architectures- examples of expert systems.

**Artificial Neural Networks (10 hours)**

Basic concepts of artificial neural networks –neural network architectures- neural network systems- ADALINE and MADALINE networks-advantages and disadvantages of artificial neural networks- neural network application domains- basics of neuro fuzzy systems.

**Unit III**

**Radar (12 hours)**

Basic principles of radar-Radar equation-MTI, Pulse and Doppler Radars-Radar signal analysis- ideas of Radar transmitters and receivers-hyperbolic systems for navigation-LORAN and DECCA systems.

**Satellite communications (10 hours)**

Satellite orbits-Geosynchronous satellites-antenna look angles-satellite classifications-spacing and frequency allocations-satellite antenna radiation patterns-satellite system link models – satellite system parameters and link equations.

**Fundamental Concepts of Data Communication (12 hours)**

Data communication codes – Baudot code, ASCII code, EBCDIC code, Bar codes – Code 39, Universal product code, Error control, Error detection- Redundancy checking, Error correction-retransmission, Forward error correction, Character synchronization- Asynchronus serial data and Synchronus serial data, Data communication hardware- Data communication circuits- line control unit- universal synchronous Receiver/Transmitter.

**Course Outcome**

(i) Demonstrate microprocessor architecture, programing and interfacing devices.

(ii) Outline the basic concepts of embedded systems, artificial intelligence and neural networks.

(iii) Illustrate fundamental data communications codes, radar and satellite communication systems.

**Books for study**


1 Sunil Mathur, *Microprocessor 8086-Architecture,Programming and ,Interfacing* PHI learning Pvt Ltd ( 2011)

2. AbishekYadav, *Microprocessor 8085 8086*, University Science Press, New Delhi (2008)

3. Carl Hamacher, Z.G. Vranesic, S.G. Zaky, *Computer organization*, 5th Edition, McGraw Hill Education (2002).

4. B. Ram, *Fundamentals of microprocessors and microcontrollers*, Dhanpat Rai Publications, New Delhi (2016).

5. Robert J Schalkoff, *Artificial Neural Networks*, Mc Graw Hill International Edition (1997).

6. V.S. Janakiraman, K. Sarukesi and P. Gopalakrishnan, *Foundations of Artificial Intelligence and Expert systems*, Macmillan Publishers India Ltd (2011).

7. E.Rich and K.Knight , *Artificial Intelligence*, Second Edition, Tata McGraw Hill Pub Co (2006).

8 W. Tomasi, *Electronic communications systems Fundamentals through Advanced*, Dorling Kinderley (India) Pvt. Ltd (2009).

9. . D.W. Patterson, *Introduction to Artificial Intelligence and Expert Systems*, Prentice Hall of India Pvt Ltd (2001).

10. S. Rajasekharan and G.A. VijalekshmiPai, *Neural Networks Fuzzy logic and Geneticalgorithms*, PHI learning Pvt Ltd (2010).

11.S.N. Sivanandan, S.Sumathi and S.N. Deepa, *Introduction to Fuzzy logic using MATLAB*, Springer (2007).

12. A.Veera Lakshmi and R.Srivel, *Television and Radio engineering*, Ane Books Pvt Ltd (2010)

13. Skolini. M.I, *Introducion to Radar systems*, Third editon, Tata Mc Graw Hill (2001)

14 Nagaraja, *Elements of Electronic navigation*, Second Edition, Tata Mc GrawHill (2006)

## PH 243 M: MATERIALS SCIENCE –II

**Objectives:** This course introduces optical and thermal properties of materials, synthesis of nanostructured materials, its characterization and applications. It also gives elements of nanoelectronics and its applications.

**Unit I**

**Optical and thermal properties (36 hrs)**

Electronic materials and properties- Electrical conductivity-Conductivity of metals and alloys-superconductivity-conduction in ionic materials-semiconductors-Insulators-dielectrics-polarisation in dielectrics-Photonic materials and properties- Electromagnetic spectrum-Reflection, refraction, absorption and transmission-Selective absorption and transmission-Emission phenomenon luminescent and phosphorescent materials Optical Properties of Materials- Absorption, Photo conductivity, General consideration of Luminescence, excitation, absorption and emission processes of luminescence, configuration coordinate diagram, energy level diagram. Radiative and non-radiative processes. Different kinds of Luminescence – Electroluminescence, photoluminescence. Color centers, different kinds of color centers in the context of luminescence in alkali halides Electrostriction-piezoelectricity piezoelectricity and ferroelectricity- Thermoelectric power-Seebeck effect, Peltier effect, and Thomson relation, figure of merit, Concept of phonon, Thermal conductivity due to phonons and electrons, conflicting thermoelectric properties,

**Unit-II**

**Nanostructured materials and properties (36 Hrs)**

Size and dimensionality effects - size effects - potential wells - partial confinement - conduction electrons and dimensionality – quantum well-quantum wires-quantum dots-Fermi gas and density of states- Carbon based nano-materials-Fullerenes-carbon nanotubes- nanoshells- graphene-biological and smart nanomaterials. Properties of nanomaterials - elctrical-optical-mechanical-and thermo dynamical properties. Synthesis of nanomaterials- CVD-Sol-gel-Combustion-hydrothermal- Colloidal growth- nanotube synthesis-Lithographic process-: Lithography, Nanolithography, split gate technology, self-assembly, limitation of lithographic process. Nonlithographic techniques: Plasma arc discharge, sputtering, evaporation. Tools of nanomaterials: X-ray diffraction-FTIR spectroscopy-Raman spectroscopy-Band assignments-UV-Visspectroscopy-Determination of band gap-Tauc's plot – ***For qualitative study only (Non evaluative):*** Scanning probe microscopy-STMAFM- NSOM- Electron Microscopies-TEM-HRTEM and SEM.

**Unit III**

**Nano-electronics (36 Hrs)**

**Introduction to Nanoelectronics**

Properties dependent on density of states - excitons - single-electron tunnelling - applications infrared detectors - quantum dot lasers-. Intrduction to Spintronics-History and overview of spin electronics; Classes of magnetic materials; Quantum Mechanics of spin; Spin relaxation mechanisms; spin relaxation in a quantum dots. Magneto resistance, Ordinary Magneto resistance, Giant Magneto resistance, Colossal Magnetoresistance, Micro-electromechanical systems (MEMSs) and Nano-electro-mechanical systems (NEMSs),

**Qualitative study only (Non evaluative)**

Resonant Tunnelling Diode, Quantum Cascade lasers, Single electron transistor -: Coulomb Blockade, single electron transistor, other SET and FET structures. Molecular Machines, Nano-biometrics- Molecular and Nano-electronics-Microbial Fuel Cells-Hydrogen storage-Nano medicine-Biological applications-Photonic nanocrystals and integrated circuits-Quantum computers Introduction to Spintronics- :Spin Galvanic effect; Spin LEDs: Fundamental and applications, Spin photoelectronic devices, Electron spin filtering, Materials for spin electronics,. Spin-Valve and spin-tunneling devices: Read Heads, MRAMS, Field Sensors, Spintronic Biosensors, Spin transistors, Quantum Computing with spins.

**Course Outcome**

(i) Discuss optical and thermal properties of materials.
(ii) Explain fundamentals of nanostructured materials, synthesis and various characterization techniques.
(iii) Discuss basic ideas and applications of nanoelectronics.

**Reference Books**


1. M.S. Ramachandra Rao, Shubra Singh, Nanoscience and Nanotechnolgy, Fundamentals to Frontiers, Wiley 2017,
2. Thermoelectrics: Basic Principles and New Materials Development, by G.S. Nolas, J. Sharp, H.J. Goldsmid, Springer, 2001
3. Introduction to Thermoelectricity, by H. Hulian Goldsmid, Springer, 2010
4. Nano The Essential-T Pradeep; Mc Graw Hill Education
5. The Science and Engineering of Materials: Donald R Askeland and Pradeep P Phule 6 Edition- Thomson Brooks/Cole.
6. Guozhong Cao Nano Structures and Nano materials , Synthesis Properties and Applications.
7. Principles of Electronic Materials and Devices , S.O.Kasap .Tata Mc Graw Hill
8. Crystallography and crystal defects, A. Kelley, G.W. Groves & P. Kidd, Wiley
9. Crystallography applied to Solid State Physics, A.R. Verma, O.N. Srivastava, NAI
10. Solid State Physics, A.J.Dekker, Macmillan, (1967).
11. Solid State Physics, S.L. Gupta and V.Kumar, Pragati Prakashan.
12. Introduction to Theory of Solids, H.M. Rosenberg, Prentice Hall.
13. Solid State Physics,J.S. Blakemore, W.B.Saunders & Co. Philadelphia.
14. Solid State Physics, N.W. Ashcroft & N.D. Mermin, Brooks/ Cole (1976).
15. Crystal Defects and Crystal Interfaces, W. Bollmann, Springer Verlag.
16. Elementary solid State physics M.Ali Omar-Pearson
17. Solid State Physics R.J.singh-Pearson
18. Introduction to Nanotechnology, Charles P. Poole, Jr. and Frank J.Owens, Wiley, (2003) 92
19. Nanotechnology An Introduction to Synthesis properties and Applications of Nanomaterials: Thomas Varghese and K.M.Balakrishna-Atlantic Publishers.
20. MEMS/NEMS: micro electro mechanical systems/nano electro mechanical systems Volume1, Design Methods, Cornelius T.Leondes, Springer, (2006).

21. Mick Wilson, Kamali Kannangara, Geoff Smith, Michelle Simmons and Burkhard Raguse "Nanotechnology", Overseas Press New Delhi ( 2005).

22 W. R. Fahrner (Ed.) "Nanotechnology and Nanoelectronics", Springer 2006. S. Bandyopadhyay,

M. Cahay

**PH 243 N: RADIATION PHYSICS (6L, 1T)**

Objectives: The course covers the interaction of radiation with matter, radioactivity, its detection, its measurement and radiation exposure and biological effects of radiation.

**Unit –I**

**Interaction of radiation with matter (36 hours)**

Ionizing radiations, terrestrial sources, extraterrestrial sources, non-ionizing radiations, natural and man-made sources, interaction of radiation with matter, energy loss rate, bremsstrahlung, range energy relation, stopping power, photoelectric absorption, Compton scattering, pair production, properties of gamma gays and neutrons.

Particle flux and fluence, Energy flux and fluence, Cross section, Linear and mass attenuation coefficients, Mass energy transfer and mass energy absorption coefficients, Stopping power – Linear Energy Transfer (LET) - Weighing Factors(W-values), Radiation and tissue weighting factors, absorbed dose- equivalent dose, effective dose, committed equivalent dose, committed effected dose – Concept of KERMA (Kinetic Energy Released per unit Mass)

**Unit II**

**Radioactivity, detection and dosimetry (36 hours)**

Law of radioactive decay, half- life, mean life, specific activity, successive disintegration, radioactive equilibriums, age of minerals and rocks, α-decay: barrier penetration, range energy relationship, β decay: Fermi theory, parity violation, Kurie-plot, γ-decay, radiative transitions in nuclei, selection rules.

Thermo luminescent Dosimeters (TLD) – Optically stimulated Luminescence dosimeters (OSLD) –Neutron Detectors – Nuclear track emulsions for fast neutrons – Solid State Nuclear track (SSNTD) detectors, Radon dosimetry, Instruments for personnel monitoring – TLD badge readers – Digital pocket dosimeters using solid state devices and GM counters - Contamination monitors for alpha, beta and gamma radiation – Scintillation monitors for X and gamma radiations - Neutron Monitors, Tissue equivalent survey meters – Flux meter and dose equivalent monitors – Pocket neutron monitors

**Unit III**

**Biological effects of radiation (36 hours)**

Somatic effects of radiation – Physical factors influencing somatic effects – Dependence on dose, dose rate, type and energy of radiation - Acute radiation sickness – Effects of chronic exposure to radiation – Induction of leukemia – Radiation Carcinogenesis – Risk of carcinogenesis – Genetic effects of radiation – Factors affecting frequency of radiation induced mutations – Dose-effects relationship- first generation effects – Effects due to mutation of recessive characteristics – Genetic burden – Prevalence of hereditary diseases and defects – Spontaneous mutation rate – Concept of doubling dose and genetic risk estimate.

**Course Outcome**

(i) To discuss sources of radiation, its interaction with matter and its measurement.

(ii) To illustrate radioactive decay and various measurements techniques used.

(iii) To list and discuss biological effects of radiation.

**Books for study**

1. G.F. Knoll, *Radiation detection and Measurement*, John Wiley & Sons, 2000
2. K. Thayalan, *Basic Radiological Physics*, Jaypee brothers medical publishers, New Delhi,2003
3. Alan Martin and Samuel A. Harbison, *An Introduction to Radiation Protection*, Third edition, Chapman and Hall, New York 1986

**References**

1. R.R. Roy & B P Nigam, Nuclear Physics Theory and Experiments, Wiley Eastern, 2000
2. UNSCEAR Report, United Nations Scientific Committee on the Effects of Atomic Radiation, 2008.

## PH 243 S: ADVANCED ASTROPHYSICS (6L,1T)

**Objectives:** This course describes general features of observational astronomy, ideas of stellar evolution, galactic physics and elements of cosmology.

### UNIT I

### General features of observational astronomy (36 hours)

Emergence of modern astronomy - Astronomy in different bands of electromagnetic radiation. Celestial co-ordinates – Spherical coordinates – Altazimuth system – Local equatorial system – universal equatorial system – Ecliptic system – Galactic coordinates – conversion of coordinates. Apparent luminosity of stars – measurement of apparent luminosity –various magnitude systems – correction for apparent magnitude. Stellar distances and absolute luminosities – measurement of distances within the solar system – trigonometric parallaxes of stars – method of measurement of luminosity -. surface temperature of stars – spectral classification of stars-stellar magnetic fields.

### UNIT II

### Stellar physics and Stellar evolution (36 hours)

Theory of radiative transfer – Radiative transfer equation – Thermodynamic equilibrium – radiative transfer through stellar atmosphere – formation of spectral lines-Basic equation of stellar structure – Hydrostatic equilibrium in stars – Virial theorem – energy transport inside

stars – convection inside stars – stellar models – some relations among stellar quantities – determination of stellar parameters – main sequence – red giants and white dwarfs

Nucleosynthesis and Nuclear reactions in stars – calculation of nuclear reaction rates – Important nuclear reactions in stellar interiors – Helioseismology – solar neutrino experiments – Stellar evolution – Evolution of binary systems – mass loss from stars – stellar winds-Stellar collapse – Degeneracy pressure of Fermi gas – structure of white dwarfs – Chandrasekhar limit – neutron stars – pulsars – binary X – ray sources. Accretion disks.

### Unit III
### Galactic Physics and elements of Cosmology (36 hours)

Normal galaxies – morphological classification - physical characteristics and kinematics – expansion of the universe – active galaxies – super luminal motion in quasars – black hole as central engine – unification scheme – cluster of galaxies – large scale distribution of galaxies – gamma ray bursts.

Space time dynamics of the universe – general relativity – the metric of the universe – Friedman equation for the scale factor – cosmic background radiation – evolution of matter dominated universe – evolution of radiation dominated universe- Primordial nucleo synthesis – cosmic neutrino background – nature of dark matter.

## Course Outcome

(1) Explain general features of observational astronomy.
(2) Describe the formation of stars and stellar structure.
(3) Explain origin of various galaxies.

References


1. Abhyankar K. D. - Astrophysics Stars and Galaxies, Universities Press.
2. Arnab Rai Choudhuri - Astrophysics for Physicists, Cambridge University Press.
3. Padmanabhan T. – Theoretical Astrophysics, Cambridge University Press.
4. Narlikar J. B - Introduction to Cosmology, Cambridge University Press.

**PH 243 T; THEORETICAL PHYSICS – II (6L, 1T)**

**Objectives:** To familiarize with the concepts of advanced theoretical physics covering functional and path integrals in quantum mechanics, theory of many particle systems and critical phenomenon.

**Unit I**

**Functional Integrals in Physics (36 hours)**

**Functionals**

Function vs functional, functional derivatives, functional integration, Gaussian integrals.

**Path integrals in quantum mechanics**

Single particle systems- Feynman path integral, propagator as a functional integral, Born approximation, Coulomb scattering.

Many particle systems - Second quantization, coherent states and many-body path integrals, field integral for the quantum partition function.

Quantum Fields - Path integrals for fields, functionals for bosonic and fermionic fields, generating functions for free and interacting fields, Wick's theorem, Perturbation theory.

**Unit II**

**Many particle physics (36 hours)**

**Broken symmetry and collective phenomena**

Mean field theory, Bose-Einstein condensation and superfluidity, superconductivity, interacting electron gas and disorder

**Response functions**

Linear response theory, analytic structure of correlation functions, electromagnetic linear response

**Unit III**

**Critical phenomena (36 hours)**

Continuous phase transitions, critical behavior, scaling, renormalization group, Ising model, RG analysis of ferromagnetic transition.

**Course Outcome**

(i) Describe functional and path integrals in quantum mechanics.
(ii) Discuss theory of many particle systems and critical phenomenon.

**References**

1. F. Scheck, Quantum Physics, Springer (2007).
2. G. Teschl, Mathematical Methods in Quantum Mechanics,

American Mathematical Society (2009).
3. P. Szekeres, Modern Mathematical Physics, Cambridge University Press (2004).
4. M. T. Vaughn, Introduction to Mathematical Physics, Wiley - VCH Verlag (2007).
5. Arfken, Mathematical Physics for Physicists, Academic Press (2013).
6. J. J. Sakurai, Modern Quantum Mechanics, Addison-Wesley Publishing Company (1994).
7. L. I. Schiff, Quantum Mechanics, McGraw-Hill Book Co. (1968).
8. L. H. Ryder, Quantum Field Theory, Cambridge University Press (2008).
9. J. J. Sakurai, Advanced Quantum Mechanics, Addison-Wesley (1967).
10. M. Le Bellac, Quantum and Statistical Field Theory, Oxford University Press (2001).
11. K. Schulten and I. Kosztin, Lectures in Theoretical Biophysics, University of Illinois at Urbana-Champaign (2000).
12. R. Kubo, M. Toda and N. Hashitsume, Statistical Physics II: Non equilibrium Statistical Mechanics, Springer-Verlag (1985).
13. G. F. Mazenko, Non equilibrium Statistical Mechanics, Wiley-VCH Verlag (2006).
14. V. Balakrishnan, Elements of Non equilibrium Statistical Mechanics, CRC Press (2008).
15. B. F. Schutz, A First course in General Relativity, Cambridge University Press (2009).
16. S. Caroll, Space time and Geometry: An Introduction to General Relativity, Addison-Wesley (2004).
17. A. Altland and B. Simons, Condensed Matter Field Theory, Cambridge University Press (2008).
18. J. W. Negele and H. Orland, Quantum Many-particle Systems, Levant Books (2006).
19. E. Fradkin, Field Theories of Condensed Matter Systems, Levant Books (2006).
20. P. M. Chaikin and T. C. Lubensky, Principles of Condensed Matter Physics, Cambridge University Press (2004).
21. A. M. Tsvelik, Quantum Field Theory in Condensed Matter Physics, Cambridge University Press (2003).
22. R. Shankar, Principles of Quantum Mechanics, Springer (1994).
23. L. E. Ballentine, Quantum Mechanics, World Scientific Publishing Co. (2000).

## PH 251: GENERAL PHYSICS PRACTICALS

**Objectives:** Demonstrate and understand various general physics experiments for acquiring fundamental concepts.

(Total of 10 experiments to be done from Section A and B)

**Section A** *(atleast 5 experiments to be done in this section)*

1. Determination of elastic constants by Cornu's method (elliptical and hyperbolic fringes)

2. Analysis of absorption spectra of liquids using spectrometer

3. Study of ultrasonic waves in liquids

4. Determination of e/k using Ge and Si transistors

5. Anderson Bridge –determination of self and mutual inductance

6. Michelson Interferometer experiments

7. Identification of Fraunhofer lines in solar spectra

8. Verification of Richardson's equation using diode valve

9. LED experiments (a) wavelength determination (b) I-V characteristics (c) output power variations with applied voltage etc.

10. Thermal diffusivity of brass

**Section B (at least 2 experiments to be done from this section)**

1. BH curve-anchor ring

2. Study of photoelectric effect and determination of of Planck's constant

3. Determination of Stefan's constant

4. Experiments using Laser:

(a) Laser beam characteristics (b) Diffraction grating (c) Diffraction at different types of slits and apertures (d) refractive index of liquids (e) particle size determination

5. Young's modulus of different materials using strain gauge

6. Determination of magnetic force in a current carrying conductor

7. Optical fibre characteristics – numerical aperture, attenuation and bandwidth of given specimen.

8. Variation of dielectric constant with temperature of ferroelectric material.
9. Dielectric constant of non-polar liquid.
10. Cauchy's constants of liquids and liquid mixtures using hollow prism and spectrometer

11. Surface tension of a liquid using Jaeger's method

12. Experiments using Phoenix Kit

    (a) Capacitor charging/discharging experiments (b) Dielectric constant of glass

**Course Outcome**

(i) To measure and analyze various physical quantities.
(ii) To calculate error in various general physics experiments.
(iii) To develop experimental skills

**PH 252 Electronics and Computer Science Practicals**

**Objectives:** Design, construct and verify various electronics circuits and object oriented programing using C++ to solve numerical problems.

## Unit I – Electronics Experiments (A total of 10 experiments to be done)

### Section A (*atleast 5 experiments to be done*)

1. Single stage CE amplifier –Design and study of frequency response
2. Study of RC Phase shift oscillator circuits using Transistors
3. Construction and study of astable multivibrator and VCO circuits using Transistors
4. Study of OP Amp circuits (a) summing amplifier (b)difference amplifier
5. OP Amp as an integrator and differentiator
6. Characteristics of JFET and MOSFET
7. Characteristics of SCR
8. Design and study of negative feedback amplifier circuits
9. Study of Clipping and Clamping circuits
10. UJT Characteristics and UJT relaxation Oscillator

### Section B (atleast 3 experiments to be done)

1. Emitter follower and source follower circuits
2. Weinberg oscillator using OP Amp
3. SR and JK Flip Flops -construction using Logic Gates and study of truth tables
4. Study of the frequency response of a tuned amplifier
5. Study of power amplifier circuits
6. Frequency multiplier using PLL

7 Study of Schmitt trigger circuits using transistors

8. Construction and study of cascade amplifier circuit using transistors.
9. Simple electronics experiments using Phoenix and Python based Kits.

**Unit II Computer Programming**

(*A minimum of 8 experiments to be done, programs should be written in C/C++ language*

1. Least square fitting

2. First derivative of tabulated function by difference table

3. Numerical integration (Trapezoidal rule and Simpson method)

4. Solution of algebraic and transcendental equations using Newton-Ralphson method

5. Solution of algebraic equations using bisection method

6. Numerical interpolation using Newton and Lagrangian methods

7. Monte Carlo simulation

8. Evaluation of Bessel and Legendre functions

9. Matrix addition, multiplication, trace, transpose and inverse.

10. Fourier series analysis

11. Study of motion of projectile in a central force field

12. Study of Planetary motion and Kepler's laws

**Course Outcome**

(i) To design and construct various electronic circuits and its validation.
(ii) To calculate error in various electronics experiments.
(iii) To develop experimental and programming skills

## PH 261 Advanced Physics Practicals

Objectives: Demonstrate and understand various advanced physics experiments for acquiring fundamental concepts and analyze various experimental data.

(*A total of 10 experiments to be done*)

### Unit I: Physics experiments

**Section A** (*atleast 5 experiments to be done*)

1. e/m of an electron-Thompson's method
2. Charge of an electron-Millikan's method
3. Determination of Fermi energy of Copper
4. Study of variation of resistance of a semiconductor with temperature and determination of band gap
5. Magnetic Susceptibility of a liquid using Quincke's method
6. Ferromagnetic studies using Guoy's method
7. Hall effect in a semiconductor
8. Rydberg constant determination using grating, spectrometer and discharge tubes.
9. Thermo-emf of bulk samples like Al, Cu. Brass etc.
10. Zeeman effect using Fabry-Perot Interferometer.

**Section B** (*at least two experiments to be done*)

1. Electrical characteristics of a solar cell
2. Studies using UV visible spectrophotometer
3. Refractive index of liquids and liquid mixtures using Abbe's refractometer
4. Optical activity studies using Polarimeters
5. Determination of temperature characteristics of a Flame

(a) Candle flame using digital photography and image analysis

(b) Sodium flame in comparison with incandescent lamp using a spectrometer

6. LDR and photodiode characteristics

7. Simple experiments using GM counter

8. Determination of dielectric constant of materials

9. Experimental determination of Avogadro's number using an electrochemical cell

10 Study of arc spectra and hydrogen spectra using an imager (CCD) and photoelectric/electronic recorder.

**Unit II: Data Analysis** *(Five experiments to be done)*

1. Analysis of the given band spectrum

2. Analysis of given rotation-vibration spectrum

3. Interpretation vibration spectra of simple molecules using Raman and IR spectra

4. Dissociation energy of diatomic molecules

5. Analysis of powder XRD data

6. Study of stellar spectral classification from low dispersion stellar spectra

7. Study of HR diagram of stars

8. Radioactive material counting statistics

9. Interpretation of UV- visible spectra of materials

10. Weather and astronomy related image processing

**Course Outcome**

(i) To measure and analyze various physical quantities.
(iii) To calculate error in various advanced physics experiments.
(iii) To develop experimental skills
(iv) To analyze and point out results of experimental data.

## PH 262 E Advanced Electronics Practicals

Objectives: Design, construct and study various electronics circuits and programing using microprocessor.

### Unit I- ELECTRONICS (*a total of seven experiments to be done*)

#### Section A (*at least 5 experiments to be done*)

1. Study of active filters using OP amps (a) low pass (b) high pass (c) band pass for both first order and second order-gain/ roll off determination

2. Wave form generation using OP amp circuits:

   (a) astable and monostable multivibrators (b) square, triangular and saw-tooth wave generation

3. IC 555 timer experiments (a) monsostable and astable multivibrators (b) VCO

4. D/A convertor circuits using OP Amp 741

5. Differential amplifier circuits using transistors

6. Design of series pass voltage regulators using
   (a) transistors with load and line regulation (b) OP Amp

#### Section B (at least 2 experiments to be done)

1 Study of IF tuned amplifier and Amplitude modulation (generation and detection) using transistor, diode etc.

2. Frequency modulator and detector circuits.

3. Pulse modulation circuits using 555 timer (a) PAM (b) PWM

4. Digital modulation circuits (a) BFSK generation using 555 timer (b) BFSK detector using 555 timer and PLL (c) BPSK generation

5. Shift register and ring counter circuits using flip flops

6. Miscellaneous transistor applications (a) automatic night light with LDR

   (b) invertor circuit (transistors as a switch) (c) time delay circuit using SCR

7. BCD to decimal decoder and seven segment display using IC 8

8. Design of Electronic counters (up and down counters)

**Unit II: Microprocessor Based Experiments**

(*Five experiments to be done*)

1. 8085 /8086 program to find out largest from a group of 8bit/16 bit numbers
2. Square wave generation using 8255A interface using 8085/8086
3. 8086 program for block additions
4. Interfacing LED display board with 8085/8086
5. 8086 program to convert binary to ASCII and ASCII to BCD
6. 8086 program to arrange a given data in ascending and descending order
7. 8086-simple traffic light controller
8. 8086 program for binary to BCD conversion and vice versa
9. Program of Fibonacci series using 8086

**Course Outcome**

(i) To design and construct various electronic circuits and its validation.
(ii) To calculate error in various electronics experiments.
(iii) To develop and test assembly language programs using microprocessors

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