# CBCS Syllabus

# for

# B.Sc. Physics

## Ramakrishna Mission Vivekananda Centenary College

**Rahara, Kolkata – 700118**

**Approximately 15% of contents have been revised in this syllabus as per BoS resolution dated 5th November, 2021.**

**2021**

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| **Contents added** | |
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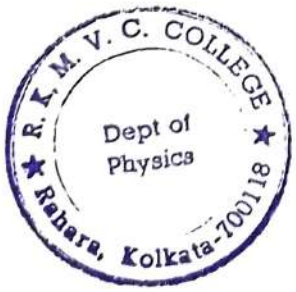

## B. Sc. Physics Syllabus Revision in 2021**

| Course Code | Course Name | Added (%) | Modified (%) | Total Change (%) |
|---|---|---|---|---|
| UGPHYCC01 | Mathematical Physics - I | 10 | 40 | 50 |
| UGPHYCC02 | Mechanics | 5 | 15 | 20 |
| UGPHYCC03 | Electricity and Magnetism | 0 | 0 | 0 |
| UGPHYCC04 | Waves and Optics | 0 | 0 | 0 |
| UGPHYCC05 | Mathematical Physics - II | 0 | 0 | 0 |
| UGPHYCC06 | Thermal Physics | 0 | 0 | 0 |
| UGPHYCC07 | Digital Systems and Applications | 0 | 0 | 0 |
| UGPHYCC08 | Mathematical Physics - III | 0 | 0 | 0 |
| UGPHYCC09 | Elements of Modern Physics | 0 | 0 | 0 |
| UGPHYCC10 | Analog Systems and Applications | 0 | 0 | 0 |
| UGPHYCC11 | Quantum Mechanics and Applications | 0 | 0 | 0 |
| UGPHYCC12 | Solid State Physics | 0 | 0 | 0 |
| UGPHYCC13 | Electromagnetic Theory | 0 | 0 | 0 |
| UGPHYCC14 | Statistical Mechanics | 0 | 0 | 0 |
| UGPHYDSE01 | Advanced Mathematical Physics - I | 20 | 60 | 80 |
| UGPHYDSE02 | Advanced Dynamics | 0 | 80 | 80 |
| UGPHYDSE03 | Communication Electronics | 0 | 0 | 0 |
| UGPHYDSE04 | Advanced Mathematical Physics - II | 20 | 60 | 80 |
| UGPHYDSE05 | Nuclear and Particle Physics | 0 | 0 | 0 |
| UGPHYDSE06 | Nano Materials and Applications | 0 | 0 | 0 |
| UGPHYDSE07 | Dissertation / Project work | 0 | 100 | 100 |
| UGPHYSEC01 | Value Education and Indian Culture | 0 | 0 | 0 |
| UGPHYSEC02 | Spoken Tutorial | 0 | 0 | 0 |
| UGPHYGE01 | Mechanics | 0 | 0 | 0 |
| UGPHYGE02 | Thermal Physics and Statistical Mechanics | 0 | 0 | 0 |
| UGPHYGE03 | Waves and Optics | 0 | 0 | 0 |
| UGPHYGE04 | Electricity and Magnetism | 0 | 0 | 0 |
| **Average of all courses (Approx.)** | | **2%** | **13%** | **15%** |

** Note: 60% weightage on Theory and 40% weightage on Practical for calculation purpose

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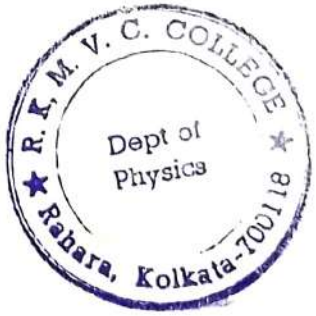
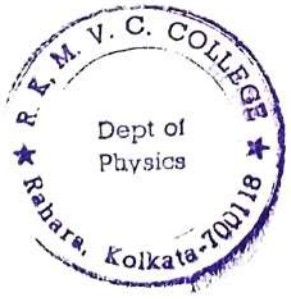
# Contents



# 1. Scheme of CBCS Curriculum



## 1.1. Basic Courses Types under CBCS

In CBCS there are some basic types of courses. The ones that are relevant to the B.Sc. curricula have been described below.

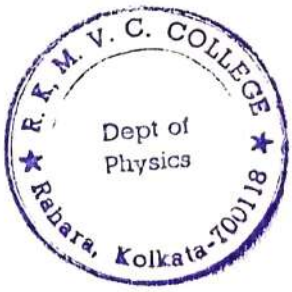
1) **Core Course (CC)**: A *discipline specific compulsory* basic course.

2) **Discipline Specific Elective Course (DSE)**: A *discipline specific elective* course which is more advanced or specialized.

3) **Generic Elective Course (GEC)**: An *inter-disciplinary elective* course to be opted from a discipline other than one main discipline(s) of choice (e.g., a course in a discipline other than in which honours has been taken).

4) **Skill enhancement Course (SEC)**: A *discipline specific elective* skill enhancement course.

5) **Ability Enhancement Compulsory Course (AECC)**: These are *compulsory* courses. There are two of them. AECC-1 is Communicative English / Modern Indian Language & AECC- 2 is Environmental Science.



## 1.2. Credit Structure & Classes

In CBCS, all courses have credits assigned to them. For any course, one of the three modes of teaching:

**(a)** Theory + Practical

**(b)** Theory + Tutorial

**(c)** Theory only will be used.

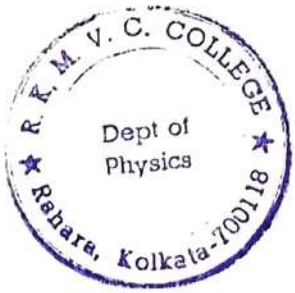
The credit structure is described below:

| Course Type | Theory + Practical | | Theory + Tutorial | | Vocational or Theory | Total Credit |
|---|---|---|---|---|---|---|
| | Theory | Practical | Theory | Tutorial | | |
| CC | 4 | 2 | 5 | 1 | -- | 6 |
| DSE | 4 | 2 | 5 | 1 | -- | 6 |
| SEC | -- | -- | -- | -- | 2 | 2 |
| GE | 4 | 2 | 5 | 1 | -- | 6 |
| AECC | -- | -- | -- | -- | 2 | 2 |

**Duration of the Semesters :** The semesters will comprise **15 weeks of direct teaching.**

**Class Assignments :** The class assignment for different course segments (theory, practical, tutorial) are as follows:

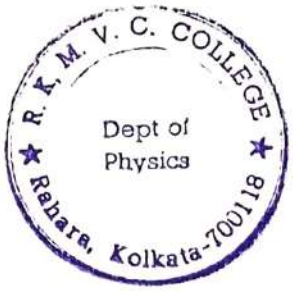
- **Theory : 1 credit = 1 hour / week**
- **Practical : 1 credit = 2 hours / week**
- **Tutorial : 1 credit = 1 hour / week**



## 1.3. B.Sc. Honours – Semester wise Courses

The number of courses to be taken in the different semesters have been specified in the table below.

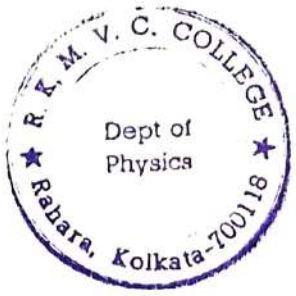
| | Number of courses | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **Sem-I** | **Sem-II** | **Sem-III** | **Sem-IV** | **Sem-V** | **Sem-VI** | **Total** | **Credits** |
| **CC** | 2 | 2 | 3 | 3 | 2 | 2 | 14 | 14×6 = 84 |
| **DSE** | -- | -- | -- | -- | 2 | 2 | 4 | 4×6 = 24 |
| **SEC** | -- | -- | 1 | 1 | -- | -- | 2 | 2×2 = 4 |
| **GE** | 1 | 1 | 1 | 1 | -- | -- | 4 | 4×6 = 24 |
| **AECC** | 1 | 1 | -- | -- | -- | -- | 2 | 2×2 = 4 |
| **Total** | 4 | 4 | 5 | 5 | 4 | 4 | **26** | **140** |



## 1.4. List of Core Courses (CC)

| Sl. No. | Course Code | Course Name | Semester |
|---|---|---|---|
| 1. | UGPHYCC01 | Mathematical Physics - I | SEM-I |
| 2. | UGPHYCC02 | Mechanics | |
| 3. | UGPHYCC03 | Electricity and Magnetism | SEM-II |
| 4. | UGPHYCC04 | Waves and Optics | |
| 5. | UGPHYCC05 | Mathematical Physics - II | SEM-III |
| 6. | UGPHYCC06 | Thermal Physics | |
| 7. | UGPHYCC07 | Digital Systems and Applications | |
| 8. | UGPHYCC08 | Mathematical Physics - III | SEM-IV |
| 9. | UGPHYCC09 | Elements of Modern Physics | |
| 10. | UGPHYCC10 | Analog Systems and Applications | |
| 11. | UGPHYCC11 | Quantum Mechanics and Applications | SEM-V |
| 12. | UGPHYCC12 | Solid State Physics | |
| 13. | UGPHYCC13 | Electromagnetic Theory | SEM-VI |
| 14. | UGPHYCC14 | Statistical Mechanics | |

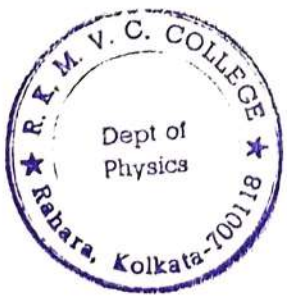
**Note:**
*All of these courses are mandatory for Physics Honours students.*



## 1.5. List of Discipline Specific Elective (DSE) Courses

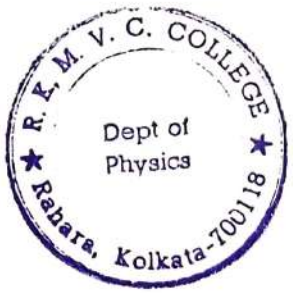
| Sl. No. | Course Code | Course Name | Semester |
|---|---|---|---|
| 1. | UGPHYDSE01 | Advanced Mathematical Physics - I | SEM-V |
| 2. | UGPHYDSE02 | Advanced Dynamics | |
| 3. | UGPHYDSE03 | Communication Electronics | |
| 4. | UGPHYDSE04 | Advanced Mathematical Physics - II | SEM-VI |
| 5. | UGPHYDSE05 | Nuclear and Particle Physics | |
| 6. | UGPHYDSE06 | Nano Materials and Applications | |
| 7. | UGPHYDSE07 | Dissertation / Project work | |

**Note:**
*Any two are to be selected in SEM-V and any two from the rest are to be selected in SEM-VI*



## 1.6. List of Skill Enhancement Courses (SEC)

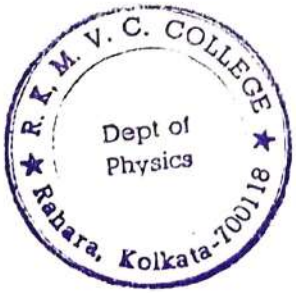
| Sl. No. | Course Code | Course Name | Semester |
|---|---|---|---|
| 1. | UGPHYSEC01 | Value Education and Indian Culture | SEM-III |
| 2. | UGPHYSEC02 | Spoken Tutorial | SEM-IV |



## 1.7. List of Generic Elective (GE) Courses

| Sl. No. | Course Code | Course Name | Semester |
|---|---|---|---|
| 1. | UGPHYGE01 | Mechanics | SEM-I |
| 2. | UGPHYGE02 | Thermal Physics and Statistical Mechanics | SEM-II |
| 3. | UGPHYGE03 | Waves and Optics | SEM-III |
| 4. | UGPHYGE04 | Electricity and Magnetism | SEM-IV |

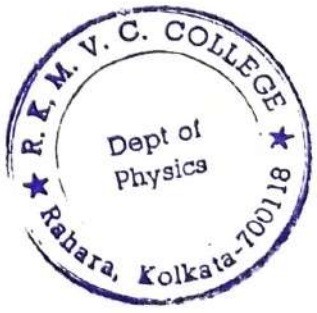
**Note:**
*To be selected by the students other than Physics Honours.*



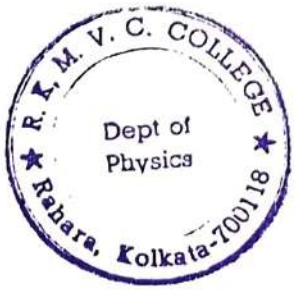
## 1.8. Semester wise course distribution (B. Sc., Physics)

| Semester | Course Code | Course Name | Credit | Total Credit |
|---|---|---|---|---|
| SEM-I | UGPHYCC01 | Mathematical Physics - I | 6×1 | 20 |
| | UGPHYCC02 | Mechanics | 6×1 | |
| | UGPHYGE01* | Mechanics | 6×1 | |
| | UGPHYAECC01 | English Communication | 2×1 | |
| SEM-II | UGPHYCC03 | Electricity and Magnetism | 6×1 | 20 |
| | UGPHYCC04 | Waves and Optics | 6×1 | |
| | UGPHYGE02* | Thermal Physics and Statistical Mechanics | 6×1 | |
| | UGPHYAECC02 | Environmental Science | 2×1 | |
| SEM-III | UGPHYCC05 | Mathematical Physics - II | 6×1 | 26 |
| | UGPHYCC06 | Thermal Physics | 6×1 | |
| | UGPHYCC07 | Digital Systems and Applications | 6×1 | |
| | UGPHYSEC01 | Value Education and Indian Culture | 2×1 | |
| | UGPHYGE03* | Waves and Optics | 6×1 | |
| SEM-IV | UGPHYCC08 | Mathematical Physics - III | 6×1 | 26 |
| | UGPHYCC09 | Elements of Modern Physics | 6×1 | |
| | UGPHYCC10 | Analog Systems and Applications | 6×1 | |
| | UGPHYSEC02 | Spoken Tutorial | 2×1 | |
| | UGPHYGE04* | Electricity and Magnetism | 6×1 | |
| SEM-V | UGPHYCC11 | Quantum Mechanics and Applications | 6×1 | 24 |
| | UGPHYCC12 | Solid State Physics | 6×1 | |
| | DSE | **Any two** are to be opted (Ref: Table-1.5) | 6×2 | |
| SEM-VI | UGPHYCC13 | Electromagnetic Theory | 6×1 | 24 |
| | UGPHYCC14 | Statistical Mechanics | 6×1 | |
| | DSE | **Any two** are to be opted (Ref: Table-1.5) | 6×2 | |
| | | **Total Credit (Full Program)** | | **140** |

** For other than Physics Honours students.*



# 2. Programme Outcomes (POs) & Programme Specific Outcomes (PSOs)



## 2.1. Programme Outcomes (POs)

After completion of the B.Sc. Degree program, the students will be able to

| PO No. | Program Outcomes | Cognitive Level |
|---|---|---|
| PO-1 | Recognize the scientific tempers and attitudes, which in turn can prove to be beneficial for the society since the scientific developments can make a nation or society to grow at a rapid pace. | R |
| PO-2 | Understand scientific knowledge and exchange ideas with other stakeholders; make people aware about sustainable utilization of resources with ethical approach. | U |
| PO-3 | Understand and apply the issues of environmental contexts and sustainable development as a basic interdisciplinary concern. | U, Ap |
| PO-4 | Create the ability to perform experiments and to analyse& interpret the obtained accurate results and thus gain the ability to solve problems, to involve in critical, independent, and creative thinking. | An, E, C |
| PO-5 | Possess expertise to apply and formulate ideas which will provide them competitive advantage in pursuing higher studies from India or abroad; and seek jobs in academia, research or industries. | Ap, E |
| PO-6 | Assemble the acquired in-depth knowledge of applied subjects towards the inculcation of professional and employment skills so that students can make a career and become an entrepreneur in diverse fields. | C |

R= remembering, U = understanding, Ap = applying, An = analysing, E = evaluating, and C = creating

## 2.2. Programme Specific Outcomes (PSOs)

After completion of the B.Sc. degree program in Physics, the students will be able to

| PSO No. | Program Specific Outcomes | Cognitive Level |
|---|---|---|
| PSO-1 | Remember basic laws of physics and have clear understanding in diverse premises of physics. | R, U |
| PSO-2 | Apply conceptual understanding of basic laws & principles of physics to analyze variety of physical phenomena of general real-world problems. | U, Ap, An |
| PSO-3 | Understand, analyze and evaluate the impact of physics in the domain of interdisciplinary science. | U, An, E |
| PSO-4 | Construct simple experimental set-ups to acquire better understanding. Inspect and design various electronic & electrical devices for domestic, engineering, medical and/or laboratory need. | An, C |
| PSO-5 | Apply computational methods in solving problems in physics and other related areas. Build up numerical models for physical processes. | Ap, C |

R= remembering, U = understanding, Ap = applying, An = analysing, E = evaluating, and C = creating

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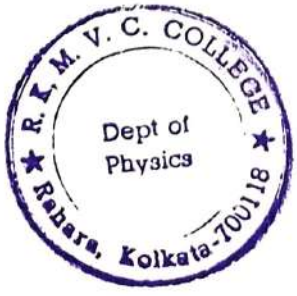
# 3. Syllabi for Core Courses (Honours)



| 3.1. Mathematical Physics – I | | | |
|---|---|---|---|
| Core Course | Course Code : UGPHYCC01 | Course Credit : 6 | SEM-I |

Content added/modified = 50%

**Course objectives**

1) To understand and apply mathematics as a tool in physical sciences.
2) Remember vector identities and apply vector algebra and calculus to analyze various physical systems.
3) Gain ability to write down computer program to solve physical problems.

| Mathematical Physics - I (Theory) | | |
|---|---|---|
| Paper: UGPHYCC01 (Theory) | Credits: 4 | Course duration: 60 Lectures. |

- **Function of a Single Variable (real)** **(04 Lectures)**
  Limit, continuity and differentiability. Example of finite, infinite and removable discontinuity.Curve plotting. Conditions of maxima and minima - illustrations with examplesfrom physics (e.g.,Fermat's principle).

- **Infinite Sequence and Series** **(05 lectures)**
  Converging and Diverging sequences – a few illustrative examples. Infinite series: Examples of Geometric, Harmonic and Telescopic series. Convergent and Divergent series: Test of convergence – Ratio test, Comparison test, Integral test and Root test. Alternating series, its absolute convergence.

- **Power series representation of functions** **(03 lectures)**
  Taylor series and expansion of trigonometric, exponential and logarithimic functions and their convergence. Binomial expansion for negative and non- integer exponent.

- **Ordinary Differential Equations (ODE)** **(08 lectures)**
  Linear first order and second order differential equations with constant coefficients. Homogeneous and inhomogeneous ODEs. General and particular solutions. Wronskian and linear independence of general solutions or a set of functions. Illustrative physical problems.

- **Calculus of functions of more than one variable** **(04 lectures)**
  Partial derivatives. Exact and inexact differentials, Integrating factors with simple illustrative examples.Constrained optimization with Lagrange's multiplier.

- **Matrices as Linear Transformation** **(06 lectures)**
  Recapitulation - addition, subtraction, multiplication of matrices; Trace, Determinant and Inverse of matrix. Rotation matrix in two dimension - orthogonal matrices. Eigen value equations involving matrices – eigen value and eigen vectors, linear independence and closure properties of eigen vectors. Definition of Hermitian and Unitary matrices.

- **Recapitulation of Vectors** **(04 lectures)**
  Definition of vector; vector algebra; scalar and vector product, scalar triple product with their geometrical interpretations - linearly independent vectors; vector triple products and vector identities. Basis vectors and their reciprocal set of vectors, uses and properties.

- **Vector Calculus** **(08 lectures)**
  Scalar and vector fields, simple examples of visualizing fields by sketching equipotential surface and vector fields in two dimension. Differentiation of vectors - directional derivatives and normal derivatives. Gradient of a scalar field and it's geometrical significance, Divergence and Curl of a vector field. Del and Laplacian operators, identities involving them.

- **Integration of Vectors** **(12 lectures)**
  Ordinary integrals of vectors, multiple integrals, Jacobian. Notion of infinitesimal line, surface and volume elements. Line, surface and volume integrals of vector fields. Flux of a vector field, Gauss's divergence theorem. Green's and Stoke's theorem and their applications.

- **Curvilinear Coordinates** **(06 lectures)**
  Orthogonal curvilinear coordinates. Derivation of gradient, divergence, curl and Laplacian operators in Cartesian, spherical and cylindrical -polar coordinates.

*Reference Books*

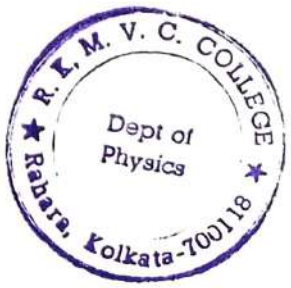

1. Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, F.E. Harris, 2013, 7th Edn., Elsevier.
2. An introduction to ordinary differential equations, E. A. Coddington, 2009, PHI learning.
3. Differential Equations, George F. Simmons, 2007, McGraw Hill.
4. Mathematical Tools for Physics, James Nearing, 2010, Dover Publications.
5. Mathematical methods for Scientists and Engineers, D. A. McQuarrie, 2003, Viva Book.
6. Advanced Engineering Mathematics, D. G. Zill and W.S. Wright, 5 Ed., 2012, Jones and Bartlett Learning.
7. Mathematical Physics, Goswami, 1st edition, Cengage Learning.
8. Engineering Mathematics, S. Pal and S. C. Bhunia, 2015, Oxford University Press.
9. Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India.
10. Essential Mathematical Methods, K. F.Riley & M. P. Hobson, 2011, Cambridge Univ. Press.
11. Mathematical methods in the Physical Sciences, M. L. Boas, 2005, Wiley.


| **Mathematical Physics - I (Practical)** | | |
|---|---|---|
| **Paper: UGPHYCC01 (Practical)** | **Credit: 2** | **Course duration: 60 hrs.** |

1. Introduction to computer as a versatile calculating machine wih limited accuracy.

2. Introduction to Gnuplot :
   (a) Plot function of one variable.
   (b) Plot vector fields in two and three dimensions.
   (c) Surface and contour plots.

3. Numerical programming in Python :
   (a) Data types in Python and method of their storage.
   (b) Structure of *while-loop*, *for-loop* and *if* statement.
   (c) Difficulty in comparing two floating numbers and its remedy.



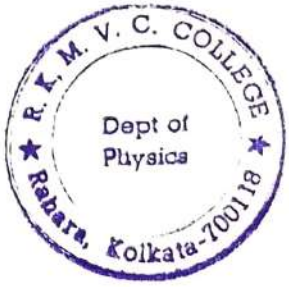
(d) Structure of one- and higher dimensional array in Python.
(e) Uses of *list()*. Defining array in NumPy.
(f) Functions and its advantages.
(g) Generate uniformly distributed random numbers within a given range using *random()* function.
(h) Basic idea of computer experiment and meaning of the term simulation (example : coin tossing experiment).

4. List of preliminary programs :
   (a) Sum of infinite series with given number of terms.
   (b) Sum of infinite series with given absolute error.
   (c) Shorting.
   (d) Roots of quadratic equation.
   (e) Vector algebra.
   (f) Matrix algebra.
   (g) Determination of number of elements within a given range of x to x+dx for a given set of random numbers.
   (h) Simulate coin tossing experiment using random() function and determine the probability of a particular event with and without ensemble average.

5. Introduction to numerical analysis and its importance
   (a) Determination of roots of an algebraic equation using Bisection and Newton-Raphson methods - limitations and accuracy.
   (b) Interpolation using Lagrange interpolating polynomials. Limitations and accuracy.
   (c) Numerical integration using trapezoidal and Simpson's one-third method. Limitations and accuracy.
   (d) Least square method of fitting straight line for a set of experimental observations. Fitting higher order polynomials for a given set of experimental observations by linearization. Limitation and accuracy.

***Reference Books***


1. Introduction to Numerical Analysis, S. S. Sastry, 5th Edn. , 2012, PHI Learning Pvt. Ltd.
2. Learning with Python-how to think like a computer scientist, J. Elkner, C. Meyer, and A. Downey, 2015, Dreamtech Press.
3. Introduction to computation and programming using Python, J. Guttag, 2013, Prentice Hall India.
4. Effective Computation in Physics- Field guide to research with Python, A. Scopatz and K. D. Huff, 2015, O'Rielly.
5. A first course in Numerical Methods, U. M. Ascher & C. Greif, 2012, PHI Learning.
6. Elementary Numerical Analysis, K. E. Atkinson, 3 rd Edn . , 2007, Wiley India Edition.
7. Numerical Methods for Scientists & Engineers, R. W. Hamming, 1973, Courier Dover Pub.
8. An Introduction to computational Physics, T. Pang, 2nd Edn., 2006,Cambridge Univ. Press.
9. Computational Physics, Darren Walker, 1st Edn., 2015, Scientific International Pvt. Ltd.

## Course Outcomes (COs)

After successful completion of this course, the students will be able to

| CO No. | Course Outcomes | Cognitive Level | PO Addressed | PSO Addressed |
|---|---|---|---|---|
| CO-1 | Understand and apply elementary calculus, limits & continuity, plotting functions, Taylor & binomial series to analyze physical problems. | U, Ap, An | PO2, PO3, PO4 | PSO2 |
| CO-2 | Simplify & formulate physical problems in differential equations and solve. | An, E, C | PO4 | PSO2, PSO3 |
| CO -3 | Remember vector identities and solve associated problems. | R, An | PO1, PO4 | PSO1 |
| CO -4 | Understand the necessity of orthogonal coordinate systems, probability theory and Dirac delta function. | U, Ap | PO5 | PSO2 |
| CO-5 | Analyze and construct computer programming to solve problems. | An, C | PO4, PO6 | PSO5 |

R= remembering, U = understanding, Ap = applying, An = analysing, E = evaluating, and C = creating

| 3.2. Mechanics | | | |
|---|---|---|---|
| Core Course | Course Code : UGPHYCC02 | Course Credit : 6 | SEM-I |

**Course objectives**

Course content added/modified = 20%

1) To understand laws of motion and apply those laws to analyze various types of motion.
2) Understand basic notion of theory of relativity.
3) Able to solve mechanical system by numerical means.

| Mechanics (Theory) | | |
|---|---|---|
| Paper: UGPHYCC02 (Theory) | Credit: 4 | Course duration: 60 Lectures. |

- **Fundamentals of Dynamics** **(06 lectures)**
  Reference frames. Inertial frames. Review of Newton'sLaws of Motion. Galilean transformations, Galilean invariance. Momentum of variable masssystem: motion of rocket.Motion of a projectile in Uniform gravitational field Dynamics of asystem of particles.Centre of Mass. Principle of conservation of momentum. Impulse.

- **Work andEnergy** **(04 lectures)**
  Work and kinetic energy theorem. Conservative and non-conservativeforces. Potentialenergy. Qualitative study of one dimensional motion from potential energycurves. Stable and unstable equilibrium. Elastic potential energy. Force as gradient of potentialenergy. Work and potential energy. Work done by non-conservative forces. Law of conservationof energy.

- **Collisions** **(03 lectures)**
  Elastic and inelastic collisions between particles. Centre ofmass and laboratory frames.

- **Rotational Dynamics** **(12 lectures)**
  Angular momentum of aparticle and system of particles. Torque. Principle of conservation of angular momentum. Rotationabout a fixed axis. Moment of Inertia. Calculationof moment of inertia for rectangular, cylindricaland spherical bodies. Kinetic energy ofrotation. Motion involving both translation and rotation.

- **Elasticity** **(06 lectures)**
  Relation between Elastic constants. Twisting torque on a Cylinder or Wire. Basic idea of bending of beam.

- **Fluid Motion** **(02 lectures)**
  Kinematics of moving fluids:Poiseuille's equation for flow of a liquid through a capillarytube.

- **Gravitation and Central ForceMotion** **(06 lectures)**
  Laws of gravitation. Gravitational potential energy. Inertial andgravitational mass. Potential and field due to spherical shell and solid sphere. Motion of a particlein centralforce field. Two body problem and its reduction to one body problem and the solution.The energy equation and energy diagram. Kepler's law.

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- **Oscillations** **(07 lectures)**
  SHM: SimpleHarmonic Oscillations. Differential equation of SHM and its solution. Kinetic energy, potentialenergy, total energy and their time average values. Damped oscillation. Forced oscillations:Transient and steady states; Resonance, sharpness ofresonance; power dissipation and QualityFactor.

- **Non-Inertial Systems** **(04 lectures)**
  Non-inertial frames and fictitious forces. Uniformlyrotating frame. Laws of Physics inrotating coordinate systems. Centrifugal force. Coriolis forceand its applications. Components of velocity and acceleration in cylindrical and sphericalcoordinate systems

- **Special Theory of Relativity** **(10 lectures)**
  Michelson-Morley experimentand its outcome. Postulates of Special Theory of Relativity.Lorentz Transformations.Simultaneityand order of events. Lorentz contraction. Time dilation. Relativistic transformation of velocity,frequency and wave number. Relativisticaddition of velocities. Variation of mass with velocity.Massless Particles. Mass-energyequivalence. Relativistic Doppler effect. Relativistic kinematics.Transformation of energy and momentum.

*Reference Books*


1. An introduction to mechanics, D. Kleppner, R. J. Kolenkow, 1973, McGraw-Hill.
2. Mechanics, Berkeley Physics, vol.1, C. Kittel, W. Knight, et.al. 2007, Tata McGraw-Hill.
3. Physics, Resnick, Halliday and Walker 8/e. 2008, Wiley.
4. Analytical Mechanics, G.R. Fowles and G. L. Cassiday. 2005, Cengage Learning.
5. Feynman Lectures, Vol. I, R. P.Feynman, R. B.Leighton, M. Sands, 2008, Pearson Education.
6. Introduction to Special Relativity, R. Resnick, 2005, John Wiley and Sons.
7. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.


*Additional Books for Reference*


8. Mechanics, D. S. Mathur, S. Chand and Company Limited, 2000.
9. University Physics. F. W Sears, M. W. Zemansky, H.D. Young 13/e, 1986, Addison Wesley.
10. Physics for scientists and Engineers with Modern Phys., J. W. Jewett, R. A. Serway, 2010, Cengage Learning.
11. Theoretical Mechanics, M. R. Spiegel, 2006, Tata McGraw Hill.


| **Mechanics (Practical)** | | |
|---|---|---|
| **Paper: UGPHYCC02 (Practical)** | **Credit: 2** | **Course duration: 60 Hrs.** |

**General Topic:** Discussion on random errors in observations.

**List of Practical**

1. Measurements of length (or diameter) using vernier callipers, screw gauge and travelling microscope.
2. To study the random error in observations.

3. To determine Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method).
4. To determine the height of a building using a Sextant.
5. To study the Motion of Spring and calculate, (a) Spring constant, (b) g and (c) Modulus of rigidity.
6. To determine the Moment of Inertia of a Flywheel.
7. To determine g and velocity for a freely falling body using Digital Timing Technique.
8. To determine the Young's Modulus of a Wire by Optical Lever Method.
9. To determine the Young's modulus of the material of a beam by flexure method.
10. To determine the Modulus of Rigidity of a Wire by Maxwell's needle.
11. To determine the elastic Constants of a wire by Searle's method.
12. To determine the value of g using Bar Pendulum.
13. To determine the value of g using Kater's Pendulum.

***Reference Books***


1. Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
3. A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Edn, 2011, Kitab Mahal.
4. Engineering Practical Physics, S. Panigrahi & B. Mallick, 2015, Cengage Learning India Pvt. Ltd.
5. Practical Physics, G. L. Squires, 2015, 4th Edition, Cambridge University Press.


## Course Outcomes (COs)

After successful completion of this course, the students will be able to

| CO No. | Course Outcomes | Cognitive Level | PO Addressed | PSO Addressed |
|---|---|---|---|---|
| CO-1 | Remember laws of motion and understand various types of motions (eg. SHM). | R, U | PO1 | PSO1 |
| CO-2 | Understand and analyze the phenomena of collisions and idea about centre of mass and laboratory frames and their correlation | U, An | PO2 | PSO2 |
| CO -3 | Understand the principles of elasticity and compare material based on elastic modulus. | U, An | PO4 | PSO4 |
| CO -4 | Apply Kepler's law to describe the motion of planets and satellite. | Ap | PO3 | PSO2 |
| CO-5 | Understand basics of special theory of relativity. | U | PO2 | PSO1, PSO2 |
| CO-6 | Construct simple experimental set-ups to acquire better understanding about the course as well as to develop skill. | U, C | PO4, PO5, PO6 | PSO4 |

R= remembering, U = understanding, Ap = applying, An = analysing, E = evaluating, and C = creating

| 3.3. Electricity and Magnetism | | | |
|---|---|---|---|
| Core Course | Course Code : UGPHYCC03 | Course Credit : 6 | SEM - II |

## Course objectives

1) To remember and understand the laws of electrodynamics and apply these laws to solve physical problems.
2) To understand basic theory of AC/DC circuit analysis and gain ability to construct circuit on demand.

| Electricity and Magnetism (Theory) | | |
|---|---|---|
| Paper: UGPHYCC03 (Theory) | Credit : 4 | Course duration: 60 Lectures. |

- **Electric field and Electric potential**
  Electric field: Electric field lines. Electric flux. Gauss' Law with applications to charge distributions with spherical, cylindrical and planar symmetry. **(06 Lectures)**

  Conservative nature of electrostatic field. Electrostatic potential. Laplace's and Poisson equations. The Uniqueness theorem. Potential and Electric Field of a dipole. Force and Torque on a dipole. **(06 Lectures)**

  Electrostatic energy of system of charges. Electrostatic energy of a charged sphere. Conductors in an electrostatic field. Surface charge and force on a conductor. Capacitance of a system of charged conductors. Parallel-plate capacitor. Capacitance of an isolated conductor. Uniqueness theorem (statement). Method of Images and its application to: (1) Plane infinite sheet and (2) Sphere. **(10 Lectures)**

- **Dielectric Properties of Matter** **(08 Lectures)**
  Electric field in matter. Polarization, Polarization charges. Electrical susceptibility and dielectric constant. Capacitor (parallel plate, spherical, cylindrical) filled with dielectric. Displacement vector $\vec{D}$. Relations between $\vec{E}$, $\vec{P}$ and $\vec{D}$. Gauss' law in dielectrics.

- **Magnetic Field** **(10 Lectures)**
  Magnetic force between current elements and definition of magnetic field $\vec{B}$. Biot-Savart's law and its simple applications: straight wire and circular loop. Current loop as a magnetic dipole and its dipole moment (analogy with electric dipole). Ampere's circuital law and its application to (1) infinite straight wire, (2) Infinite planar surface current, and (3) Solenoid. Properties of $\vec{B}$ : curl and divergence. Axial vector property of $\vec{B}$ and its consequences. Vector Potential. Magnetic force on (1) point charge (2) current carrying wire (3) between current elements. Torque on a current loop in a uniform magnetic field.

- **Magnetic Properties of Matter** **(05 Lectures)**
  Magnetization vector (M). Magnetic Intensity (H). Magnetic susceptibility and permeability. Relation between $\vec{B}$, $\vec{H}$, $\vec{M}$. Ferromagnetism. B-H curve and hysteresis.

- **Electromagnetic Induction** **(06 Lectures)**
  Faraday's law. Lenz's law. Self-inductance and mutual inductance. Reciprocity theorem. Energy stored in a magnetic field. Introduction to Maxwell's equations. Charge conservation and displacement current.

- **Electrical Circuits** **(04 Lectures)**
  AC Circuits: Kirchhoff's laws for AC circuits. Complex reactance and impedance. Series LCR circuit: (1) Resonance, (2) Power dissipation and (3) Quality factor, and (4) Band width. Parallel LCR circuit.

- **Network Theorems** **(04 Lectures)**
  Ideal Constant-voltage and Constant-current sources. Network theorems: Thevenin theorem, Norton theorem, Superposition theorem, Reciprocity theorem, Maximum power transfer theorem. Applications to dc circuits.

*Reference Books*


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


| **Electricity and Magnetism (Practical)** | | |
|---|---|---|
| **Paper: UGPHYCC03 (Practical)** | **Credit: 2** | **Course duration: 60 Hrs.** |

**List of Practical:**

1. To study the characteristics of a series RC Circuit.
2. To determine an unknown Low Resistance using Potentiometer.
3. To determine an unknown Low Resistance using Carey Foster's Bridge.
4. To determine the resistance of a galvanometer using Thomson's method.
5. Measurement of field strength B and its variation in a solenoid (determine $\frac{dB}{dx}$).
6. To verify the Thevenin and Norton theorems.
7. To verify the Superposition, and Maximum power transfer theorems.
8. To determine self-inductance of a coil by Anderson's bridge.
9. To study response curve of a Series LCR circuit and determine its (a) Resonant frequency, (b) Impedance at resonance, (c) Quality factor Q, and (d) Band width.
10. To study the response curve of a parallel LCR circuit and determine its (a) Anti-resonant frequency and (b) Quality factor Q.

*Reference Books*

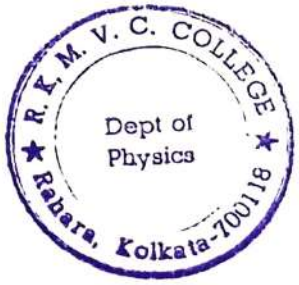
1. Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House.
2. A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal.
3. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
4. Engineering Practical Physics, S. Panigrahi and B. Mallick, 2015, Cengage Learning.
5. A Laboratory Manual of Physics for undergraduate classes, D. P. Khandelwal, 1985, Vani Pub.

## Course Outcomes (COs)

After successful completion of this course, the students will be able to

| CO No. | Course Outcomes | Cognitive Level | PO Addressed | PSO Addressed |
|---|---|---|---|---|
| CO-1 | Remember and understands fundamental laws of electrodynamics | R, U | PO1, PO2 | PSO1 |
| CO-2 | Understand complex reactance & impedance in AC circuits. | U | PO2, PO3, PO4 | PSO2, PSO3 |
| CO -3 | Apply laws of electricity and magnetism to evaluate electro-magnetic fields for charges and currents. | Ap | PO4, PO6 | PSO3, PSO4 |
| CO -4 | Simplify complicated networks through network theorems. Construct DC circuits for better understanding. | An, C | PO4 | PSO4, PSO5 |

R= remembering, U = understanding, Ap = applying, An = analysing, E = evaluating, and C = creating



| 3.4. Waves and Optics | | | |
|---|---|---|---|
| Core Course | Course Code : UGPHYCC04 | Course Credit : 6 | SEM - II |

## Course objectives

1) To understand wave motion in elastic media.
2) To understand various terms associated with acoustics and address them inb environmental context.
3) To understand basic theory of light wave and associated physics.
4) To analyze optical properties of material by spectrum analysis.

| Waves and Optics ( Theory ) | | |
|---|---|---|
| Paper: UGPHYCC04 (Theory) | Credit : 4 | Course duration: 60 Lectures. |

- **Superposition of Collinear Harmonic oscillations** **(06 Lectures)**
  Linearity and Superposition Principle. Superposition of two collinear oscillations having (1) equal frequencies and (2) different frequencies (Beats). Superposition of N collinear Harmonic Oscillations with (1) equal phase differences and (2) equal frequency differences.

- **Superposition of two perpendicular Harmonic Oscillations** **(02 Lectures)**
  Graphical and Analytical Methods. Lissajous Figures with equal an unequal frequency and their uses.

- **Wave Motion** **(06 Lectures)**
  Plane and Spherical waves. Longitudinal and Transverse waves. Plane progressive (travelling) waves. Wave equation. Particle and wave velocities. Differential equation. Pressure of a Longitudinal wave. Energy transport. Intensity of wave.

- **Velocity of Waves** **(08 Lectures)**
  Velocity of transverse vibrations of stretched strings. Velocity of longitudinal waves in a fluid in a pipe. Newton's formula for velocity of sound. Laplace's correction.

- **Superposition of Two Harmonic Waves** **(07 Lectures)**
  Standing (Stationary) waves in a string: Fixed and free ends. Analytical treatment. Phase and Group velocities. Changes with respect to position and time. Energy of vibrating string. Transfer of energy. Normal modes of stretched strings. Plucked and Struck strings. Melde's experiment. Longitudinal standing waves and Normal modes. Open and Closed pipes. Superposition of N-harmonic waves.

- **Wave Optics** **(03 Lectures)**
  Electromagnetic nature of light. Definition and properties of wave front. Huygens Principle. Temporal and Spatial Coherence.

- **Interference** **(09 Lectures)**
  Division of amplitude and wavefront. Young's double slit experiment. Lloyd's Mirror and Fresnel's biprism. Phase change on reflection: Stokes' treatment. Interference in Thin Films: parallel and

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

**(04 Lectures)**

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

**(15 Lectures)**

- **Diffraction**
  Kirchhoff's Integral theorem, Fresnel-Kirchhoff's Integral formula. (Qualitative discussion only). *Fraunhofer diffraction:* Single slit. Circular aperture, Resolving Power of a telescope. Double slit. Multiple slits. Diffraction grating. Resolving power of grating. Fresnel diffraction: Fresnel's assumptions. Fresnel's half-period zones for plane wave. Explanation of rectilinear propagation of light. Theory of a zone plate: Multiple foci of a zone plate. Fresnel's integral, Fresnel diffraction pattern of a straight edge, a slit and a wire.

*Reference Books*


1. Waves: Berkeley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGraw-Hill.
2. Fundamentals of Optics, F. A. Jenkins and H. E. White, 1981, McGraw-Hill.
3. Principles of Optics, Max Born and Emil Wolf, 7th Edn., 1999, Pergamon Press.
4. Optics, Ajoy Ghatak, 2008, Tata McGraw Hill.
5. The Physics of Vibrations and Waves, H. J. Pain, 2013, John Wiley and Sons.
6. The Physics of Waves and Oscillations, N.K. Bajaj, 1998, Tata McGraw Hill.
7. Fundamental of Optics, A. Kumar, H. R. Gulati and D. R. Khanna, 2011, R. Chand Publications.


| **Waves and Optics (Practical)** | | |
|---|---|---|
| **Paper: UGPHYCC04 (Practical)** | **Credit: 2** | **Course duration: 60 Hrs.** |

**List of Practical**

1. To determine the frequency of an electric tuning fork by Melde's experiment and verify $\lambda^2$ –T law.
2. To investigate the motion of coupled oscillators.
3. To study Lissajous figures.
4. Familiarization with: Schuster's focusing; determination of angle of prism.
5. To determine refractive index of the material of a prism using sodium source.
6. To determine the dispersive power and Cauchy constants of the material of a prism using mercury source.
7. To determine the wavelength of sodium source using Michelson's interferometer.
8. To determine wavelength of sodium light using Fresnel biprism.
9. To determine wavelength of sodium light using Newton's rings.
10. To determine the thickness of a thin paper by measuring the width of the interference fringes produced by a wedge-shaped Film.
11. To determine wavelength of (1) Na source and (2) spectral lines of Hg source using plane diffraction grating.
12. To determine dispersive power and resolving power of a plane diffraction grating.

*Reference Books*

1. Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House.
2. A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal.
3. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
4. A Laboratory Manual of Physics for undergraduate classes, D. P. Khandelwal, 1985, Vani Pub.

## Course Outcomes (COs)

After successful completion of this course, the students will be able to

| CO No. | Course Outcomes | Cognitive Level | PO Addressed | PSO Addressed |
|---|---|---|---|---|
| CO-1 | Understand oscillatory motions. Solve differential equations of free, damped and forced oscillations. | U | PO2 | PSO1 |
| CO-2 | Remember and understand the acoustical terms like sound intensity, loudness, intensity level, Bel, decibel, phon. | R, U | PO1, PO3 | PSO1 |
| CO -3 | Analyze vibration of stretched string to determine formation of different tones. | An, E | PO4, PO5 | PSO3 |
| CO -4 | Remember and understand basic principles of light propagation. Understand interference, diffraction. | R, U | PO1, PO2, PO4 | PSO1, PSO2, PSO3 |
| CO-5 | Estimate the chemical nature of the source from spectrum analysis. | An, C | PO4, PO6 | PSO4, PSO5 |

R= remembering, U = understanding, Ap = applying, An = analysing, E = evaluating, and C = creating

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| 3.5. Mathematical Physics – II | | | |
|---|---|---|---|
| Core Course | Course Code : UGPHYCC05 | Course Credit : 6 | SEM - III |

## Course objectives

1) To gain extensive knowledge on Fourier series, differential equations, variational calculus and special functions and their applicability in physical systems.
2) Gain ability to write down computer program to solve physical system through numerical methods.

| Mathematical Physics - II (Theory ) | | |
|---|---|---|
| Paper: UGPHYCC05 (Theory) | Credit : 4 | Course duration: 60 Lectures. |

- **Fourier Series** **(10 Lectures)**
  Periodic functions. Orthogonality of sine and cosine functions, Dirichlet conditions (Statement only). Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients. Complex representation of Fourier series. Expansion of functions with arbitrary period. Expansion of non-periodic functions over an interval. Even and odd functions and their Fourier expansions. Application. Summing of Infinite Series. Term-by-term differentiation and integration of Fourier series. Parseval identity.

- **Frobenius Method and Special Functions** **(24 Lectures)**
  Singular points of second order linear differential equations and their importance. Frobenius method and its applications to differential equations. Legendre, Bessel, Hermite and Laguerre differential equations. Properties of Legendre polynomials: Rodrigues formula, Generating function, Orthogonality. Simple recurrence relations. Expansion of function in a series of Legendre polynomials.

- **Some Special Integrals** **(04 Lectures)**
  Beta and Gamma functions and relation between them. Expression of integrals in terms of Gamma functions. Error function (Probability integral).

- **Variational calculus in physics** **(12 Lectures)**
  Functionals. Basic ideas of functionals. Extremization of action as a basic principle in mechanics. Lagrangian fomulation. Euler's equations of motion for simple systems: harmonics oscillators, simple pendulum, spherical pendulum, coupled oscillators. Cyclic coordinates. Symmetries and conservation laws. Legendre transformations and the Hamiltonian formulation of mechanics. Canonical equations of motion. Applications to simple systems.

- **Partial Differential Equations** **(10 Lectures)**
  Solutions to partial differential equations, using separation of variables: Laplace's Equation in problems of rectangular, cylindrical and spherical symmetry. Wave equation and its solution for vibrational modes of a stretched string.

*Reference Books*


1. Mathematical Methods for Physicists: Arfken, Weber, 2005, Harris, Elsevier.
2. Fourier Analysis by M. R. Spiegel, 2004, Tata McGraw-Hill.
3. Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole.
4. Differential Equations, George F. Simmons, 2006, Tata McGraw-Hill.
5. Partial Differential Equations for Scientists & Engineers, S. J. Farlow, 1993, Dover Pub.
6. Engineering Mathematics, S. Pal and S. C. Bhunia, 2015, Oxford University Press.
7. Mathematical methods for Scientists & Engineers, D. A. McQuarrie, 2003, Viva Books.
8. Mathematical Physics, P. K. Chattopadhyay, 2014, New Academic Science.


| **Mathematical Physics - II (Practical)** | | |
|---|---|---|
| **Paper: UGPHYCC05 (Practical)** | **Credit : 2** | **Course duration: 60 hrs.** |

- **Introduction to Numerical computation using numpy and scipy**
  Introduction to the python numpy module. Arrays in numpy, array operations, array item selection, slicing, shaping arrays. Basic linear algebra using the linalg submodule. Introduction to online graph plotting using matplotlib. Introduction to the scipy module. Uses in optimization and solution of differential equations.
  Introduction to OCTAVE (if time permits)

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

- **Solution of Linear system of equations by Gauss elimination method and Gauss Seidal method. Diagonalization of matrices, Inverse of a matrix, Eigen vectors, eigen values problems**
  - Solution of mesh equations of electric circuits (3 meshes).
  - Solution of coupled spring mass systems (3 masses).

- **Generation of Special functions using User defined functions**
  Generating and plotting Legendre polynomials.

- **Solution of ODE First order Differential equation Euler, modified Euler and Runge-Kutta second order methods Second order differential equation Fixed difference method**

  *First order differential equation*

  1. Radioactive decay.
  2. Current in RC, LC circuits with DC source.
  3. Newton's law of cooling.
  4. Classical equations of motion second order differential equation.
  5. Harmonic oscillator (no friction).
  6. Damped Harmonic oscillator.
  7. Over damped.
  8. Critical damped.
  9. Oscillatory.

10. Forced Harmonic oscillator.
11. Transient and Steady state solution.
12. Apply above to LCR circuits also.

*Partial differential equations*

1. Wave equation.
2. Heat equation.
3. Poisson equation.
4. Laplace equation.

***Reference Books***

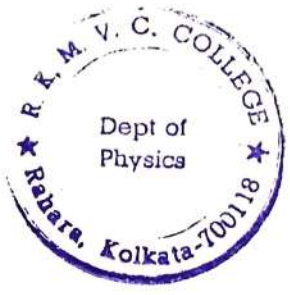

1. Mathematical Methods for Physics and Engineers, K. F Riley, M. P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press.
2. Complex Variables, A.S . Fokas & M. J. Ablowitz, 8th Ed., 2011, Cambridge Univ. Press.
3. Computational Physics, D. Walker, 1st Edn., 2015, Scientific International Pvt. Ltd.
4. Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A. V. Wouwer, P. Saucez, C. V. Fernández. 2014 Springer


## Course Outcomes (COs)

After successful completion of this course, the students will be able to

| CO No. | Course Outcomes | Cognitive Level | PO Addressed | PSO Addressed |
|---|---|---|---|---|
| CO-1 | Understand Fourier series and Fourier transform. Apply to analyze various periodic & non-periodic functions. | U, Ap, An | PO2, PO6 | PSO2, PSO3, PSO5 |
| CO-2 | Understand the technique of series solution of 2nd order linear differential equations. Solve partial differential equations by the method of separation of variables. | U, AP | PO3, PO5, PO6 | PSO2, PSO5 |
| CO -3 | Understand special mathematical functions and orthogonal polynomials. | U | PO2, PO5 | PSO2, PSO3 |
| CO -4 | Understand the basic ideas of variational calculus. Apply in simple problems. | U, Ap | PO3, PO5 | PSO2, PSO3, PSO5 |
| CO-5 | Construct numerical programming to solve differential equations. | An, C | PO4, PO6 | PSO5 |

R= remembering, U = understanding, Ap = applying, An = analysing, E = evaluating, and C = creating



| 3.6. Thermal Physics | | | |
|---|---|---|---|
| Core Course | Course Code : UGPHYCC06 | Course Credit : 6 | SEM - III |

## Course objectives

1) To understand basic theory of thermodynamics and its applicability in various interdisciplinary/multidisciplinary fields.
2) To understand and analyze behaviour of ideal gas and real gas systems.
3) Gain ability to perform experiments to demonstrate basics of thermal physics.

| Thermal Physics ( Theory ) | | |
|---|---|---|
| Paper: UGPHYCC06 (Theory) | Credit: 4 | Course duration: 60 lectures. |

- **Introduction to Thermodynamics**

*Zeroth and First Law of Thermodynamics*: **(08 Lectures)**
Extensive and intensive Thermodynamic variables, Thermodynamic equilibrium, Zeroth law of thermodynamics & concept of temperature, Concept of work & heat, State functions, First law of thermodynamics and its differential form, Internal energy, First law & various processes, Applications of first law: General relation between $C_P$ and $C_V$, Work done during Isothermal and Adiabatic processes, Compressibility and Expansion co-efficient.

*Second Law of Thermodynamics*: **(10 Lectures)**
Reversible and Irreversible process with examples. Conversion of work into heat and heat into work. Heat engines. Carnot's cycle, Carnot engine & efficiency. Refrigerator & coefficient of performance, 2nd law of thermodynamics: Kelvin-Planck and Clausius statements and their equivalence. Carnot's theorem. Applications of second law of thermodynamics: Thermodynamic scale of temperature and its equivalence to perfect gas scale.

*Entropy*: **(07 Lectures)**
Concept of Entropy, Clausius theorem. Clausius inequality, Second law of thermodynamics in terms of entropy. Entropy of a perfect gas. Principle of increase of entropy. Entropy changes in Reversible and Irreversible processes with examples. Entropy of the Universe. Temperature–Entropy diagrams for cycle. Third law of thermodynamics. Unattainability of absolute zero.

- **Thermodynamic Potentials** **(07 Lectures)**
*Thermodynamic Potentials*: Internal energy, Enthalpy, Helmholtz free energy, Gibb's free energy. Their definitions, Properties and applications. Surface films and variation of surface tension with temperature. Magnetic work, cooling due to adiabatic demagnetization, First and second order phase transitions with examples, Clausius Clapeyron equation and Ehrenfest equations.

- **Maxwell's Thermodynamic Relations** **(07 Lectures)**
Derivations and applications of Maxwell's relations, Maxwell's relations:(1) Clausius Clapeyron equation, (2) Values of $C_P - C_V$, (3) T-dS equations, (4) Joule-Kelvin coefficient for ideal and Van der Waal gases, (5) Energy equations, (6) Change of temperature during adiabatic process.

- **Kinetic Theory of Gases**

**(07 Lectures)**

*Distribution of Velocities*:
Maxwell-Boltzmann law of distribution of velocities in an ideal gas and its experimental verification. Doppler broadening of spectral lines and Stern's experiment. Mean, RMS and Most Probable Speeds. Degrees of freedom. Law of equipartition of energy (No proof required). Specific heats of Gases.

**(04 Lectures)**

*Molecular Collisions*:
Mean free path. Collision probability. Estimates of mean free path. Transport phenomenon in Ideal gases: (1) Viscosity, (2) Thermal conductivity and (3) Diffusion. Brownian motion and its significance.

**(10 Lectures)**

*Real Gases*:
Behaviour of real gases: Deviations from the ideal gas equation. The Virial equation. Andrew's experiments on $CO_2$ gas. Critical constants. Continuity of liquid and gaseous state. Vapour and gas. Boyle temperature. Van der Waal's equation of state for real gases. Values of critical constants. Law of corresponding states. Comparison with experimental curves. P-V diagrams. Joule's experiment. Free adiabatic expansion of a perfect gas. Joule-Thomson porous plug experiment. Joule-Thomson effect for real and Van der Waal gases. Temperature of inversion. Joule-Thomson cooling.

***Reference Books***


1. Heat and Thermodynamics, M. W. Zemansky, Richard Dittman, 1981, McGraw-Hill.
2. Thermal Physics, S. Garg, R. Bansal and Ghosh, 2nd Edition, 1993, Tata McGraw-Hill.
3. Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer.
4. Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Sears & Salinger. 1988, Narosa.
5. Concepts in Thermal Physics, S. J. Blundell and K. M. Bhundell, 2nd Ed., 2012, Oxford University Press.
6. Thermodynamics and an introduction to thermostatistics, H. B. Callen, 1985, Wiley.
7. Thermal Physics, A. Kumar and S. P. Taneja, 2014, R. Chand Publications.


| **Thermal Physics (Practical)** | | |
|---|---|---|
| **Paper: UGPHYCC06 (Practical)** | **Credit : 2** | **Course duration: 60 hrs.** |

**List of Practical:**

1. To determine Mechanical Equivalent of Heat, J, by Callender and Barne's constant flow method.
2. To determine the Coefficient of Thermal Conductivity of Cu by Searle's Apparatus.
3. To determine the Coefficient of Thermal Conductivity of Cu by Angstrom's Method.
4. To determine the Coefficient of Thermal Conductivity of a bad conductor by Lee and Charlton's disc method.
5. To determine the Temperature Coefficient of Resistance by Platinum Resistance Thermometer (PRT).
6. To study the variation of Thermo-emf of a Thermocouple with difference of temperature of its two junctions.
7. To calibrate a thermocouple to measure temperature in a specified range using (1) Null Method,

(2) Direct measurement using Op-Amp difference amplifier and to determine Neutral temperature.

***Reference Books***


1. Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House,
2. A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal.
3. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
4. A Laboratory Manual of Physics for undergraduate classes, D. P. Khandelwal, 1985, Vani Pub.


## Course Outcomes (COs)

After successful completion of this course, the students will be able to

| CO No. | Course Outcomes | Cognitive Level | PO Addressed | PSO Addressed |
|---|---|---|---|---|
| CO-1 | Remember and understand laws of thermodynamics | R, U | PO1, PO2 | PSO1 |
| CO-2 | Understand the interrelationship between thermodynamic functions and able to use these relationships to solve practical problems. | U, Ap | PO2, PO3 | PSO2 |
| CO -3 | Understand basic ideas of kinetic theory of gas, Maxwell-Boltzmann law of velocity distribution and transport properties. | U | PO2 | PSO5 |
| CO -4 | Understand real gas behaviour and apply equation of states to determine critical constants. | U, Ap | PO3, PO5 | PSO2, PSO5 |
| CO-5 | Construct simple experimental set-ups to validate theoretical aspects. | An, C | PO4, PO6 | PSO4 |

R= remembering, U = understanding, Ap = applying, An = analysing, E = evaluating, and C = creating

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| 3.7. Digital Systems and Applications | | | |
|---|---|---|---|
| Core Course | Course Code : UGPHYCC07 | Course Credit : 6 | SEM - III |

## Course objectives

1) To understand Boolean logic and binary number system as pillars of digital era.
2) To understand basic logic gate operation and apply it to develop digital circuits.
3) To understand basics of computer architecture.

| Digital Systems and Applications (Theory) | | |
|---|---|---|
| Paper: UGPHYCC07 (Theory) | Credit : 4 | Course duration: 60 lectures. |

- **Integrated Circuits** **(04 Lectures)**
  Active & Passive components. Discrete components. Wafer. Chip. Advantages and drawbacks of ICs. Scale of integration: SSI, MSI, LSI and VLSI (basic idea and definitions only). Classification of ICs. Examples of linear and digital ICs.

- **Digital Circuits** **(07 Lectures)**
  Difference between Analog and Digital circuits. Binary numbers. Decimal to Binary and Binary to Decimal conversion. BCD, Octal and Hexadecimal numbers. AND, OR and NOT Gates (realization using Diodes and Transistor). NAND and NOR Gates as Universal Gates. XOR and XNOR Gates and application as Parity checkers.

- **Boolean algebra** **(07 Lectures)**
  De Morgan's theorems. Boolean laws. Simplification of Logic circuit using Boolean algebra. Fundamental products. Idea of Minterms and Maxterms. Conversion of a Truth table into equivalent Logic circuit by (1) Sum of products method and (2) Karnaugh map.

- **Data processing circuits** **(06 Lectures)**
  Basic idea of Multiplexers, De-multiplexers, Decoders, Encoders.

- **Circuits**
  *Arithmetic Circuits*: **(06 Lectures)**
  Binary addition. Binary subtraction using 2's Complement. Half and Full adders. Half & Full subtractors, 4-bit binary adder/subtractor.

  *Sequential Circuits*: **(08 Lectures)**
  SR, D, and JK Flip-Flops. Clocked (Level and Edge Triggered) Flip-Flops. Presetand Clear operations. Race-around conditions in JK Flip-Flop. M/S JK Flip-Flop.

- **Timers** **(05 Lectures)**
  IC 555: block diagram and applications: Astable multivibrator and Monostable multivibrator.

- **Shift registers** **(04 Lectures)**
  Serial-in-Serial-out, Serial-in-Parallel-out, Parallel-in-Serial-out and Parallel-in-Parallel-out Shift Registers (only up to 4 bits).

- **Counters (4 bits)** **(04 Lectures)**
  Ring Counter. Asynchronous counters, Decade Counter. Synchronous Counter.

- **Computer Organization** **(08 Lectures)**
  Input/Output Devices. Data storage (idea of RAM and ROM). Computer memory. Memory organization & addressing. Memory interfacing. Memory map.

*Reference Books*


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


| **Digital Systems and Applications (Practical)** | | |
|---|---|---|
| **Paper: UGPHYCC07 (Practical)** | **Credit: 2** | **Course duration: 60 hrs.** |

**List of Practical:**

1. To measure (a) Voltage, and (b) Time period of a periodic waveform using CRO.
2. To test a Diode and Transistor using a Multimeter.
3. To design a switch (NOT gate) using a transistor.
4. To verify and design AND, OR, NOT and XOR gates using NAND gates.
5. To design a combinational logic system for a specified Truth Table.
6. To convert a Boolean expression into logic circuit and design it using logic gate ICs.
7. To minimize a given logic circuit.
8. Half Adder, Full Adder and 4-bit binary Adder.
9. Half Subtractor, Full Subtractor, Adder-Subtractor using Full Adder I.C.
10. To build Flip-Flop (RS, Clocked RS, D-type and JK) circuits using NAND gates.
11. To build JK Master-slave flip-flop using Flip-Flop ICs
12. To build a 4-bit Counter using D-type/JK Flip-Flop ICs and study timing diagram.
13. To make a 4-bit Shift Register (serial and parallel) using D-type/JK Flip-Flop ICs.
14. To design an astable multivibrator of given specifications using 555 Timer.
15. To design a monostable multivibrator of given specifications using 555 Timer.

***Reference Books***

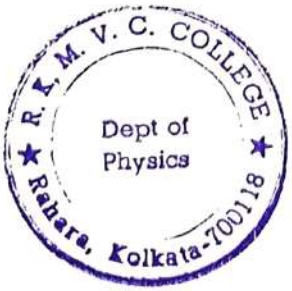
1. Modern Digital Electronics, R. P. Jain, 4th Edition, 2010, Tata McGraw Hill.
2. Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M. A. Miller, 1994, Mc-Graw Hill.

## Course Outcomes (COs)

After successful completion of this course, the students will be able to

| CO No. | Course Outcomes | Cognitive Level | PO Addressed | PSO Addressed |
|---|---|---|---|---|
| CO-1 | Remember and understand Boolean logic and its connection to digital electronics. | R, U | PO1, PO2 | PSO1 |
| CO-2 | Understand basics of number system and their arithmetic operations | U | PO2, PO5 | PSO1, PSO3 |
| CO -3 | Synthesize Boolean functions, simplify digital circuits by employing Boolean algebra. | An, Ap, E | PO4, PO6 | PSO3, PSO4 |
| CO -4 | Understand operation of sequential and combinational circuits to construct simple devices. | U, Ap, C | PO4, PO6 | PSO3, PSO4 |
| CO-5 | Understand fundamentals of basic computer architecture. | U | PO2, PO5 | PSO1, PSO5 |

R= remembering, U = understanding, Ap = applying, An = analysing, E = evaluating, and C = creating



| 3.8. Mathematical Physics - III | | | |
|---|---|---|---|
| Core Course | Course Code : UGPHYCC08 | Course Credit : 6 | SEM - IV |

## Course objectives

1) To gain extensive knowledge on complex analysis, integral transformations and linear algebra as mathematical tools to analyze physical systems.
2) Gain ability to write down computer program to solve physical system through numerical methods.

| Mathematical Physics - III (Theory) | | |
|---|---|---|
| Paper: UGPHYCC08 (Theory) | Credit : 4 | Course duration: 60 lectures |

- **Complex Analysis** **(30 Lectures)**
  Brief revision of complex numbers and their graphical representation. Euler's formula, De Moivre's theorem, Roots of complex numbers. Functions of complex variables. Analyticity and Cauchy-Riemann conditions. Examples of analytic functions. Singular functions: poles and branch points, order of singularity, branch cuts. Integration of a function of a complex variable. Cauchy's inequality. Cauchy's integral formula. Simply and multiply connected region. Laurent and Taylor's expansion. Residues and Residue theorem. Application in solving definite integrals.

- **Integrals Transforms** **(15 Lectures)**
  Fourier transforms: Fourier integral theorem. Fourier transform. Examples. Fourier transform of trigonometric, Gaussian, finite wave train & other functions. Representation of Dirac delta function as a Fourier integral. Fourier transform of derivatives, Inverse Fourier transform, Convolution theorem. Properties of Fourier transforms (translation, change of scale, complex conjugation, etc.). Three dimensional Fourier transforms with examples. Application of Fourier transforms to differential equations: One dimensional wave and diffusion/heat flow equations.

- **Matrices** **(10 Lectures)**
  Addition and Multiplication of matrices. Null matrices. Diagonal, Scalar and Unit matrices. Upper-triangular and Lower-triangular matrices. Transpose of a matrix. Symmetric and Skew-symmetric matrices. Conjugate of a matrix. Hermitian and Skew-Hermitian matrices. Singular and Non-singular matrices. Orthogonal and Unitary matrices. Trace of a matrix. Inner product.

- **Eigen-values and Eigenvectors** **(05 Lectures)**
  Cayley-Hamiliton theorem. Diagonalization of matrices. Solutions of coupled linear ordinary differential equations. Functions of a matrix.

*Reference Books*

1. Mathematical Methods for Physics and Engineers, K. F Riley, M. P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press.
2. Mathematics for Physicists, P. Dennery and A. Krzywicki, 1967, Dover Publications.

3. Complex Variables, A. S.Fokas & M. J. Ablowitz, 8th Ed., 2011, Cambridge Univ. Press.
4. Complex Variables, A. K. Kapoor, 2014, Cambridge Univ. Press.
5. Complex Variables and Applications, J. W. Brown & R. V. Churchill, 7th Ed. 2003, Tata McGraw-Hill.
6. First course in complex analysis with applications, D. G. Zill and P. D. Shanahan, 1940, Jones & Bartlett

| **Mathematical Physics - III (Practical)** | | |
|---|---|---|
| **Paper: UGPHYCC08 (Practical)** | **Credit: 2** | **Course duration: 60 hrs.** |

**List of Practical**

1. Solve differential equations:

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

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

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

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

2. Dirac Delta Function

   Evaluate $\frac{1}{\sqrt{2\pi\sigma^2}} \int e^{\frac{-(x-2)^2}{2\sigma^2}} (x+3)dx$, for $\sigma = 0,0.1,0.01$ and show it tends to 5.

3. Fourier Series:

   Program to sum $\sum_{n=1}^{\infty}(0.2)^n$. Evaluate the Fourier coefficients of a given periodic function (squarewave).

4. Frobenius method and Special Functions:

   $\int_{-1}^{+1} P_n(\mu)\, P_m(\mu)d\mu = \delta_{n,m}$ Plot $P_n(x), j_v(x)$. Show recursion relation.

5. Calculation of error for each data point of observations recorded in experiments done in previous semesters (choose any two).
6. Calculation of least square fitting manually without giving weightage to error. Confirmation of least square fitting of data through computer program.
7. Compute the nth roots of unity for n = 2, 3, and 4.
8. Find the two square roots of −5+12j.
9. Integral transform: FFT of $e^{-x^2}$



*Reference Books*

1. Mathematical Methods for Physics and Engineers, K. F Riley, M. P. Hobson and S. J. Bence, 3rd Ed., 2006, Cambridge University Press.
2. Mathematics for Physicists, P. Dennery and A. Krzywicki, 1967, Dover Publications.

3. Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández. 2014 Springer ISBN: 978-3319067896.
4. A Guide to MATLAB, B. R. Hunt, R. L. Lipsman, J. M. Rosenberg, 2014, 3rd Edn., Cambridge University Press.
5. https://web.stanford.edu/~boyd/ee102/laplace_ckts.pdf
6. https://ocw.nthu.edu.tw/ocw/upload/12/244/12handout.pdf

## Course Outcomes (COs)

After successful completion of this course, the students will be able to

| CO No. | Course Outcomes | Cognitive Level | PO Addressed | PSO Addressed |
|---|---|---|---|---|
| CO-1 | Understand and apply theory of complex variables to solve physical problems. | U, Ap | PO2, PO5 | PSO2, PSO5 |
| CO-2 | Understand Fourier transform and analyze various functions | U, Ap | PO3 | PSO2, PSO3 |
| CO -3 | Apply matrix algebra to solve linear systems. | Ap, An | PO5, PO6 | PSO3, PSO5 |
| CO -4 | Write down computer programs to solve physical problems. | An, C | PO4, PO5, PO6 | PSO3, PSO5 |

R= remembering, U = understanding, Ap = applying, An = analysing, E = evaluating, and C = creating

| 3.9. Elements of Modern Physics | | | |
|---|---|---|---|
| Core Course | Course Code : UGPHYCC09 | Course Credit : 6 | SEM - IV |

## Course objectives

1) To understand basic notion of quantum mechanics and appreciate its applicability in nuclear physics and laser physics to analyze the systems as quantum systems.
2) Gain ability to perform experiment with quantum mechanical systems.

| Elements of Modern Physics (Theory) | | |
|---|---|---|
| Paper: UGPHYCC09 (Theory) | Credit : 4 | Course duration: 60 lectures |

- **Unit 1 : Quantum Mechanics (Part-A)** **(14 Lectures)**

  Planck's quantum, Planck's constant and light as a collection of photons; Blackbody Radiation: Quantum theory of Light; Photo-electric effect and Compton scattering. De Broglie wavelength and matter waves; Davisson-Germer experiment. Wave description of particles by wave packets. Group and Phase velocities and relation between them. Two-Slit experiment with electrons. Probability. Wave amplitude and wave functions.

- **Unit 2 : Quantum Mechanics (Part-B)** **(15 Lectures)**

  Position measurement - gamma ray microscope thought experiment; Wave-particle duality, Heisenberg uncertainty principle (Uncertainty relations involving Canonical pair of variables): Derivation from Wave Packets impossibility of a particle following a trajectory; Estimating minimum energy of a confined particle using uncertainty principle; Energy-time uncertainty principle- application to virtual particles and range of an interaction. Two slit interference experiment with photons, atoms and particles; linear superposition principle as a consequence; Matter waves and wave amplitude; Schrödinger equation for non-relativistic particles; Momentum and Energy operators; stationary states; physical interpretation of a wave function, probabilities and normalization; Probability and probability current densities in one dimension.

- **Unit 3 :** **(16 Lectures)**
  - **Quantum Mechanics (Part-C)**

    One dimensional infinitely rigid box- energy eigenvalues and eigenfunctions, normalization; Quantum dot as example; Quantum mechanical scattering and tunnelling in one dimension- across a step potential & rectangular potential barrier.

  - **Nuclear Structure**

    Size and structure of atomic nucleus and its relation with atomic weight; Impossibility of an electron being in the nucleus as a consequence of the uncertainty principle. Nature of nuclear force, N-Z graph, Liquid Drop model: semi-empirical mass formula and binding energy, Nuclear Shell Model and magic numbers.

- **Unit 4:** **(15 Lectures)**
  - **Radioactivity**

    Stability of the nucleus; Law of radioactive decay; Mean life and half-life; Alpha decay; Beta decay- energy released, spectrum and Pauli's prediction of neutrino; Gamma ray emission,

energy-momentum conservation: electron-positron pair creation by gamma photons in the vicinity of a nucleus.

- **Fission and fusion**
  Mass deficit, relativity and generation of energy; Fission - nature of fragments and emission of neutrons. Nuclear reactor: slow neutrons interacting with Uranium 235; Fusion and thermonuclear reactions driving stellar energy (brief qualitative discussions).

- **Lasers**
  Einstein's A and B coefficients. Metastable states. Spontaneous and Stimulated emissions. Optical pumping and Population inversion. Three-Level and Four-Level Lasers. Ruby Laser and He-Ne Laser. Basic lasing.

*Reference Books*


1. Concepts of Modern Physics, Arthur Beiser, 2002, McGraw-Hill.
2. Introduction to Modern Physics, Rich Meyer, Kennard, Coop, 2002, Tata McGraw Hill.
3. Introduction to Quantum Mechanics, David J. Griffith, 2005, Pearson Education.
4. Physics for scientists and Engineers with Modern Physics, Jewett and Serway, 2010, Cengage Learning.
5. Modern Physics, G. Kaur and G. R. Pickrell, 2014, McGraw Hill.
6. Quantum Mechanics: Theory & Applications, A. K.Ghatak & S. Lokanathan, 2004. Macmillan.


*Additional Books for Reference*


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


| **Elements of Modern Physics (Practical)** | | |
|---|---|---|
| **Paper: UGPHYCC09 (Practical)** | **Credit : 2** | **Course duration: 60 hrs.** |

**List of Practical**

1. Measurement of Planck's constant using black body radiation and photo-detector.
2. Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light.
3. To determine work function of material of filament of directly heated vacuum diode.
4. To determine the Planck's constant using LEDs of at least 4 different colours.
5. To determine the wavelength of H-alpha emission line of Hydrogen atom.
6. To determine the ionization potential of mercury.
7. To determine the absorption lines in the rotational spectrum of Iodine vapour.
8. To determine the value of e/m by (a) Magnetic focusing or (b) Bar magnet.
9. To setup the Millikan oil drop apparatus and determine the charge of an electron.

10. To show the tunnelling effect in tunnel diode using I-V characteristics.
11. To determine the wavelength of laser source using diffraction of single slit.
12. To determine the wavelength of laser source using diffraction of double slits.
13. To determine (1) wavelength and (2) angular spread of He-Ne laser using plane diffraction grating.

*Reference Books*

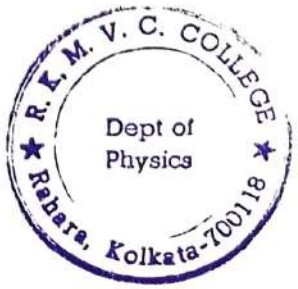
1. Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
3. A Text Book of Practical Physics, I. Prakash & Ramakrishna,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

## Course Outcomes (COs)

After successful completion of this course, the students will be able to

| CO No. | Course Outcomes | Cognitive Level | PO Addressed | PSO Addressed |
|---|---|---|---|---|
| CO-1 | Understand the inadequacies of classical mechanics and appreciate the historical development of quantum mechanics and its applicability. | U, Ap | PO3, PO5 | PSO1, PSO2 |
| CO-2 | Apply Schrödinger equation to analyze time dependent and time independent quantum mechanical problems | Ap | PO2, PO4 | PSO2, PSO5 |
| CO -3 | Remember and understand nuclear properties (eg. nuclear structure, radioactivity, fission, fusion etc.) | R, U | PO2, PO5 | PSO1 |
| CO -4 | Understand basics of laser theory and apply laser techniques as experimental device. | U, Ap, C | PO3, PO5, PO6 | PSO3, PSO4 |
| CO-5 | Understand quantum mechanical tunnelling and determine fundamental constants through experiments. | U, E | PO4, PO5 | PSO2, PSO4 |

R= remembering, U = understanding, Ap = applying, An = analysing, E = evaluating, and C = creating



| 3.10. Analog Systems and Applications | | | |
|---|---|---|---|
| Core Course | Course Code : UGPHYCC10 | Course Credit : 6 | SEM - IV |

## Course objectives

1) To understand basics of solid state electronic devices and their applications towards industrial and household demands.
2) To perform experiments to understand basic mechanism of devices and also to construct circuits for practical purpose.

| Analog Systems and Applications (Theory) | | |
|---|---|---|
| Paper: UGPHYCC10 (Theory) | Credit : 4 | Course duration: 60 lectures |

- **Semiconductor Diodes** **(10 Lectures)**
  P and N type semiconductors. Energy level diagram. Conductivity and mobility, concept of drift velocity. PN junction fabrication (simple idea). Barrier formation in PN junction diode. Static and dynamic resistance. Current flow mechanism in Forward and Reverse biased diode. Drift velocity. Derivation for barrier potential, Barrier width and Current for Step junction.

- **Two-terminal Devices and their Applications** **(06 Lectures)**
  Rectifier Diode: Half-wave rectifiers. Centre-tapped and Bridge full-wave rectifiers, Calculation of ripple factor and rectification efficiency, C-filter.
  Zener diode and voltage regulation. Principle and structure of (1) LEDs, (2) Photodiode and (3) Solar cell.

- **Bipolar Junction transistors** **(06 Lectures)**
  n-p-n and p-n-p transistors. Characteristics of CB, CE and CC configurations. Current gains $\alpha$ and $\beta$ relations between $\alpha$ and $\beta$. Load line analysis of transistors. DC load line and Q-point. Physical mechanism of current flow. Active, Cutoff and Saturation regions.

- **Field Effect transistors** **(02 Lectures)**
  Basic principle of operations only.

- **Amplifiers**
  *Amplifiers*: **(10 Lectures)**
  Transistor biasing and Stabilization circuits. Fixed bias and voltage divider bias. Transistor as 2-port network. h-parameter equivalent circuit. Analysis of a single-stage CE amplifier using hybrid model. Input and output impedance. Current, Voltage and Power gains. Classification of class A, B & C amplifiers. Frequency response of a CE amplifier.

  *Coupled Amplifier*: **(04 Lectures)**
  Two stage RC-coupled amplifier.

  *Feedback in Amplifiers*: **(04 Lectures)**
  Effects of Positive and Negative feedback on input impedance, output impedance, Gain, Stability, Distortion and Noise.

*Sinusoidal Oscillators*: **(04 Lectures)**
Barkhausen's criterion for self-sustained oscillations. RC phase shift oscillator, determination of Frequency. Hartley & Colpitts oscillators.

*Operational Amplifiers (Black Box approach)*: **(04 Lectures)**
Characteristics of an ideal and practical Op-Amp. (IC741) Open-loop and Closed-loop gain. Frequency response. CMRR. Slew rate and concept of virtual ground.

*Applications of Op-Amps*: **(09 Lectures)**
Linear - (1) Inverting and non-inverting amplifiers, (2) Adder, (3) Subtractor, (4) Differentiator, (5) Integrator, (6) Log amplifier, (7) Zero crossing detector (8) Weinbridge oscillator.
Non-linear – (1) inverting and non-inverting comparators, (2) Schmidt triggers.

*Conversion*: **(03 Lectures)**
Resistive network (weighted and R-2R ladder). Accuracy and Resolution. A/D conversion (successive approximation)

***Reference Books***


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


| **Analog Systems and Applications (Practical)** | | |
|---|---|---|
| **Paper: UGPHYCC10 (Practical)** | **Credit : 2** | **Course duration: 60 hrs.** |

**List of Practical**

1. To study V-I characteristics of PN junction diode, and Light emitting diode.
2. To study the V-I characteristics of a Zener diode and its use as voltage regulator.
3. Study of V-I & power curves of solar cells, and find maximum power point & efficiency.
4. To study the characteristics of a Bipolar Junction Transistor in CE configuration.
5. To study the various biasing configurations of BJT for normal class A operation.
6. To design a CE transistor amplifier of a given gain (mid-gain) using voltage divider bias.
7. To study the frequency response of voltage gain of a RC-coupled transistor amplifier.
8. To design a Wien bridge oscillator for given frequency using an op-amp.
9. To design a phase shift oscillator of given specifications using BJT.
10. To study the Colpitt's oscillator.

11. To design a digital to analog converter (DAC) of given specifications.
12. To study the analog to digital convertor (ADC) IC.
13. To design an inverting amplifier using Op-amp (741,351) for dc voltage of given gain.
14. To design inverting amplifier using Op-amp (741,351) and study its frequency response.
15. To design non-inverting amplifier using Op-amp (741,351) & study its frequency response.
16. To study the zero-crossing detector and comparator.
17. To add two dc voltages using Op-Amp in inverting and non-inverting mode.
18. To design a precision differential amplifier of given I/O specification using Op-Amp.
19. To investigate the use of an op-amp as an integrator.
20. To investigate the use of an op-amp as a differentiator.
21. To design a circuit to simulate the solution of a 1st/2nd order differential equation.

*Reference Books*

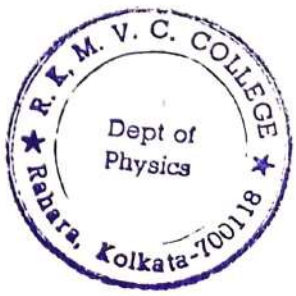
1. Basic Electronics: A text lab manual, P. B. Zbar, A. P. Malvino, M.A. Miller, 1994, Mc-Graw Hill.
2. OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall.
3. Electronic Principle, Albert Malvino, 2008, Tata Mc-Graw Hill.
4. Electronic Devices & Circuit Theory, R. L. Boylestad & L. D. Nashelsky, 2009, Pearson.

## Course Outcomes (COs)

After successful completion of this course, the students will be able to

| CO No. | Course Outcomes | Cognitive Level | PO Addressed | PSO Addressed |
|---|---|---|---|---|
| CO-1 | Understand working mechanism of various semiconductor devices like diodes, solar cell, rectifier, transistors etc. | U | PO2, PO5, PO6 | PSO1, PSO2 |
| CO-2 | Evaluate transistor parameters and employ it as amplifier stage in analog circuits. | An, C | PO4, | PSO3, PSO4 |
| CO -3 | Understand the working of OP-AMP and its versatile applications. | U, Ap | PO3, PO5 | PSO3, PSO4 |
| CO -4 | Understand the working principle of oscillator and apply the knowledge to design oscillator circuit of specific frequencies. | Ap, C | PO4, PO6 | PSO4 |

R= remembering, U = understanding, Ap = applying, An = analysing, E = evaluating, and C = creating



| 3.11. Quantum Mechanics and Applications | | | |
|---|---|---|---|
| Core Course | Course Code : UGPHYCC11 | Course Credit : 6 | SEM - V |

## Course objectives

1) Understand quantum mechanical states and operators.
2) Gain ability to apply formulation of quantum mechanics for analyzing quantum systems (e.g. atoms) in absence/presence of external perturbations.
3) To perform experiments and computer simulations to observe quantum mechanical effects.

| Quantum Mechanics and Applications (Theory) | | |
|---|---|---|
| Paper: UGPHYCC11 (Theory) | Credit : 4 | Course duration: 60 lectures |

- **Schrodinger Equation** **(16 Lectures)**

Time dependent Schrödinger equation: Time dependent Schrodinger equation and dynamical evolution of a quantum state; Properties of wave function. Interpretation of wave function probability and probability current densities in three dimensions; Conditions for physical acceptability of wave functions. Normalization. Linearity and Superposition principles. Eigenvalues and Eigenfunctions. Position, momentum and energy operators; commutator of position and momentum operators; expectation values of position and momentum. Wave Function of a Free particle.

Time independent Schrödinger equation - Hamiltonian, stationary states and energy eigenvalues; expansion of an arbitrary wave function as a linear combination of energy eigenfunctions; General solution of the time dependent Schrödinger equation in terms of linear combinations of stationary states; Application to spread of Gaussian wave-packet for a free particle in one dimension; wave packets, Fourier transforms and momentum space wave function; Position-momentum uncertainty principle.

- **General discussion of bound states in an arbitrary potential** **(12 Lectures)**

Continuity of wave function, boundary condition and emergence of discrete energy levels; application to one-dimensional problem - square well potential; Quantum mechanics of simple harmonic oscillator - energy levels and energy eigenfunctions using Frobenius method; Hermite polynomials; ground state, zero point energy & uncertainty principle.

- **Quantum theory of hydrogen-like atoms** **(10 Lectures)**

Time independent Schrödinger equation in spherical polar coordinates; separation of variables for second order partial differential equation; angular momentum operator & quantum numbers; Radial wave functions from Frobenius method; shapes of the probability densities for ground & first excited states; Orbital angular momentum quantum numbers l and m; s, p, d shells.

- **Atoms in Electric & Magnetic Fields** **(08 Lectures)**

Electron angular momentum. Space quantization. Electron spin and spin angular momentum. Larmor's theorem. Spin magnetic moment. Stern-Gerlach experiment. Zeeman effect: Electron magnetic moment and magnetic energy, Gyromagnetic ratio and Bohr magneton.

- **Atoms in External Magnetic Fields** **(04 Lectures)**
  Normal and Anomalous Zeeman effect. Paschen Back and Stark effect (Qualitative discussion only).

- **Many electron atoms** **(10 Lectures)**
  Pauli's exclusion principle. Symmetric & Antisymmetric wave functions. Periodic table. Fine structure. Spin orbit coupling. Spectral notations for atomic states. Total angular momentum. Vector model. Spin-orbit coupling in atoms - *L-S* and *J-J* couplings. Hund's rule. Term symbols. spectra of hydrogen and alkali atoms (Na etc.).

*Reference Books*


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

*Additional Books for Reference*

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


| **Quantum Mechanics and Applications (Practical)** | | |
|---|---|---|
| **Paper: UGPHYCC11 (Practical)** | **Credit: 2** | **Course duration: 60 hrs.** |

**List of Practical**

1. Solve the s-wave radial Schrödinger equation for the ground state and the first excited state of the hydrogen atom.
2. Solve the s-wave radial Schrödinger equation for an atom for the screened coulomb potential.
3. Solve the s-wave radial Schrödinger equation for a particle of mass m for an anharmonic oscillator potential.
4. Solve the s-wave radial Schrödinger equation for the vibrations of hydrogen molecule.

*Laboratory Based Experiments*

5. Study of Electron spin resonance- determine magnetic field as a function of the resonance frequency.
6. Study of Zeeman effect: with external magnetic field; Hyperfine splitting.
7. To show the tunnelling effect in tunnel diode using I-V characteristics.
8. Quantum efficiency of CCDs.

*Reference Books*

1. An introduction to computational Physics, T. Pang, 2nd Edn., 2006, Cambridge Univ. Press.
2. Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific &Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández.2014 Springer.

## Course Outcomes (COs)

After successful completion of this course, the students will be able to

| CO No. | Course Outcomes | Cognitive Level | PO Addressed | PSO Addressed |
|---|---|---|---|---|
| CO-1 | Understand Schrödinger equation and dynamical evolution of quantum states, acceptability & interpretation of wave function, operators, eigen values, eigen functions. | U | PO2, PO5 | PSO1, PSO2 |
| CO-2 | Gain knowledge on bound quantum systems and apply to analyse bound quantum mechanical systems like simple harmonic oscillator, hydrogen-like atoms etc. | Ap, An | PO3, PO4, PO5 | PSO2, PSO3 |
| CO -3 | Understand and explain the vector atom model, angular momentums, concepts of space quantization etc. | U | PO3 | PSO1, PSO2 |
| CO -4 | Explain observed dependence of atomic spectral lines on external perturbations (Zeeman effect, Paschen Back & Stark effect). | An | PO4, PO5 | PSO3, PSO4 |
| CO-5 | Perform experiments to observe quantum phenomena and construct specific experimental techniques to identify chemical nature of source of radiation. | An, E, C | PO4, PO5, PO6 | PSO3, PSO4 |
| CO-6 | Estimate of magnetic field at a remote location by analyzing the spectrum of outcoming radiation. | C | PO4, PO5, PO6 | PSO3, PSO4, PSO5 |

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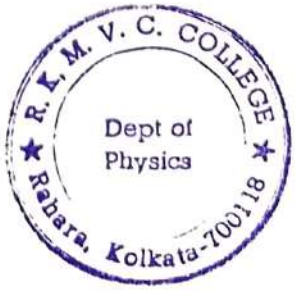

| 3.12. Solid State Physics | | | |
|---|---|---|---|
| Core Course | Course Code : UGPHYCC12 | Course Credit : 6 | SEM - V |

## Course objectives

1) To understand basics of crystalline systems and analyze crystal structures.
2) To classify solid substances based on electrical and magnetic properties and associated applicability of these in material sciences.
3) To analyze macroscopic properties of solids through experiments.

| Solid State Physics (Theory) | | |
|---|---|---|
| Paper: UGPHYCC12 (Theory) | Credit : 4 | Course duration: 60 lectures |

- **Crystal Structure** **(12 Lectures)**
  Solids: Amorphous and Crystalline materials. Lattice translation vectors. Lattice with a basis – central and non-central elements. Unit Cell. Miller indices. Reciprocal lattice. Types of lattices. Brillouin zones. Diffraction of X-rays by crystals. Bragg's law. Atomic scattering factor. Geometrical structure factor.

- **Elementary Lattice Dynamics** **(08 Lectures)**
  Lattice vibrations and phonons: Linear monoatomic and diatomic chains. Acoustical and Optical phonons. Qualitative description of the phonon spectrum in solids. Dulong and Petit's law, Einstein and Debye theories of specific heat of solids. $T^3$ law.

- **Magnetic Properties of Matter** **(08 Lectures)**
  Dia-, Para-, Ferri- and Ferromagnetic materials. Langevin's classical theory of dia– and paramagnetism. Quantum mechanical treatment of paramagnetism. Curie's law. Weiss's theory of Ferromagnetism and Ferromagnetic domains. Discussion of B-H curve. Hysteresis and energy loss.

- **Dielectric Properties of Materials** **(08 Lectures)**
  Polarization. Local electric field at an atom. Depolarization field. Electric susceptibility. Polarizability. Clausius Mosotti equation. Classical theory of electric polarizability. Normal and Anomalous dispersion. Cauchy and Sellmeir relations. Langevin-Debye equation. Complex dielectric constant. Optical phenomena. Application: Plasma oscillations, Plasma frequency, Plasmons, TO modes.

- **Elementary band theory** **(08 Lectures)**
  Kronig Penny model. Band structure. Band gap. Energy ($E$) vs. wave vector ($k$) relationship. Brillouin zones. Concept of effective mass of electrons and holes. Distinction between metals, insulators and semiconductors. Drift velocity, mobility and conductivity.

- **Semiconductors** **(08 Lectures)**
  Intrinsic and Extrinsic semiconductors. Carrier concentration and Fermi level for intrinsic and extrinsic semiconductors. Law of mass action. Hall effect. Measurement of conductivity (4-probe method) & Hall coefficient.

- **Superconductivity** **(08 Lectures)**
  Experimental results. Critical temperature. Critical magnetic field. Meissner effect. Type-I and type-II superconductors, London's equation and penetration depth. Isotope effect, idea of BCS theory (no derivation).

*Reference Books*


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


| **Solid State Physics (Practical)** | | |
|---|---|---|
| **Paper: UGPHYCC12 (Practical)** | **Credit: 2** | **Course duration: 60 hrs.** |

**List of Practical**

1. Measurement of susceptibility of paramagnetic solution (Quinck`s tube method).
2. To measure the magnetic susceptibility of solids.
3. To determine the coupling coefficient of a piezoelectric crystal.
4. To measure the dielectric constant of a dielectric materials with frequency.
5. To determine the complex dielectric constant and plasma frequency of metal using surface plasmon resonance (SPR).
6. To determine the refractive index of a dielectric layer using SPR.
7. To draw the BH curve of Fe using solenoid & determine energy loss from hysteresis.
8. To measure the resistivity of a semiconductor (Ge) with temperature by four-probe method (room temperature to 150 $^{0}$C) and to determine its band gap.
9. To determine the Hall coefficient of a semiconductor sample.

*Reference Books*


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

## Course Outcomes (COs)

After successful completion of this course, the students will be able to

| CO No. | Course Outcomes | Cognitive Level | PO Addressed | PSO Addressed |
|---|---|---|---|---|
| CO-1 | Understand basic concept of crystal structure. Apply the ideas to analyze crystal structure of unknown sample. | U, Ap, An | PO3, PO4, PO6 | PSO2. PSO4 |
| CO-2 | Understand elementary lattice vibrations, phonons, specific heat of solids, dielectric properties of materials etc. | U | PO2, PO5 | PSO1, PSO5 |
| CO -3 | Understand energy band formation in solids and analyze materials as metal, insulator and semiconductors based on band structure. | U, An | PO4, PO5 | PSO2, PSO3 |
| CO -4 | Understand magnetism in material and the superconductivity phenomena. | U | PO2, PO5 | PSO2, PSO3 |
| CO-5 | Perform experiments to demonstrate various important phenomena and predict the crystal structure of an unknown. | U, E, C | PO4, PO6 | PSO3, PSO4, PSO5 |

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Dept of Physics
Rahara, Kolkata-700118

| 3.13. Electromagnetic Theory | | | |
|---|---|---|---|
| Core Course | Course Code : UGPHYCC13 | Course Credit : 6 | SEM - VI |

## Course objectives

1) To understand the theory of electromagnetism governed by Maxwell's equations.
2) To understand electromagnetic wave and application of it in modern communication systems.
3) To analyze optically active substances using polarized light through experiments.

| Electromagnetic Theory (Theory) | | |
|---|---|---|
| Paper: UGPHYCC13 (Theory) | Credit : 4 | Course duration: 60 lectures |

- **Maxwell Equations** **(12 Lectures)**
  Maxwell's equations. Displacement current. Vector and scalar potentials. Gauge transformations: Lorentz and Coulomb gauge. Boundary conditions at interface between different media. Wave equations. Plane waves in dielectric media. Poynting theorem and Poynting vector. Electromagnetic (EM) energy density. Physical concept of electromagnetic field energy density, Momentum density and angular momentum density.

- **EM Wave Propagation in Unbounded Media** **(10 Lectures)**
  Plane EM waves through vacuum and isotropic dielectric medium, transverse nature of plane EM waves, refractive index and dielectric constant, wave impedance. Propagation through conducting media, relaxation time, skin depth. Wave propagation through dilute plasma, electrical conductivity of ionized gases, plasma frequency, refractive index, skin depth, application to propagation through ionosphere.

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

- **Polarization of Electromagnetic Waves** **(12 Lectures)**
  Description of linear, circular and elliptical polarization. Propagation of EM waves in anisotropic media. Symmetric nature of dielectric tensor. Fresnel's formula. Uniaxial and Biaxial crystals. Light propagation in Uniaxial crystal. Double refraction. Polarization by double refraction. Nicol prism. Ordinary & extraordinary refractive indices. Production & detection of plane, circularly and elliptically polarized light. Phase retardation plates: Quarter-wave and half-wave plates. Babinet compensator and its uses. Analysis of polarized light

- **Rotatory Polarization** **(05 Lectures)**
  Optical rotation. Biot's laws for rotatory polarization. Fresnel's theory of optical rotation. Calculation of angle of rotation. Experimental verification of Fresnel's theory. Specific rotation. Laurent's half-shade polarimeter.

- **Wave guides** **(08 Lectures)**
  Planar optical wave guides. Planar dielectric wave guide. Condition of continuity at interface. Phase shift on total reflection. Eigenvalue equations. Phase and group velocity of guided waves. Field energy and power transmission.

- **Optical Fibres** **(03 Lectures)**
  Numerical aperture. Step and Graded indices (definitions only). Single and multiple mode fibres (concept and definition only).

*Reference Books*


1. Introduction to Electrodynamics, D. J. Griffiths, 3rd Ed., 1998, Benjamin Cummings.
2. Optics, E. Hecht, 2016, Pearson.
3. Elements of Electromagnetics, M. N. O. Sadiku, 2001, Oxford University Press.
4. Introduction to Electromagnetic Theory, T. L. Chow, 2006, Jones & Bartlett Learning.
5. Fundamentals of Electromagnetics, M. A. W. Miah, 1982, Tata McGraw Hill.
6. Electromagnetic field Theory, R. S. Kshetrimayun, 2012, Cengage Learning .
7. Engineering Electromagnetic, Willian H. Hayt, 8th Edition, 2012, McGraw Hill.
8. Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010.


*Additional Books for Reference.*


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


| **Electromagnetic Theory (Practical)** | | |
|---|---|---|
| **Paper: UGPHYCC13 (Practical)** | **Credit : 2** | **Course duration: 60 hrs.** |

**List of Practical**

1. To verify the law of Malus for plane polarized light.
2. To analyze elliptically polarized Light by using a Babinet's compensator.
3. To study dependence of radiation on angle for a simple dipole antenna.
4. To determine the wavelength and velocity of ultrasonic waves in a liquid (Kerosene Oil, Xylene, etc.) by studying the diffraction through ultrasonic grating.
5. To study the reflection, refraction of microwaves.
6. To study polarization and double slit interference in microwaves.
7. To determine the refractive index of liquid by total internal reflection using Wollaston's air-film.
8. To determine the refractive Index of (1) glass and (2) a liquid by total internal reflection using a Gaussian eyepiece.

9. To study the polarization of light by reflection and determine the polarizing angle for air-glass interface.
10. To verify the Stefan's law of radiation and to determine Stefan's constant.
11. To determine the Boltzmann constant using V-I characteristics of PN junction diode.

*Reference Books*

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

## Course Outcomes (COs)

After successful completion of this course, the students will be able to

| CO No. | Course Outcomes | Cognitive Level | PO Addressed | PSO Addressed |
|---|---|---|---|---|
| CO-1 | Remember and understand basic laws of electrodynamics. | R, U | PO2 | PSO1 |
| CO-2 | Deduce wave equation from Maxwell's equations. | Ap | PO3, PO5 | PSO2 |
| CO -3 | Apply Maxwell's equations to understand the reflection and refraction of EM wave. Understand wave guides. | Ap, An | PO3, PO4 | PSO2, PSO3 |
| CO -4 | Understand polarization of light. Analyze polarization states by retardation plates. | U, An | PO4, PO5 | PSO3, PSO4 |
| CO-5 | Understand the phenomenon associated with EM wave through experiments and estimate concentration of optically active solutes. | U, An, C | PO3, PO4, PO6 | PSO3, PSO4 |

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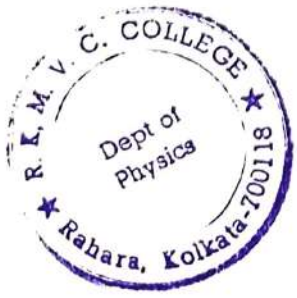


| 3.14. Statistical Mechanics | | | |
|---|---|---|---|
| Core Course | Course Code : UGPHYCC14 | Course Credit : 6 | SEM - VI |

## Course objectives

1) To understand basic notion of statistical mechanics and apply the formulation of statistical mechanics for macroscopic systems to analyze their macroscopic properties.
2) Gain ability to write down computer program to simulate statistical systems to obtain various physical properties.

| Statistical Mechanics (Theory) | | |
|---|---|---|
| Paper: UGPHYCC14 (Theory) | Credit : 4 | Course duration: 60 lectures |

- **Classical Statistical Mechanics** **(18 Lectures)**
  Macrostate & microstate, elementary concept of ensemble, microcanonical ensemble, phase space, entropy and thermodynamic probability, canonical ensemble, partition function, thermodynamic functions of an ideal gas, classical entropy expression, Gibbs paradox, Sackur Tetrode equation. Law of equipartition of energy (with proof) – Applications to specific heat and its limitations. Thermodynamic functions of a two-energy levels system, negative temperature. Grand canonical ensemble and chemical potential.

- **Classical Theory of Radiation** **(09 Lectures)**
  Properties of thermal radiation. Blackbody radiation. Pure temperature dependence. Kirchhoff's law. Stefan-Boltzmann law: Thermodynamic proof. Radiation pressure. Wien's displacement law. Wien's distribution law. Saha's ionization formula. Rayleigh-Jean's law. Ultraviolet catastrophe.

- **Quantum Theory of Radiation** **(05 Lectures)**
  Spectral distribution of black body radiation. Planck's quantum postulates. Planck's law of blackbody radiation: experimental verification. Deduction of (1) Wien's distribution law, (2) Rayleigh-Jeans law, (3) Stefan-Boltzmann l, (4) Wien's displacement law from Planck's law.

- **Bose-Einstein Statistics** **(13 Lectures)**
  B-E distribution law, Thermodynamic functions of a strongly degenerate Bose gas, Bose-Einstein condensation, properties of liquid He (qualitative description). Radiation as a photon gas and thermodynamic functions of photon gas. Bose derivation of Planck's law.

- **Fermi-Dirac Statistics** **(15 Lectures)**
  Fermi-Dirac distribution law. Thermodynamic functions of a completely and strongly degenerate Fermi gas, Fermi energy. Electron gas in a metal, specific heat of metals. Relativistic Fermi gas, white dwarf stars, Chandrasekhar mass limit.

***Reference Books***

1. Statistical Mechanics, R. K. Pathria, Butterworth Heinemann: 2nd Ed.,1996, Oxford University Press.
2. Statistical Physics, Berkeley Physics Course, F. Reif, 2008, Tata McGraw-Hill.

3. Statistical and Thermal Physics, S. Lokanathan and R. S. Gambhir. 1991, Prentice Hall.
4. Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Francis W. Sears and Gerhard L. Salinger, 1986, Narosa.
5. Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer.
6. An Introduction to Statistical Mechanics & Thermodynamics, R. H. Swendsen, 2012, Oxford Univ. Press.
7. Statistical Mechanics – an elementary outline, A. Lahiri, 2008, Universities Press.

| **Statistical Mechanics (Practical)** | | |
|---|---|---|
| **Paper: UGPHYCC14 (Practical)** | **Credit : 2** | **Course duration: 60 hrs.** |

**List of Practical**

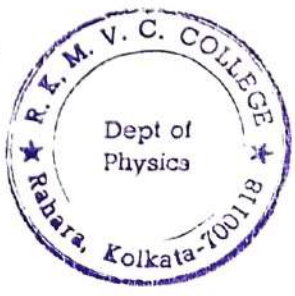
1. Computational analysis of the behaviour of a collection of particles in a box that satisfy Newtonian mechanics and interact via the Lennard-Jones potential, varying the total number of particles N and the initial conditions:
   (a) Study of local number density in the equilibrium state (i) average; (ii) fluctuations
   (b) Study of transient behaviour of the system (approach to equilibrium)
   (c) Relationship of large N and the arrow of time
   (d) Computation of the velocity distribution of particles for the system and comparison with the Maxwell velocity distribution
   (e) Computation and study of mean molecular speed and its dependence on particle mass
   (f) Computation of fraction of molecules in an ideal gas having speed near the most probable speed

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

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

4. Plot specific heat of solids (a) Dulong-Petit law, (b) Einstein distribution function, (c) Debye distribution function for high temperature and low temperature and compare them for these two cases.

5. Plot the following functions with energy at different temperatures:
   (a) Maxwell-Boltzmann distribution
   (b) Fermi-Dirac distribution
   (c) Bose-Einstein distribution



***Reference Books***


1. Elementary Numerical Analysis, K. E. Atkinson, 3 rd Edn . 2007 , Wiley India Edition.
2. Statistical Mechanics, R. K. Pathria, Butterworth Heinemann: 2nd Ed., 1996, Oxford University Press.
3. Introduction to Modern Statistical Mechanics, D. Chandler, Oxford University Press, 1987.
4. Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Francis W. Sears and Gerhard L. Salinger, 1986, Narosa.
5. Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer.
6. Statistical and Thermal Physics with computer applications, Harvey Gould and Jan Tobochnik, Princeton University Press, 2010.
7. Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández. 2014 Springer ISBN: 978-3319067896


## Course Outcomes (COs)

After successful completion of this course, the students will be able to

| CO No. | Course Outcomes | Cognitive Level | PO Addressed | PSO Addressed |
|---|---|---|---|---|
| CO-1 | Remember and understand laws of thermodynamics and their applications. | R, U | PO2 | PSO1 |
| CO-2 | Appreciate statistical interpretation of thermodynamics, microcanonical, canonical and grand canonical ensembles. | U | PO3, PO6 | PSO1, PSO5 |
| CO -3 | Apply the statistical approach to calculate macroscopic properties of bosonic and fermionic systems. | Ap, An | PO3, PO4, PO5 | PSO2, PSO5 |
| CO -4 | Apply theoretical knowledge to write down computer codes to simulate and extract statistical properties of system of particles. | Ap, C | PO5, PO6 | PSO2, PSO4, PSO5 |

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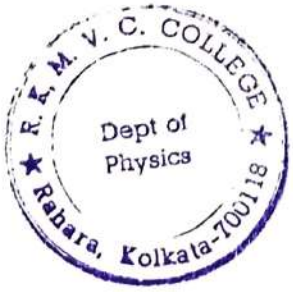
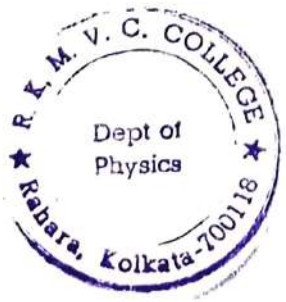


# 4. Syllabi for Discipline Specific Elective (DSE) Courses



| 4.1. Advanced Mathematical Physics – I | | | |
|---|---|---|---|
| DSE Course | Course Code : UGPHYDSE01 | Course Credit : 6 | SEM – V |

**Course objectives** Course content added/modified = 80%

1) To understand Lagrangian and Hamiltonian formulation to analyze dynamical systems.
2) To understand linear vector space and its application in physics.
3) To have detail knowledge on the theory of probability and distribution function to describe random processes in physical systems.

| Advanced Mathematical Physics - I | | |
|---|---|---|
| Paper: UGPHYDSE01 | Credit : 6 | Course duration: 75 lectures |

- **Analytical Dynamics** **(25 lectures)**

Recapitulation of Lagrangian and Hamiltonian formulations of mechanics. Symmetries and conservation principles. Determination of constraint forces. Canonical transformations and generating fucntions; their use in solving canonical equations of motion; Maxwell's relations. Poisson brackets and their invariance under canonical transformations. Time variation of a dynamical variable in terms of Poisson bracket; relation with constants of motion, determination of new constants of motion using Poisson bracket. Liouville's theorem.

- **Linear Vector Spaces** **(25 lectures)**

Abstract Systems. Binary Operations and Relations. Introduction to Groups and Fields. Definition and properties of Linear Vector Spaces and Subspaces. Linear Independence and Dependence of Vectors. Basis and Dimensions of a Vector Space - definitions and properties. Inner products. Gram-Schmidt orthogonalization. Orthogonal basis. Change of basis. Homomorphism and Isomorphism of Vector Spaces. Linear Transformations andlinear Operators. Algebra of Linear Transformations. Non-singular Transformations. Representation of Linear Transformations by Matrices. Orthogonal and unitary transformations and their matrix representations.

- **Advanced Probability Theory** **(25 Lectures)**

Fundamental Probability Theorems. Conditional Probability, Bayes' Theorem, Repeated Trials, Binomial and Multinomial expansions. Random Variables and probability distributions, Expectation and Variance, Special Probability distributions; The binomial distribution, The Poisson distribution, Continuous distribution: The Gaussian (or normal) distribution, Central limit theorem. The principle of least squares. Chi-squared distribution - goodness of fit.

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***Reference Books***


1. Classical Mechanics, H.Goldstein, C.P. Poole, J.L. Safko, 3rd Edn. 2002, Pearson Education.
2. Classical Mechanics: System of Particles and Hamiltonian Dynamics. W. Greiner, 2nd Edn. 2010, Springer.
3. Mechanics, Vol 1, Course on Theoretical Physics, L.D. Landau and E. M. Lifshitz, 3rd Edition. 2000, Butterworth-Heinemann.
4. Classical Mechanics: A Course of Lectures, A. K. Raychaudhuri, 1983, Oxford University Press.

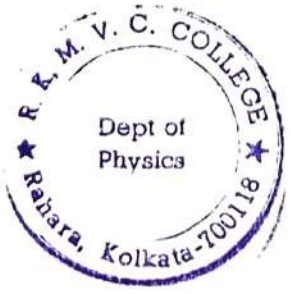
5. Classical Mechanics, R. Douglas Gregory, 2015, Cambridge University Press.
6. Mathematical Methods for Physicis& Engineers, K. F. Riley, M.P. Hobson, S.J. Bence, 3rd Ed., 2006, Cambridge University Press.
7. Mathematical Methods for Physicists: Weber and Arfken, 2005, Academic Press.
8. Mathematical Tools for Physics, James Nearing, 2010, Dover Publications .
9. Modern Mathematical Methods for Physicists and Engineers, C.D. Cantrell, 2011, Cambridge University Press.
10. Introduction to Matrices and Linear Transformations, D.T. Finkbeiner, 1978, Dover Pub.
11. Linear Algebra, W. Cheney, E.W.Cheney&D.R.Kincaid, 2012, Jones & Bartlett Learning.
12. Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole.
13. Mathematical Methods for Physicists: A Concise Introduction: Tai L. Chow, 2000, Cambridge Univ. Press.
14. Introduction to Mathematical Physics: Methods & Concepts: Chun Wa Wong, 2012, Oxford University Press.
15. Introduction to Mathematical Probability, J. V. Uspensky, 1937, Mc Graw-Hill.

## Course Outcomes (COs)

After successful completion of this course, the students will be able to

| CO No. | Course Outcomes | Cognitive Level | PO Addressed | PSO Addressed |
|---|---|---|---|---|
| CO-1 | Understand the mathematical concept of Lagrangian and the Hamiltonian formulation, canonical transformation and Poisson's bracket. Gain ability to analyze dynamical systems with these formulations. | U, Ap | PO2, PO3 | PSO2, PSO3 |
| CO-2 | Understand basic idea of Linear Vector Space. Gain ability to apply their understandings on various physical problems. | U, Ap | PO2, PO3 | PSO2, PSO3 |
| CO -3 | Understand theory of probability, distribution functions, $\chi^2$ distribution for fitting of large data samples. | U | PO2, PO5 | PSO2 |
| CO -4 | Gain ability to write down codes to analyze various physical systems | C | PO3, PO6 | PSO5 |

R= remembering, U = understanding, Ap = applying, An = analysing, E = evaluating, and C = creating



| 4.2. Advanced Dynamics | | | |
|---|---|---|---|
| DSE Course | Course Code : UGPHYDSE02 | Course Credit : 6 | SEM – V |

Course content added/modified = 80%

**Course objectives**

1) To understand statistical description of large system dynamics.
2) To have detail understanding of oscillatory motion and its connection in interdisciplinary sciences.
3) Understand the detail theory of STR and related dynamics.

| Advanced Dynamics | | |
|---|---|---|
| Paper: UGPHYDSE02 | Credit : 6 | Course duration: 75 lectures |

- **Statistical Description of Large System Dynamics** **(25 lectures)**

Elementary concept of ensemble. Phase space trajectories, density function. Liouville's theorem. Macrostate & Microstate. Concept of time averaging in a macroscopic measurement. Statement of Ergodic hypothesis Ensemble average. Microcanonical ensemble, postulate of equal a priori probability. Entropy and Thermodynamic Probability, Canonical ensemble, Partition Function, Thermodynamic Functions of an Ideal Gas, Classical Entropy Expression, Gibbs Paradox, Sackur Tetrode equation, Law of Equipartition of Energy. Thermodynamic Functions of a Two-Energy Levels System, Negative Temperature. Grand canonical ensemble and chemical potential. Collection of non-interacting identical particles. Classical approach and quantum approach: Distinguishability and indistinguishability. Occupation number and MB distribution, emergence of Boltzmann factor. Composite system postulate and symmetry postulate of quantum mechanics. Bosons and Fermions. Spin statistics theorem (statement only). Pauli exclusion principle for Fermions. Bose-Einstein and Fermi-Dirac distributions - their features.

- **Small Amplitude Oscillations and Beyond** **(17 lectures)**

Phase space trajectories for single particle motion in one dimension: Equilibrium points and their stability analysis; Nature of nearby trajectories. Minima of potential energy for a system of particles. and points of stable equilibrium, expansion of the potential energy around a minimum, small amplitude oscillations about the minimum, normal modes of oscillations example of N identical masses connected in a linear fashion to (N –1) identical springs. Phase space trajectories for one-dimensional harmonic oscillator; modification of trajectories with introduction of cubic and quartic terms in the expansion of potential energy. Phase space trajectories of a pendulum.

- **Special Theory of Relativity** **(33 lectures)**

Postulates of Special Theory of Relativity. Lorentz Transformations. Minkowski space. The invariant interval, light cone and world lines. Space-time diagrams. Time- dilation, length contraction and twin paradox. Four-vectors: space-like, time-like and light-like. Four-velocity and acceleration. Metric and alternating tensors. Minkowski Space. Contravariant & Covariant Vectors. Contravariant, Covariant and Mixed Tensors. Four momentum and energy- momentum relation. Doppler effect from a four vector perspective. Concept of four-force. Conservation of four-momentum. Relativistic kinematics. Application to two-body decay of an unstable particle.

***Reference Books***

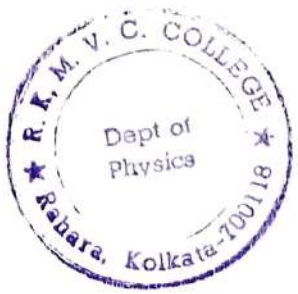

1. Classical Mechanics, H. Goldstein, C. P. Poole, J. L. Safko, 3rd Edn. 2002, Pearson Education.
2. Mechanics, L. D. Landau and E. M. Lifshitz, 1976, Pergamon.
3. Classical Electrodynamics, J. D. Jackson, 3rd Edn., 1998, Wiley.
4. The Classical Theory of Fields, L. D. Landau, E. M Lifshitz, 4th Edn., 2003, Elsevier.
5. Introduction to Electrodynamics, D. J. Griffiths, 2012, Pearson Education.
6. Classical Mechanics, P. S. Joag, N. C. Rana, 1st Edn., McGraw Hall.
7. Classical Mechanics, R. Douglas Gregory, 2015, Cambridge University Press.
8. Classical Mechanics: An introduction, Dieter Strauch, 2009, Springer.
9. Solved Problems in classical Mechanics, O. L. Delange and J. Pierrus, 2010, Oxford Press


## Course Outcomes (COs)

After successful completion of this course, the students will be able to

| CO No. | Course Outcomes | Cognitive Level | PO Addressed | PSO Addressed |
|---|---|---|---|---|
| CO-1 | Understand microstates and macrostates to appreciate macroscopic behaviour of many body systems as a manifestation of microscopic dynamics. | U, Ap | PO2, PO5 | PSO3 |
| CO-2 | Understand behaviour of mechanical system near equilibrium and analyze small amplitude oscillatory systems. | U, An | PO3, PO4 | PSO3, PSO4 |
| CO -3 | Understand tensor in the context of STR. | U, Ap | PO2, PO5 | PSO1, PSO2 |
| CO -4 | Write down computer programming to analyze dynamical systems. | C | PO5, PO6 | PSO5 |

R= remembering, U = understanding, Ap = applying, An = analysing, E = evaluating, and C = creating



| 4.3. Communication Electronics | | | |
|---|---|---|---|
| DSE Course | Course Code : UGPHYDSE03 | Course Credit : 6 | SEM – V |

## Course objectives

1) To understand the basic theory of communication systems.
2) To perform experiment with communication system devices.
3) Gain ability to be equipped with modern technologies as per present industrial demands.

| Communication Electronics (Theory) | | |
|---|---|---|
| Paper: UGPHYDSE03 (Theory) | Credit : 4 | Course duration: 60 lectures |

- **Electronic communication** **(08 Lectures)**
  Introduction to communication – means and modes. Need for modulation. Block diagram of an electronic communication system. Brief idea of frequency allocation for radio communication system in India (TRAI). Electromagnetic communication spectrum, band designations and usage. Channels and base-band signals. Concept of noise, signal-to-noise (S/N) ratio.

- **Analog Modulation** **(12 Lectures)**
  Amplitude modulation, modulation index and frequency spectrum. Generation of AM (emitter modulation), Amplitude demodulation (diode detector). Concept of single side band generation and detection. Frequency Modulation (FM) and Phase Modulation (PM), modulation index and frequency spectrum, equivalence between FM and PM, Generation of FM using VCO, FM detector (slope detector), Qualitative idea of super heterodyne receiver

- **Analog Pulse Modulation** **(09 Lectures)**
  Channel capacity, Sampling theorem, Basic Principles- PAM, PWM, PPM, modulation and detection technique for PAM only, Multiplexing.

- **Digital Pulse Modulation** **(10 Lectures)**
  Need for digital transmission, Pulse Code Modulation, Digital Carrier Modulation techniques, Sampling, Quantization and Encoding. Concept of Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK), Phase Shift Keying (PSK), and Binary Phase Shift Keying (BPSK).

- **Introduction to Communication and Navigation systems**

  - ***Satellite Communication:*** **(10 Lectures)**

  Introduction, need, Geosynchronous satellite orbits geostationary satellite advantages of geostationary satellites. Satellite visibility, transponders (C-band), path loss, ground station, simplified block diagram of earth station. Uplink and downlink.

  - ***Mobile Telephony System:*** **(09 Lectures)**

  Basic concept of mobile communication, frequency bands used in mobile communication, concept of cell sectoring and cell splitting, SIM number, IMEI number, need for data encryption, architecture (block diagram) of mobile communication network, idea of GSM, CDMA, TDMA and FDMA technologies, simplified block diagram of mobile phone handset, 2G, 3G and 4G concepts (qualitative only).

- ***GPS navigation system*** (qualitative idea only) **(01 Lectures)**

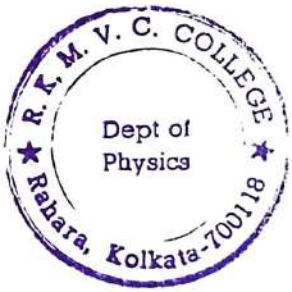
*Reference Books*


1. Electronic Communications, D. Roddy and J. Coolen, Pearson Education India.
2. Advanced Electronics Communication Systems- Tomasi, 6th edition, Prentice Hall.
3. Electronic Communication systems, G. Kennedy, 3rd Edn, 1999, Tata McGraw Hill.
4. Principles of Electronic communication systems – Frenzel, 3rd edition, McGraw Hill.
5. Communication Systems, S. Haykin, 2006, Wiley India.
6. Electronic Communication system, Blake, Cengage, 5th edition.
7. Wireless communications, Andrea Goldsmith, 2015, Cambridge University Press


| **Communication Electronics (Practical)** | | |
|---|---|---|
| **Paper: UGPHYDSE03 (Practical)** | **Credit : 2** | **Course duration: 60 hrs.** |

**List of Practical**

1. To design an Amplitude Modulator using transistor.
2. To study envelope detector for demodulation of AM signal.
3. To study FM - Generator and Detector circuit.
4. To study AM transmitter and receiver.
5. To study FM transmitter and receiver.
6. To study Time Division Multiplexing (TDM).
7. To study Pulse Amplitude Modulation (PAM).
8. To study Pulse Width Modulation (PWM).
9. To study Pulse Position Modulation (PPM).
10. To study ASK, PSK and FSK modulators.




*Reference Books*


1. Electronic Communication systems, G. Kennedy, 1999, Tata McGraw Hill.
2. Electronic Communication system, Blake, Cengage, 5th edition.


## Course Outcomes (COs)

After successful completion of this course, the students will be able to

| CO No. | Course Outcomes | Cognitive Level | PO Addressed | PSO Addressed |
|---|---|---|---|---|
| CO-1 | Understand the basic idea and development of electronic communication systems | U | PO2, PO5 | PO2, PO3 |
| CO-2 | Understand electronic signal processing: modulation and demodulation. Apply their understandings to analyze signal-to-noise ratio. | An, C | PO4, PO6 | PSO4, PSO5 |
| CO -3 | Gain an extended knowledge in navigation systems and have a clear idea on GPS | U | PO2, PO6 | PSO2, PSO3 |
| CO -4 | Design few simple communication devices: modulator, demodulator etc through their laboratory works. | Ap, C | PO3, PO5, PO6 | PSO5 |

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| 4.4. Advanced Mathematical Physics - II | | | |
|---|---|---|---|
| DSE Course | Course Code : UGPHYDSE04 | Course Credit : 6 | SEM – VI |

Course content added/modified = 80%

**Course objectives**

1) To understand basics of group theory and its applications in physics.
2) To understand tensor analysis and its applications in physics.
3) Gain ability to write down computer programming.

| Advanced Mathematical Physics - II | | |
|---|---|---|
| Paper: UGPHYDSE04 | Credit : 6 | Course duration: 75 lectures |

- **Group Theory** **(35 lectures)**

Review of sets, Mapping and Binary Operations, Relation, Types of Relations. Groups: Elementary properties of groups, uniqueness of solution, subgroup, centre of a group, co-sets of a subgroup, cyclic group, Permutation/Transformation. Homomorphism and Isomorphism of group. Normal and conjugate subgroups, Completeness and Kernel. Some special groups with operators. Matrix Representations: Reducible and Irreducible representations. Schur's lemma. Orthogonality theorems. Character tables and their uses. Application to small vibrations. Continuous groups: Generator of Lie group. Rotation group and angular momentum as its generator. Homomorphism between SO(3) and SU(2). Application in quantum mechanics. Homogeneous Lorentz group.

- **Cartesian Tensors** **(30 lectures)**

Transformation of Co-ordinates. Einstein's Summation Convention. Relation between Direction Cosines. Tensors. Algebra of Tensors. Sum, Difference and Product of Two Tensors. Contraction. Quotient Law of Tensors. Symmetric and Anti- symmetric Tensors. Invariant Tensors: Kronecker and Alternating Tensors. Association of Antisymmetric Tensor of Order Two and Vectors. Vector Algebra and Calculus using Cartesian Tensors: Scalar and Vector Products, Scalar and Vector Triple Products. Differentiation. Gradient, Divergence and Curl of Tensor Fields. Vector identities. Tensorial Formulation of Analytical Solid Geometry: Equation of a Line. Angle Between Lines. Projection of a Line on another Line: Condition for Two Lines to be Coplanar. Foot of the Perpendicular from a Point on a Line. Rotation Tensor (No Derivation). Isotropic Tensors. Tensorial Character of physical Quantities. Moment of Inertia Tensor. Stress and Strain Tensors: Symmetric Nature. Elasticity Tensor. Generalized Hooke's Law.

- **General Tensors** **(10 lectures)**

Transformation of Co-ordinates. Minkowski Space. Contravariant & Covariant Vectors. Contravariant, Covariant and Mixed Tensors. Kronecker Delta and Permutation Tensors. Algebra of Tensors. Sum, Difference & Product of Two Tensors. Contraction. Quotient Law of Tensors. Symmetric and Anti-symmetric Tensors. Metric Tensor. Covariant derivative. Vector operators (gradient, divergence, curl, Laplacian) in tensor form. Geodesics.

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*Reference Books*

1. Mathematical Methods for Physicists: Weber and Arfken, 2005, Academic Press.
2. Mathematical Methods for Physicists: A Concise Introduction: Tai L. Chow, 2000, Cambridge Univ. Press.

3. Elements of Group Theory for Physicists by A. W. Joshi, 1997, John Wiley.
4. Group Theory and its Applications to Physical Problems by Morton Hamermesh, 1989, Dover.
5. Introduction to Mathematical Physics: Methods & Concepts: Chun Wa Wong, 2012, Oxford University Press.
6. Introduction to Mathematical Probability, J. V. Uspensky, 1937, Mc Graw-Hill.

## Course Outcomes (COs)

After successful completion of this course, the students will be able to

| CO No. | Course Outcomes | Cognitive Level | PO Addressed | PSO Addressed |
|---|---|---|---|---|
| CO-1 | Understand basics of Sets and Group theory. Understand classifications of groups. | U | PO2, PO5 | PSO2 |
| CO-2 | Understand and apply the method of coordinate transformations to analyze physical systems through tensor algebra | U, An | PO3, PO5 | PSO3 |
| CO -3 | Understand Contravariant & Covariant vectors. Contravariant, Covariant and Mixed Tensors. | U | PO2, PO6 | PSO2 |
| CO -4 | Write down computer programming to analyze dynamical systems. | C | PO5, PO6 | PSO5 |

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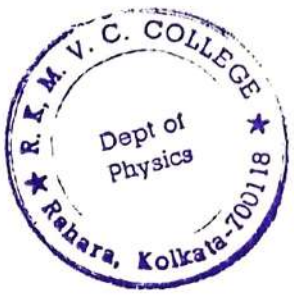


| 4.5. Nuclear and Particle Physics | | | |
|---|---|---|---|
| DSE Course | Course Code : UGPHYDSE05 | Course Credit : 6 | SEM – VI |

## Course objectives

1) To understand the structure of nucleus and related semi-classical models to describe sub-nuclear processes (e.g. alpha decay, fission, fusion etc.)
2) To understand radioactivity process and its application towards multidisciplinary fields (e.g. medical science).
3) To understand mechanism of nuclear detectors and particle accelerator.

| Nuclear and Particle Physics | | |
|---|---|---|
| Paper : UGPHYDSE05 | Credit : 6 | Course duration: 75 lectures |

- **General Properties of Nuclei** **(10 Lectures)**
  Constituents of nucleus and their Intrinsic properties, quantitative facts about mass, radii, charge density (matter density), binding energy, average binding energy and its variation with mass number, main features of binding energy versus mass number curve, N/A plot, angular momentum, parity, magnetic moment, electric moments, nuclear excites states.

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

- **Radioactivity decay** **(10 Lectures)**
  (a) *Alpha decay*: basics of alpha decay processes, theory of alpha emission, Gamow factor, Geiger Nuttall law, alpha decay spectroscopy.
  (b) *Beta decay*: energy kinematics for beta decay, positron emission, electron capture, neutrino hypothesis.
  (c) *Gamma decay*: Gamma rays emission & kinematics, internal conversion.

- **Nuclear Reactions** **(08 Lectures)**
  Types of Reactions, Conservation Laws, kinematics of reactions, Q-value, reaction rate, reaction cross section, Concept of compound and direct Reaction, resonance reaction, Coulomb scattering (Rutherford scattering).

- **Interaction of Nuclear Radiation with matter** **(08 Lectures)**
  Energy loss due to ionization (Bethe- Block formula), energy loss of electrons, Cerenkov radiation. Gamma ray interaction through matter, photoelectric effect, Compton scattering, pair production, neutron interaction with matter.

- **Detector for Nuclear Radiations** **(08 Lectures)**
  Gas detectors: estimation of electric field, mobility of particle, for ionization chamber and GM Counter. Basic principle of Scintillation Detectors and construction of photo-multiplier tube (PMT).

Semiconductor Detectors (Si and Ge) for charge particle and photon detection (concept of charge carrier and mobility), neutron detector.

- **Particle Accelerators** **(05 Lectures)**
  Accelerator facility available in India: Van-de Graaff generator (Tandem accelerator), Linear accelerator, Cyclotron, Synchrotrons.

- **Particle Physics** **(14 Lectures)**
  Particle interactions; basic features, types of particles and its families. Symmetries and Conservation Laws: energy and momentum, angular momentum, parity, baryon number, Lepton number, Isospin, Strangeness and charm, concept of quark model, color quantum number and gluons.

***Reference Books***


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


## Course Outcomes (COs)

After successful completion of this course, the students will be able to

| CO No. | Course Outcomes | Cognitive Level | PO Addressed | PSO Addressed |
|---|---|---|---|---|
| CO-1 | Gain in-depth and up-to date information about nuclear and particle physics. | R, U | PO2 | PSO1 |
| CO-2 | Understand the notions of nuclear models and application of these models to explain nuclear phenomenon. | U, Ap | PO3, PO4, PO5 | PSO2, PSO3, PSO5 |
| CO -3 | Understand radioactivity: α, β and γ-decay. Application of radioactivity in various branches (e.g., nuclear medicine, carbon dating etc.) | U, Ap, C | PO3, PO5, PO6 | PSO2, PSO3, PSO5 |
| CO -4 | Understand nuclear reaction mechanisms, interaction of nuclear particles and radiation with matter, nuclear detector mechanism. | U, An, C | PO4, PO6 | PSO3, PSO4 |
| CO-5 | Have an idea about fundamental particles and particle accelerator. | R, U | PO1, PO5 | PSO1 |

R= remembering, U = understanding, Ap = applying, An = analysing, E = evaluating, and C = creating

| 4.6. Nano Materials and Applications | | | |
|---|---|---|---|
| DSE Course | Course Code : UGPHYDSE06 | Course Credit : 6 | SEM – VI |

## Course objectives

1) To understand the essential modifications of physical properties of materials in nano scale dimension.
2) Gain ability to synthesize nano materials and characterize their properties with sophisticated instruments.
3) To understand the extensive application of nano materials in multidisciplinary fields.

| Nano Materials and Applications ( Theory ) | | |
|---|---|---|
| Paper: UGPHYDSE06 (Theory) | Credit : 4 | Course duration: 60 lectures |

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

- **Synthesis of Nanostructure Materials** **(08 Lectures)**
  Top-down and bottom-up approach. Photolithography. Ball Milling. Gas phase condensation. Vacuum deposition. Physical vapour deposition (PVD): Thermal evaporation, Pulsed Laser deposition. Chemical vapour deposition (CVD). Sol-Gel. Electro deposition. Spray pyrolysis. Hydrothermal synthesis. Preparation through colloidal methods. MBE growth of quantum dots.

- **Characterization** **(08 Lectures)**
  X-Ray Diffraction. Optical Microscopy. Scanning Electron Microscopy. Transmission Electron Microscopy. Atomic Force Microscopy. Scanning Tunneling Microscopy.

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

- **Electron Transport** **(06 Lectures)**
  Carrier transport in nanostrucutures. Coulomb blockade effect, thermionic emission, tunneling and hoping conductivity. Defects and impurities: Deep level and surface defects.

- **Applications** **(14 Lectures)**
  Applications of nanoparticles, quantum dots, nanowires and thin films for photonic devices (LED, solar cells). Single electron transfer devices (no derivation). CNT based transistors. Nanomaterial Devices: Quantum dots heterostructure lasers, optical switching and optical data storage. Magnetic

quantum well; magnetic dots -magnetic data storage. Micro Electromechanical Systems (MEMS), Nano Electromechanical Systems (NEMS).

*Reference Books*


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


| **Nano Materials and Applications ( Practical )** | | |
|---|---|---|
| **Paper: UGPHYDSE06 (Practical)** | **Credit : 2** | **Course duration: 60 hrs.** |

**List of Practical**

1. Synthesis of metal nanoparticles by chemical route.
2. Synthesis of semiconductor nanoparticles.
3. Surface Plasmon study of metal nanoparticles by UV-Visible spectrophotometer.
4. XRD pattern of nanomaterials and estimation of particle size.
5. To study the effect of size on color of nanomaterials.
6. To prepare composite of CNTs with other materials.
7. Growth of quantum dots by thermal evaporation.
8. Prepare a disc of ceramic of a compound using ball milling, pressing and sintering, and study its XRD.
9. Fabricate a thin film of nanoparticles by spin coating (or chemical route) and study transmittance spectra in UV-Visible region.
10. Prepare a thin film capacitor and measure capacitance as a function of temperature or frequency.
11. Fabricate a PN diode by diffusing Al over the surface of N-type Si and study its V-I characteristic.

*Reference Books*

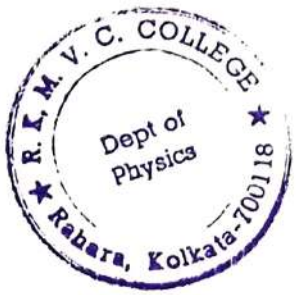

1. C.P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology (Wiley India Pvt. Ltd.).
2. S.K. Kulkarni, Nanotechnology: Principles & Practices (Capital Publishing Company).
3. K.K. Chattopadhyay and A.N. Banerjee, Introduction to Nanoscience & Technology (PHI Learning Private Limited).
4. Richard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

## Course Outcomes (COs)

After successful completion of this course, the students will be able to

| CO No. | Course Outcomes | Cognitive Level | PO Addressed | PSO Addressed |
|---|---|---|---|---|
| CO-1 | Understand the properties of materials having nano-scale dimension. | U | PO3, PO6 | PSO1, PSO3 |
| CO-2 | Have detail knowledge on device applications of nano materials (like carbon nano-tubes). | Ap, C | PO4, PO5, PO6 | PSO3, PSO5 |
| CO -3 | Understand electron dynamics in nano dimension for further understanding of transport phenomena and optical properties. | U, An | PO3, PO5 | PSO3, PSO5 |
| CO -4 | Capable of dealing with sophisticated instruments to characterize properties of nano materials. | Ap, An, C | PO4, PO6 | PSO4, PSO5 |

R= remembering, U = understanding, Ap = applying, An = analysing, E = evaluating, and C = creating



| 4.7. Dissertation or Project work | | | |
|---|---|---|---|
| DSE Course | Course Code : UGPHYDSE07 | Course Credit : 6 | SEM - VI |

Course content added/modified = 100%

**Course objectives**

1) To gain clear understanding to address new problems.
2) Apply the knowledge in physics and allied areas to analyze the assigned problem.
3) Acquire adequate level of creativity to extend the assigned problem or related problem.

## Course Outcomes (COs)

After successful completion of this course (Project Work), the students will be able to

| CO No. | Course Outcomes | Cognitive Level | PO Addressed | PSO Addressed |
|---|---|---|---|---|
| CO-1 | Understand the assigned problem. | U | PO2, PO3 | PSO1 |
| CO-2 | Apply suitable method to examine the problem critically. | Ap, An | PO3, PO4 | PSO2, PSO3, PSO4 |
| CO -3 | Draw some conclusions after completion of the project work. | E | PO4, PO5 | PSO3 |
| CO -4 | Plan an extended version of the same problem or a similar kind of problem associated with the given problem. | C | PO4, PO5, PO6 | PSO4, PSO5 |

R= remembering, U = understanding, Ap = applying, An = analysing, E = evaluating, and C = creating

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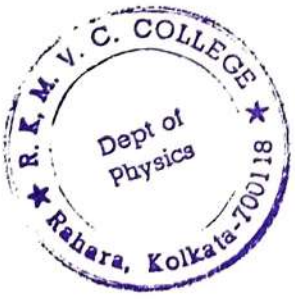
# 5. Syllabi for Skill Enhancement Courses (SEC)



| 5.1. Value Education and Indian Culture | | | |
|---|---|---|---|
| Course : SEC | Course Code : UGPHYSEC01 | Course Credit : 2 | SEM – III |

## Course objectives

1) Attain awareness about daily routine, self-evaluation & Integral Personality Development.
2) Understand the educational needs, the Power of thoughts and the Science of Peace.
3) Understand the relation: Values and enlightened citizenship.
4) Attain awareness about the Indian Practice and Culture.
5) Demonstrate the importance of Four Yogas.
6) Acquire idea about Modern India: her hopes, challenges and Swami Vivekananda.

| Value Education and Indian Culture | | |
|---|---|---|
| **Paper: UGPHYSEC01** | **Credit : 2** | **Course duration: 30 lectures** |

- **Unit-1: Daily Routine** **(02 lectures)**
  - A suggested daily routine
  - The daily routine & the concept of Biological clock: key to a healthy and productive life
  - Necessity for an all-round daily routine
  - Combining Rest and Activity, Hardships and Joy in a daily routine
  - The scope of developing the power of concentration and detachment through a daily routine.
  - Daily Routine disciplines the system but confers conviction on oneself

- **Unit-2: Self Evaluation & Integral Personality Development** **(02 lectures)**
  - Why is Self-Evaluation important? Because if you win yourself, you win the world
  - Quantitative Self Evaluation for a qualitative change: A method
  - Traits to track Personality Development: Academic Excellence, Social Compatibility, Participation in Group events, Sense of Responsibility, Role as a Consumer, Scientific Temperament, Aesthetic taste and creativity, Leisure time Activities, Concern for others, Spiritual values.
  - Close and Constant Self Evaluation : a stitch in time saves nine
  - The world *is* as we *are* : A minor inner change may nullify a major outer perturbation

- **Unit-3: Our Educational Needs** **(02 lectures)**
  - The need of a correct blend of inner and outer well-being in education
  - Man-making, Character building education : growing from within , a surer foundation of progress
  - The outer crust and the inner core of our personality: "What you are shouts so loudly in my ears that I cannot hear what you say."
  - A 5-point training in Discipline, Cleanliness, Behaviour, Manners and Ambition Sharpening the sword of will: controlling its expression, a basic educational need
  - How to study effectively

- **Unit-4: The Power of thoughts and the Science of Peace** **(03 lectures)**
  - Shanti Mantras: Peace can be radiated from and reflected back upon ourselves

- You can create an ambience and others can enjoy it, can be benefitted by it.
- How to create a positive, peaceful and inspiring ambience?- the aggressive exertion and the unquestioning sacrifice involved in it.

- **Unit-5: Subhashita: The Well said** **(02 lectures)**
  - Bringing home high thoughts in nuggets of wisdom
  - Pearls of Wisdom and flames of fire: simple parables and anecdotes from the great ones

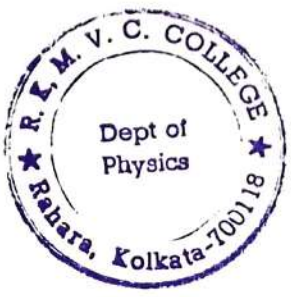
- **Unit-6: Values and Enlightened Citizenship** **(02 lectures)**
  - Intrinsic and Instrumental Values
  - What makes a man great? A powerful will to do good born out of self-control and self-sacrifice
  - Learning the art of inter-personal relations: Not I but You
  - The combination of the Head, Heart and Hand: a valuable value for Enlightened Citizenship

- **Unit-7: Indian Practice and Culture** **(02 lectures)**
  - The idea of sacredness & its necessity
  - Every aspect of life is sacred in India
  - Renunciation and service the twin ideals for India
  - My freedom from Nature helps me to serve nature and the world better
  - I never say I am the body, I always say this body is mine : I as a master of the body-mind complex
  - Weakness is death: in search of real strength of self-knowledge, reliance on God and unselfish service
  - Meditation, Concentration and the silent Indian path for becoming a dynamo of power
  - The Indian concept of Unity in diversity: Harmony of Religions

- **Unit-8: Four Yogas** **(03 lectures)**
  - The Real and Apparent Man, the science of knowing myself: Jnana Yoga
  - Taming the mighty current of emotions and giving them their right food: Bhakti Yoga
  - The Science of working wisely: Karma Yoga
  - The Process of making my mind mine: Raja Yoga
  - Selected portions from Swami Vivekananda's Karma Yoga
  - Harmony of 4 Yogas: a needed balance for the modern man

- **Unit-9: Modern India: her hopes, challenges and Swami Vivekananda** **(02 lectures)**
  - Swami Vivekananda's method of combining the best of the East & the West: where Indian values and Western workmanship join hands
  - Invigorating rationality in the field of the Indian search for the supreme joy : erasing the misconception of dogmatism.
  - Rousing a sense of pride in the age-long Indian discoveries in the field of inner truths as opposed to an inferiority complex posed by Western material supremacy.
  - Do you feel: Service, Swami Vivekananda's acid test for modern science and traditional spirituality.

- **Unit10: Students' Presentations/Project: (may be in groups)** **(10 hrs.)**
  - Project on Service, Teaching and Cleanliness



## Course Outcomes (COs)

After successful completion of this course, the students will be able to

| CO No. | Course Outcomes: | PO Addressed | PSOs Addressed | Cognitive Level |
|---|---|---|---|---|
| CO-1 | Define, understand and apply the daily routine, self evaluation & Integral Personality Development | PO1 | PSO2 | R, U, Ap |
| CO-2 | Learn, and apply the Power of thoughts & the Science of Peace | PO3 | PSO2, PSO3 | U, Ap |
| CO-3 | Understand the relation: Values and enlightened citizenship | PO2 | PSO2 | U |
| CO-4 | Discuss the awareness about the Indian Practice and Culture | PO4 | PSO3 | C |
| CO-5 | Demonstrate and practice the Four Yogas | PO6 | PSO3 | U, Ap |
| CO-6 | Explain and analyze the idea about Modern India: her hopes, challenges and Swami Vivekananda | PO6 | PSO2, PSO3 | U, An |

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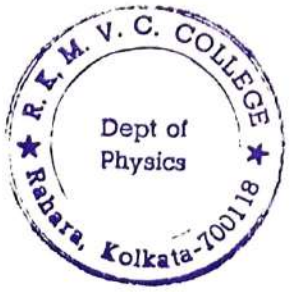
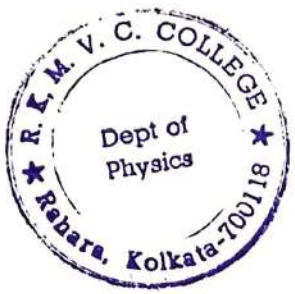
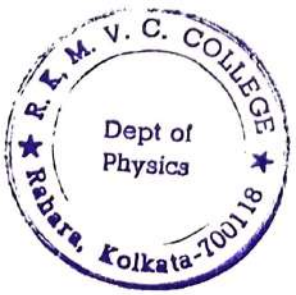


| 5.2. Spoken Tutorial | | | |
|---|---|---|---|
| Course : SEC | Course Code : UGPHYSEC02 | Course Credit : 2 | SEM – IV |

This Skill Enhancement Course is conducted as "***Spoken Tutorial Courses***" in collaboration with national level higher education institutes (e.g. IITs) according to their course schedule in a particular academic session.



# 6. Syllabi for Generic Elective (GE) Courses



| 6.1. Mechanics | | | |
|---|---|---|---|
| GE Course | Course Code : UGPHYGE01 | Course Credit : 6 | SEM – I |

## Course objectives

1) To understand mathematics as a tool for quantitative analysis of physical systems.
2) To analyze mechanical systems to describe the associated dynamics.
3) To understand general properties of matter form multidisciplinary point of view.

| Mechanics (Theory) | | |
|---|---|---|
| Paper: UGPHYDGE01 (Theory) | Credit : 4 | Course duration: 60 lectures |

- **Vectors** **(10 Lectures)**
  Vector algebra. Scalar and vector products. Gradient, divergence, Curl and their significance,Vector Differentiation, Vector Integration, Line, surface and volume integrals of Vector fields, Gauss-divergence theorem and Stoke's theorem of vectors (statement only).

- **Ordinary Differential Equations** **(06 Lectures)**
  1st order homogeneous differential equations. 2nd order homogeneous differential equations with constant coefficients.

- **Laws of Motion** **(10 Lectures)**
  Frames of reference. Newton's Laws of motion. Dynamics of a system of particles. Centre of Mass.

- **Momentum and Energy** **(06 Lectures)**
  Conservation of momentum. Work and energy. Conservation of energy. Motion of rockets.

- **Rotational Motion** **(05 Lectures)**
  Angular velocity and angular momentum. Torque. Conservation of angular momentum.

- **Gravitation** **(08 Lectures)**
  Newton's Law of Gravitation. Motion of a particle in a central force field (motion is in a plane, angular momentum is conserved, areal velocity is constant). Kepler's Laws (statement only). Satellite in circular orbit and applications. Geosynchronous orbits. Basic idea of global positioning system (GPS). Weightlessness. Physiological effects on astronauts.

- **Elasticity** **(08 Lectures)**
  Hooke's law - Stress-strain diagram - Elastic moduli-Relation between elastic constants - Poisson's Ratio-Expression for Poisson's ratio in terms of elastic constants - Work done in stretching and work done in twisting a wire - Twisting couple on a cylinder - Determination of Rigidity modulus by static torsion – Torsional pendulum-Determination of Rigidity modulus and moment of inertia.

- **Special Theory of Relativity** **(07 Lectures)**
  Constancy of speed of light. Postulates of Special Theory of Relativity. Length contraction. Time dilation. Relativistic addition of velocities.

***Reference Books***


1. University Physics. F.W. Sears, M.W. Zemansky and H.D. Young, 13/e, 1986. Addison-Wesley.
2. Mechanics Berkeley Physics, v.1: Charles Kittel, et.al. 2007, Tata McGraw-Hill.
3. Physics – Resnick, Halliday & Walker 9/e, 2010, Wiley.
4. Engineering Mechanics, Basudeb Bhattacharya, 2nd edn., 2015, Oxford University Press.
5. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

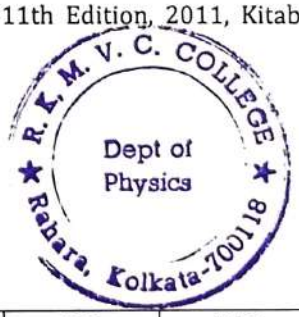

| **Mechanics (Practical)** | | |
|---|---|---|
| **Paper: UGPHYDGE01 (Practical)** | **Credit : 2** | **Course duration: 60 hrs.** |

**List of Practical**

1. Measurements of length (or diameter) using verniercaliper, screw gauge and travelling microscope.
2. To determine the Height of a Building using a Sextant.
3. To determine the Moment of Inertia of a Flywheel.
4. To determine the Young's Modulus of a Wire by Optical Lever Method.
5. To determine the Modulus of Rigidity of a Wire by Maxwell's needle.
6. To determine the Elastic Constants of a Wire by Searle's method.
7. To determine g by Bar Pendulum.
8. To determine g by Kater's Pendulum.
9. To study the Motion of a Spring and calculate (a) Spring Constant, (b) g.

***Reference Books***


1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
3. Engineering Practical Physics, S.Panigrahi & B.Mallick, 2015, Cengage Learning India Pvt. Ltd.
4. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.


**Course Outcomes (COs)**

After successful completion of this course, the students will be able to

| CO No. | Course Outcomes | Cognitive Level | PO Addressed | PSO Addressed |
|---|---|---|---|---|
| CO-1 | Understand to apply basic mathematical tools to solve mechanical systems. | U, Ap | PO2, PO3 | PSO1, PSO2 |
| CO-2 | Remember laws of motion and understand various types of motions. | R, U | PO2 | PSO1 |
| CO -3 | Understand the principles of elasticity and compare | U, An | PO3, PO4 | PSO2, |

| | | | | |
|---|---|---|---|---|
| | material based of elastic modulus. | | | PSO3 |
| CO -4 | Apply Kepler's law to describe the motion of planets and satellite in circular orbit, through the study of law of Gravitation | Ap | PO3, PO5 | PSO2, PSO5 |
| CO-5 | Understand basics of special theory of relativity | U | PO2, PO5 | PSO2, PSO3 |
| CO-6 | Construct simple experimental set-ups to acquire better understanding about the course as well as to develop skill. | Ap, C | PO4, PO5, PO6 | PSO4, PSO5 |

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| 6.2. Thermal Physics and Statistical Mechanics | | | |
|---|---|---|---|
| GE Course | Course Code : UGPHYGE02 | Course Credit : 6 | SEM - II |

## Course objectives

1) To understand the laws of thermodynamics and their applications in multidisciplinary fields
2) To understand basic notion of statistical mechanics and its application to analyze properties of gaseous systems.

| Thermal Physics and Statistical Mechanics (Theory) | | |
|---|---|---|
| Paper: UGPHYDGE02 (Theory) | Credit : 4 | Course duration: 60 lectures |

- **Laws of Thermodynamics** **(22 Lectures)**
  Thermodynamic Description of system: Zeroth Law of thermodynamics and temperature. First law and internal energy, conversion of heat into work, Various Thermodynamical Processes, Applications of First Law: General Relation between $C_P$ and $C_V$, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Coefficient, Reversible and irreversible processes, Second law and Entropy,Carnot's cycle & theorem, Entropy changes in reversible & irreversible processes, Entropy-temperature diagrams, Third law of thermodynamics, Unattainability of absolute zero.

- **Thermodynamical Potentials** **(10 Lectures)**
  Enthalpy, Gibbs, Helmholtz and Internal Energy functions, Maxwell's relations and applications - Joule-Thompson Effect, Clausius- Clapeyron Equation, Expression for $C_P - C_V$ , $C_P/C_V$ and $T - dS$ equations.

- **Kinetic Theory of Gases** **(10 Lectures)**
  Derivation of Maxwell's law of distribution of velocities and its experimental verification, Mean free path (Zeroth Order), Transport Phenomena: Viscosity, Conduction and Diffusion (for vertical case), Law of equipartition of energy (no derivation) and its applications to specific heat of gases; mono-atomic and diatomic gases.

- **Theory of Radiation** **(06 Lectures)**
  Blackbody radiation, Spectral distribution, Concept of Energy Density, Derivation of Planck's law, Deduction of Wien's distribution law, Rayleigh- Jeans Law, Stefan Boltzmann Law and Wien's displacement law from Planck's law.

- **Statistical Mechanics** **(12 Lectures)**
  Phase space, Macrostate and Microstate, Entropy and Thermodynamic probability, Maxwell-Boltzmann law - distribution of velocity - Quantum statistics - Fermi-Dirac distribution law - electron gas - Bose-Einstein distribution law - photon gas - comparison of three statistics.

*Reference Books*


1. Thermal Physics, S. Garg, R. Bansal and C. Ghosh, 1993, Tata McGraw-Hill.
2. A Treatise on Heat, Meghnad Saha, and B.N. Srivastava, 1969, Indian Press.
3. Thermodynamics, Enrico Fermi, 1956, Courier Dover Publications.
4. Heat and Thermodynamics, M.W.Zemasky and R. Dittman, 1981, McGraw Hill.

5. Thermodynamics, Kinetic theory & Statistical thermodynamics, F.W.Sears and G.L. Salinger. 1988, Narosa.
6. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
7. Thermal Physics, A. Kumar and S.P. Taneja, 2014, R. chand Publications.

| **Thermal Physics and Statistical Mechanics (Practical)** | | |
|---|---|---|
| **Paper: UGPHYDGE02 (Practical)** | **Credit : 2** | **Course duration: 60 hrs.** |

**List of Practicals**

1. To determine Mechanical Equivalent of Heat, J, by Callender and Barne's constant flowmethod.
2. Measurement of Planck's constant using black body radiation.
3. To determine Stefan's Constant.
4. To determine the coefficient of thermal conductivity of Cu by Searle's Apparatus.
5. To determine the Coefficient of Thermal Conductivity of Cu by Angstrom's Method.
6. To determine the coefficient of thermal conductivity of a bad conductor by Lee and Charlton's disc method.
7. To determine the temperature co-efficient of resistance by Platinum resistance thermometer.
8. To study the variation of thermo-emf across two junctions of a thermocouple with temperature.
9. To record and analyze the cooling temperature of a hot object as a function of time using a thermocouple and suitable data acquisition system
10. To calibrate Resistance Temperature Device (RTD) using Null Method/Off- BalanceBridge.

***Reference Books***

1. Advanced Practical Physics for students, B.L.Flint & H.T.Worsnop, 1971, Asia Publishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
3. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.
4. A Laboratory Manual of Physics for Undergraduate Classes, D.P. Khandelwal, 1985, Vani Publication.



**Course Outcomes (COs)**

After successful completion of this course, the students will be able to

| CO No. | Course Outcomes | Cognitive Level | PO Addressed | PSO Addressed |
|---|---|---|---|---|
| CO-1 | Remember and understand laws of thermodynamics | R, U | PO2 | PSO1 |
| CO-2 | Understand the interrelationship between thermodynamic potentials and use these relationships to solve practical problems. | U, Ap | PO3 | PSO2, PSO4, |

| | | | | |
|---|---|---|---|---|
| CO -3 | Understand basic ideas of kinetic theory of gas, Maxwell-Boltzmann's law of velocity distribution and transport properties. | U | PO3, PO4 | PSO3, PSO4 |
| CO -4 | Understand the formulation of statistical mechanics and its application to macroscopic systems. | U, Ap | PO3, PO4, PO5 | PSO3, PSO4, PSO5 |
| CO-5 | Construct simple experimental set-ups to validate theoretical aspects. | E, C | PO4, PO6 | PSO4, PSO5 |

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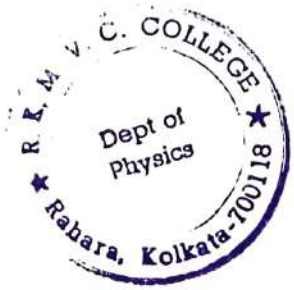

| 6.3. Waves and Optics | | | |
|---|---|---|---|
| GE Course | Course Code : UGPHYGE03 | Course Credit : 6 | SEM - III |

## Course objectives

1) To understand oscillatory motion and analyze associated dynamical systems.
2) To appreciate electrical analogy of mechanical systems.
3) To understand and analyze elastic and electromagnetic wave propagation and associated phenomena.

| Waves and Optics (Theory) | | |
|---|---|---|
| **Paper: UGPHYDGE03 (Theory)** | **Credit : 4** | **Course duration: 60 lectures** |

- **Oscillations** **(07 Lectures)**
  Simple harmonic motion. Differential equation of SHM and its solutions. Forced vibrations and resonance -Kinetic and Potential Energy, Total Energy and their time averages. Damped oscillations.

- **Superposition of Two Collinear Harmonic oscillations** **(04 Lectures)**
  Linearity & Superposition Principle. (1) Oscillations having equal frequencies and (2) Oscillations having different frequencies (Beats).

- **Superposition of Two Perpendicular Harmonic Oscillations** **(03 Lectures)**
  Graphical and Analytical Methods. Lissajous Figures with equal an unequal frequency and their uses.

- **Waves Motion- General** **(07 Lectures)**
  Transverse waves on a string. Travelling and standing waves on a string. Normal Modes of a string. Group velocity, Phase velocity. Plane waves. Spherical waves, Wave intensity.

- **Sound** **(06 Lectures)**
  Fourier's Theorem - Application to saw tooth wave and square wave - Intensity and loudness of sound - Decibels - Intensity levels - musical notes - musical scale. Acoustics of buildings: Reverberation and time of reverberation - Absorption coefficient - Sabine's formula - measurement of reverberation time - Acoustic aspects of halls and auditoria.

- **Wave Optics** **(04 Lectures)**
  Electromagnetic nature of light. Definition and Properties of wave front. Huygens Principle.

- **Interference** **(10 Lectures)**
  Interference: Division of amplitude and division of wavefront. Young's Double Slit experiment. Lloyd's Mirror and Fresnel's Biprism. Phase change on reflection: Stokes' treatment. Interference in Thin Films: parallel and wedge-shaped films. Fringes of equal inclination (Haidinger Fringes); Fringes of equal thickness (Fizeau Fringes). Newton's Rings: measurement of wavelength and refractive index.

- **Diffraction** **(14 Lectures)**
  Fraunhofer diffraction- Single slit; Double Slit. Multiple slits and Diffraction grating. Fresnel Diffraction: Half-period zones. Zone plate. Fresnel Diffraction pattern of a straight edge, a slit and a wire using half-period zone analysis.

- **Polarization** **(05 Lectures)**
  Transverse nature of light waves. Plane polarized light – production and analysis. Circular and elliptical polarization.

*Reference Books*


1. Fundamentals of Optics, F.A Jenkins and H.E White, 1976, McGraw-Hill.
2. Principles of Optics, B.K. Mathur, 1995, Gopal Printing.
3. Fundamentals of Optics, H.R. Gulati and D.R. Khanna, 1991, R. Chand Publications.
4. University Physics. F.W. Sears, M.W. Zemansky and H.D. Young. 13/e, 1986. Addison-Wesley.


| **Waves and Optics (Practical)** | | |
|---|---|---|
| **Paper: UGPHYDGE03 (Practical)** | **Credit : 2** | **Course duration: 60 hrs.** |

**List of Practical**

1. To investigate the motion of coupled oscillators.
2. To determine the Frequency of an Electrically Maintained Tuning Fork by Melde's Experiment and to verify $\lambda^2 - T$ Law.
3. To study Lissajous Figures.
4. Familiarization with Schuster's focussing; determination of angle of prism.
5. To determine the Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method).
6. To determine the Refractive Index of the Material of a Prism using Sodium Light.
7. To determine Dispersive Power of the Material of a Prism using Mercury Light.
8. To determine the value of Cauchy Constants.
9. To determine the Resolving Power of a Prism.
10. To determine wavelength of sodium light using Fresnel Biprism.
11. To determine wavelength of sodium light using Newton's Rings.
12. To determine the wavelength of Laser light using Diffraction of Single Slit.
13. To determine wavelength of (1) Sodium and (2) Spectral lines of the Mercury light using plane diffraction Grating.
14. To determine the Resolving Power of a Plane Diffraction Grating.
15. To measure the intensity using photosensor and laser in diffraction patterns of single and double slits.



*Reference Books*


1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted

1985, Heinemann Educational Publishers.
3. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.

## Course Outcomes (COs)

After successful completion of this course, the students will be able to

| CO No. | Course Outcomes | Cognitive Level | PO Addressed | PSO Addressed |
|---|---|---|---|---|
| CO-1 | Understand oscillatory motions. Solve differential equations of free, damped and forced oscillations. | U, Ap | PO2, PO3, PO5 | PSO2, PSO4, PSO5 |
| CO-2 | Remember and understand the acoustical terms like sound intensity, loudness, intensity level, Bel, decibel, phon. | R, U | PO2, PO3, PO5 | PSO1, PSO3 |
| CO -3 | Remember and understand basic principles of light propagation. Understand interference, diffraction. | R, U | PO4, PO6 | PSO1, PSO4 |
| CO -4 | Determine wavelength of light, dispersive power of prism and frequencies of string vibration through experiments. | An, E, C | PO4, PO5, PO6 | PSO3, PSO4, PSO5 |

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| 6.4. Electricity and Magnetism | | | |
|---|---|---|---|
| GE Course | Course Code : UGPHYGE04 | Course Credit : 6 | SEM - IV |

## Course objectives

1) To understand and apply laws of electricity and magnetism to analyze physical systems.
2) Perform experiment to evaluate physical parameters in connection to electricity and magnetism.

| Electricity and Magnetism (Theory) | | |
|---|---|---|
| Paper: UGPHYDGE04 (Theory) | Credit : 4 | Course duration: 60 lectures |

- **Electrostatics** **(22 Lectures)**
  Electrostatic Field, electric flux, Gauss's theorem of electrostatics. Applications of Gauss theorem- Electric field due to point charge, infinite line of charge, uniformly charged spherical shell and solid sphere, plane charged sheet, charged conductor. Electric potential as line integral of electric field, potential due to a point charge, electric dipole, uniformly charged spherical shell and solid sphere. Calculation of electric field from potential. Capacitance of an isolated spherical conductor. Parallel plate, spherical and cylindrical condenser. Energy per unit volume in electrostatic field. Dielectric medium, Polarisation, Displacement vector. Gauss's theorem in dielectrics. Parallel plate capacitor completely filled with dielectric.

- **Magnetism** **(20 Lectures)**
  Magnetostatics: Biot-Savart's law and its applications- straight conductor, circular coil, solenoid carrying current. Divergence and curl of magnetic field. Magnetic vector potential. Ampere's circuital law.Magnetic properties of materials: Magnetic intensity, magnetic induction, permeability, magnetic susceptibility. Brief introduction of dia-, para-and ferro- magnetic materials.

- **Electromagnetic Induction** **(07 Lectures)**
  Faraday's laws of electromagnetic induction, Lenz's law, self and mutual inductance, L of single coil, M of two coils. Energy stored in magnetic field.

- **Maxwell's equations and Electromagnetic wave propagation** **(11 Lectures)**
  Equation of continuity of current, Displacement current, Maxwell's equations, Poynting vector, energy density in electromagnetic field, electromagnetic wave propagation through vacuum and isotropic dielectric medium, transverse nature of EM waves, polarization.

***Reference Books***


1. Electricity and Magnetism, Edward M. Purcell, 1986, McGraw-Hill Education.
2. Electricity & Magnetism, J.H. Fewkes & J.Yarwood. Vol. I, 1991, Oxford Univ. Press.
3. Electricity and Magnetism, D C Tayal, 1988, Himalaya Publishing House.
4. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
5. D.J.Griffiths, Introduction to Electrodynamics, 3rd Edn, 1998, Benjamin Cummings.

| Electricity and Magnetism (Practical) | | |
|---|---|---|
| Paper: UGPHYDGE04 (Practical) | Credit : 2 | Course duration: 60 hrs. |

**List of Practical:**

1. To use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, (d) Checking electrical fuses.
2. Ballistic Galvanometer: (a) Measurement of charge and current sensitivity,(b) Measurement of CDR, (c) Determine a high resistance by Leakage Method, (d)To determine Self Inductance of a Coil by Rayleigh's Method.
3. To compare capacitances using De'Sauty's bridge.
4. Measurement of field strength B and its variation in a Solenoid (Determine $\frac{dB}{dx}$)
5. To study the Characteristics of a Series RC Circuit.
6. To study a series LCRcircuit and determine its (a) Resonant frequency, (b) Quality factor.
7. To study a parallel LCR circuit and determine its: (a)Anti-resonant frequency and (b) Quality factor Q.
8. To determine a Low Resistance by Carey Foster's Bridge.
9. To verify the Thevenin and Norton theorems.
10. To verify the Superposition, and Maximum Power Transfer Theorems

*Reference Books*


1. Advanced Practical Physics for students, B.L.Flint & H.T.Worsnop, 1971, Asia Publishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
3. A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed.2011, Kitab Mahal.
4. Engineering Practical Physics, S.Panigrahi & B.Mallick,2015, Cengage Learning India Pvt. Ltd.


## Course Outcomes (COs)

After successful completion of this course, the students will be able to

| CO No. | Course Outcomes | Cognitive Level | PO Addressed | PSO Addressed |
|---|---|---|---|---|
| CO-1 | Remember and understands fundamental laws of electrodynamics | R, U | PO2 | PSO2 |
| CO-2 | Apply laws of electricity and magnetism to evaluate electro-magnetic fields for charges and currents. | Ap, An | PO3, PO4, PO5 | PSO2, PSO3, PSO4 |
| CO-3 | Understand the self and mutual inductance. | U | PO2, PO4 | PSO2, PSO4 |
| CO -4 | Understand the Maxwell's equations and apply Maxwell's equations to deduce EM wave equation, electromagnetic field energy and field momentum. | U, Ap | PO3, PO5, PO6 | PSO3, PSO4, PSO5 |
| CO-5 | Perform several experiments related to the course for better understanding and developing skill. | Ap, C | PO4, PO6 | PSO4, PSO5 |

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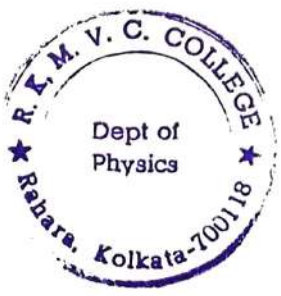
# 7. Syllabi for Ability Enhancement Compulsory Course (AECC)



| 7.1. English Communication | | | |
|---|---|---|---|
| **AEC Course** | **Course Code : UGPHYAECC01** | **Course Credit : 2** | **SEM - I** |

## Course objectives

1) To enhance English communication skill for further higher studies.
2) Gain an insight into cultural literacy and cross-cultural awareness.

| English Communication | | |
|---|---|---|
| **Paper: UGPHYAECC01** | **Credit : 2** | **Course duration: 30 lectures** |

- **Unit I: Introduction to Communication** **(10 lectures)**
  Process of Communication; Levels of Communication; Flow of Communication; Verbal and Non-Verbal Communication; Barriers to Communication

- **Unit II: Listening and Speaking Skills** **(10 lectures)**
  Listening and its types; Barriers to effective listening; Trials of a good listener; Introduction to English Phonetic Symbols: Consonants and Vowels with illustrations in use; Dialogue; Group Discussion; Presentation; Interview Technique.

- **Unit III: Reading and Writing Skills** **(10 lectures)**
  Techniques of Reading; Types of Reading; Reading Comprehension (unseen passage); Paragraph Writing; Letter Writing; Email Writing; Report Writing; Proposal writing; Book Review; Poster Making

***Reference Books***

1. Vibrant English (New Delhi: Orient Black Swan)
2. Speak Well (New Delhi: Orient Black Swan) a compulsory supplementary Work Book for exercises on Interactions, dialogue, presentation skills, Group discussions, debates and Interviews.

*Recommended Readings for advanced learning*

1. Advanced Skills in English.eds E Suresh Kumar et al..
2. Practising Writing Skills, Work Book
3. Enhancing English and Employability Skills
4. Business Communication,
5. English for Fluency
6. English Language Practice
7. Basics of Academic English- 1 and 2
8. Practising English (all these are Orient Black Swan publications)

## Course Outcomes (COs)

After successful completion of this course, the students will be able to

| CO. No. | Course Outcome | Cognitive Level | POs Addressed | PSOs Addressed |
|---|---|---|---|---|
| CO 1 | Engage in self-directed English language learning. | R, | PO1, PO2, PO3 | PSO1 |
| CO 2 | Be responsible and ethical English users. | R, U | PO1, PO2, PO3 | PSO1, PSO2 |
| CO 3 | Enhance their English language proficiency in the aspects of reading, writing, listening and speaking. | R, U | PO1, PO2, PO3 | PSO1, PSO2 |
| CO 4 | Develop academic literacy required for undergraduate learning, further studies and research. | Ap | PO3, PO5 | PSO2, PSO4 |
| CO 5 | Apply the requisite communicative skills and strategies to future careers. | Ap | PO3, PO5 | PSO3, PSO5 |
| CO 6 | Gain an insight into cultural literacy and cross-cultural awareness. | Ap | PO3, PO5 | PSO3 |

R= remembering, U = understanding, Ap = applying, An = analysing, E = evaluating, and C = creating

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Dept of Physics
Rahara, Kolkata-700118

| 7.2. Environmental Science | | | |
|---|---|---|---|
| AEC Course | Course Code : UGPHYAECC02 | Course Credit : 2 | SEM - II |

## Course objectives

1) Remembers and understands the concept, components and function of natural resources and ecosystems.
2) Understand and evaluate the Cause, effects and control measures of various environmental pollutants.
3) Understand the basic idea about the disasters and its management.
4) Understand and apply the knowledge about the social, environmental issues and environmental legislation.

| Environmental Science | | |
|---|---|---|
| Paper: UGPHYAECC02 | Credit : 2 | Course duration: 30 lectures |

- **Definitions** **(01 lectures)**
  Scope and importance. Need for public awareness.

- **Natural Resources** **(04 lectures)**
  Renewable and non-renewable: Forest, Water, Mineral, Food, Energy & Land resources – Use and associated problems.

- **Ecosystems** **(06 lectures)**
  Concept, Structure and function, Energy flow, Ecological succession, Food chains, food webs and ecological pyramids. Types – Forest, Grassland, Desert & Aquatic (ponds, streams, lakes, rivers, oceans, estuaries) ecosystems.

- **Environmental Pollution** **(05 lectures)**
  Definition, Cause, effects and control measures of - Air, Water, Soil, Noise pollution and Nuclear hazards. Solid waste Management. Role of an individual in prevention of pollution.

- **Disasters and management** **(04 lectures)**
  Floods, Earthquake, Cyclone and Landslides.

- **Social Issues and the Environment** **(05 lectures)**
  Water conservation, rain water harvesting, watershed management. Resettlement and rehabilitation of people; its problems and concerns. Environmental ethics: Issues and possible solutions. Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust. Wasteland reclamation. Consumerism and waste products. Urban problems related to energy.

- **Environmental legislation** **(04 lectures)**
  Environment Protection Act. Air (Prevention and Control of Pollution) Act. Water (Prevention and control of Pollution) Act. Wildlife Protection Act. Forest Conservation Act. Issues involved in enforcement of environmental legislation. Public awareness.

- **Human Population and the Environment** **(03 lectures)**
  Population growth, variation among nations; Population explosion – Family Welfare Programme; Environment and human health (including HIV/AIDS); Human Rights; Role of Information Technology in Environment and human health.

*Reference Books*


1. Agarwal KC, 2001. Environmental Biology, Nidi Publishers Ltd. Bikaner.
2. Bharucha Erach, 2003. The Biodiversity of India, Mapin Publishing Pvt. Ltd, Ahmedabad – 380013, India. Email: mapin@icenet.net
3. Brunner RC, 1989, Hazardous Waste Incineration, McGraw Hill Inc. 480pgs.
4. Clark RS, Marine Pollution, Clanderson Press, Oxofrd (TB).
5. Cunningham WP, Cooper TH, Gorhani E & Hepworth MT, 2001. Environmental Encyclopaedia, Jaico Publishing House, Mumbai, 1196pgs.
6. De AK, Environmental Chemistry, Wiley Eastern Ltd.
7. Down to Earth, Center for Science and Environment (R)
8. Hawkins RE, Encyclopaedia of Indian Natural History, Bombay Natural History Society, Bombay (R)
9. Heywood V H and Watson R T, 1995. Global Biodiversity Assessment. Cambridge University Press 1140pgs.
10. Jadhav H and Bhosale VM, 1995. Environmental Protection and Laws. Himalaya Publishing House, Delhi 284pgs.
11. Mckinney ML and Schoch RM, 1996. Environmental Science Systems and Solutions. Web enhanced edition, 639pgs.
12. Mhaskar AK, Matter Hazardous, Techno-Science Publications (TB)
13. Miller TG, Jr. Environmental Science, Wadsworth Publishing CO. (TB)
14. Odum EP, 1971. Fundamentals of Ecology. WB Saunders Co. USA, 574pgs.
15. Rao MN and Datta AK, 1987. Waste Water Treatment. Oxford and IBH Publishing Co. Pvt. Ltd. 345pgs.


## Course Outcomes (COs)

After successful completion of this course, the students will be able to

| CO No. | Course Outcomes: | PO Addressed | PSOs Addressed | Cognitive Level |
|---|---|---|---|---|
| CO-1 | Define and demonstrate the concept, components and function of natural resources and ecosystems. | PO1 | PSO3 | R, U |
| CO-2 | Define, illustrate and analyse the cause, effects and control measures of various environmental pollutants. | PO3 | PSO3 | R, U, An |
| CO-3 | Demonstrate the basic idea about the disasters and its management. | PO3 | PSO3 | U |
| CO-4 | Illustrate and apply the knowledge about the social, environmental issues and environmental legislation. | PO4 | PSO3 | U, Ap |
| CO-5 | Define, demonstrate and evaluate the impact of human population on the Environment | PO6 | PSO3, PSO5 | R, U, E |

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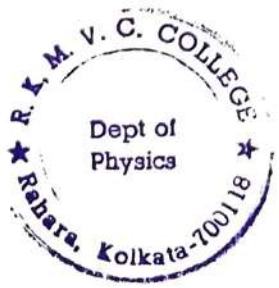
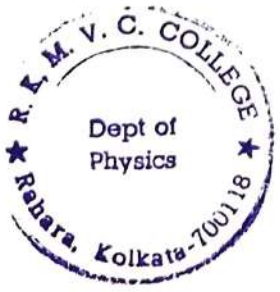
# 8. Question Patterns



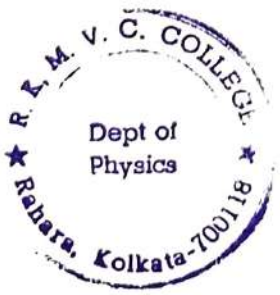
| **8.1. Core Courses Question Pattern** | | | |
|---|---|---|---|
| **Full Marks : 50** | | **Exam Duration : 2 hrs.** | |
| **Group – A ( 24 marks )** | | **Group – B ( 26 marks )** | |
| **Question Type** | **Marks** | **Question Type** | **Marks** |
| Two short questions out of three.<br>(2 marks each) | 2×2 = 4 | Three short questions out of five.<br>(2 marks each) | 3×2 = 6 |
| Two long questions out of three.<br>(10 marks each with subdivision therein) | 2×10 = 20 | Two long questions out of three.<br>(10 marks each with subdivision therein) | 2×10 = 20 |
| | **24** | | **26** |

**Note:**
*In some special situations/cases, the following patterns may have minor changes.*



| 8.2. DSE Courses Question Pattern | | | |
|---|---|---|---|
| **Full Marks : 50** | | **Exam Duration : 2 hrs.** | |
| **Group – A ( 24 marks )** | | **Group – B ( 26 marks )** | |
| **Question Type** | **Marks** | **Question Type** | **Marks** |
| Two short questions out of three.<br>(2 marks each) | 2×2 = 4 | Three short questions out of five.<br>(2 marks each) | 3×2 = 6 |
| Two long questions out of three.<br>(10 marks each with subdivision therein) | 2×10 = 20 | Two long questions out of three.<br>(10 marks each with subdivision therein) | 2×10 = 20 |
| | **24** | | **26** |

**Note:**
*In some special situations/cases, the following patterns may have minor changes.*

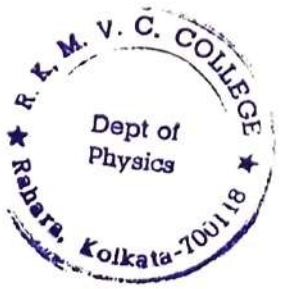


## 8.3. GE Courses Question Pattern

**Full Marks : 50** **Exam Duration : 2 hrs.**

| Group – A ( 24 marks ) | | Group – B ( 26 marks ) | |
|---|---|---|---|
| **Question Type** | **Marks** | **Question Type** | **Marks** |
| Two short questions out of three.<br>(2 marks each) | 2×2 = 4 | Three short questions out of five.<br>(2 marks each) | 3×2 = 6 |
| Two long questions out of three.<br>(10 marks each with subdivision therein) | 2×10 = 20 | Two long questions out of three.<br>(10 marks each with subdivision therein) | 2×10 = 20 |
| | **24** | | **26** |

**Note:**
*In some special situations/cases, the following patterns may have minor changes.*



| 8.4. AEC Courses Question Pattern | | |
|---|---|---|
| **Full Marks : 50** | | |
| **Component** | **Question Type** | **Marks** |
| Part A | Short answers | 5×1 = 5 Marks |
| Part B | Listening | 1× 5 = 5 Marks |
| Part C | Speaking (Presentation and Project submission) | 1×15 = 15 Marks |
| Part D | Reading Comprehension | 1×5 = 5 Marks |
| Part E | Writing | 2×5 = 10 Marks<br>1×10 = 10 Marks |
| | **Total Marks** | **50** |

**Note:**
*In some special situations/cases, the following patterns may have minor changes.*