UNIVERSITY OF CALCUTTA

NotificationNo.CSR/47/19

It is notified for information of all concerned that the Syndicate at its meeting held on 08.08.2019 (vide Item No.19) subsequently confirmed by the Syndicate 27.08.2019 (Item No.01) approved the revised syllabus of B.Sc. Physics (Honours/General) under CBCS, under this University, as laid down in the accompanying pamphlet.

The above shall take effect from the academic session 2019 -2020 and the students who are at present attending semester-3 classes will continue with the old syllabus.

SENATE HOUSE
KOLKATA-700 073
The 11th November, 2019.

Prof.(Dr.) Debasis Das
Registrar

U.G. Syllabus

for

Physics (Honours and General)

(Revised)

University of Calcutta

2019

Choice Based Semester System (CBCS)

Basic Scheme of CBCS for Science in University of Calcutta

The details for CBCS scheme for Science and Arts (Humanities) are described in CSR Number CUS/268 (Cir)/18 dated 07.05.2018. The relevent portions for Physics (H) and Physics (G) termed as PHSA and PHSG are mentioned here.

The choice bases credit system is comprised of several type of courses. Some courses are compulsory. They are termed as Core Course (CC). There are again two type of core courses subject specific core courses (termed as CC only) and abitlity enhancement core courses (termed as AECC).

The choice is actually available for elective subjects. There are three kind of elective subjects,

- Generic Elective (GE): It can be chosen from other disciplines
- Skill Enhancement Course (SEC): It can be chosen from the subject which is opted for CC
- Discipline Specific Elective course (DSE): It can be chosen from the subject which is opted for CC

Each courses has definite credit. They are summarised in the table given below:

Basic Course Types and Credits under CBCS

Course Type	Description	Credit
Core Course (CC)	Compulsory Basic course *from Physics*	6
Generic Elective Course (GE)	Elective course *other than Phyiscs* [In first four semesters]	6
Skill Enhancement Course (SEC)	Skill based elective course *from Physics* [In 3rd and 4th Semesters for Hons] [In 3rd, 4th, 5th, 6th Semesters for Gen]	2
Discipline Specific Elective Course (DSE)	Specialised elective course *from Physics* [In 5th and 6th Semester]	6
Ability Enhancement Compulsory Course (AECC) AECC-1 [In 1st Semester] AECC-2 [In 2nd Semester]	*Not related to Physics* Language Environment Science	2

A. Teaching Methods
For any course, one of the following modes of teaching will be used

1. Theory + Practical
2. Theory + Tutorial
3. Theory + Project
4. Theory only

B. 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
- Project: 1 credit = 1 hour/week

C. Duration of the Semesters: The semesters will comprise 15 weeks.

D. The total number of classes
The number of classes for each part is summarised below:

- Theoretical module (Credit 4) = 60 Classes
- Practical module (Credit 2) = 60 Classes
- Tutorial (Credit 1) = 15 Classes
- Theoretical module, SEC (Credit 2) = 30 Classes
- Theoretical module, (project type) SEC (credit 1) = 15 Classes
- Project module, (project type) SEC (credit 1) = 15 Classes
- Theoretical module, DSE (Credit 5) = 75 Classes

E. Marks Distribution

The total number for evaluation of each course is 100. Twenty (20) out of hundred (100) is reserved as internal marks where 10 marks come from attendance and 10 from internal assessment examination. The other 80 marks are distributed among different components in different ways for a particular courses. The number distributions are mentioned below.

- CC/GE
  - Attendance 10
  - Internal Assessment 10
  - Theory Examination 50
  - Practical 30
- DSE
  - Attendance 10
  - Internal Assessment 10
  - Theory Examination 65
  - Tutorial 15
- SEC type **1** (Knowledge skill - Theory based)
  - Attendance 10
  - Internal Assessment 10
  - Theory Examination 65
  - Tutorial 15
- SEC type **2** (Technical Skill - Theory & Project based)
  - Attendance 10
  - Internal Assessment 10
  - Theory Examination 20
  - Project 60

Contents

Part I

Physics Syllabus: Honours Course

Basic Course Structure for Honours Course

Students of B.Sc. Physics Honours Course have to take 14 (fourteen) Core Courses (CC) from Physics and these Core Courses are distributed over all the six semesters. Two subjects other than physics are to be chosen as Generic Elective (GE). The modules of the GE courses are confined to the first four semesters. e.g., a student of physics Honours had chosen Chemistry and Mathematics as his/her generic elective subjects. The corresponding subject codes will be CEMG-GE and MTMG-GE. We refer to them as subject 111G-GE and 222G-GE. i.e., 111≡CEM and 222≡MTM. Two modules from each subject will be taken in any two semester. The possible combinations of GE modules are described in the third table.

Skill Enhancement Course, SEC must be opted in 3rd, 4th Semester only. SEC A is meant for 3rd Semesters and SEC B is meant for 4th Semesters. Student of Physics Honours will take SEC course from Physics. In each semester there is one project type and one theory SEC is available.

Student should take two Discipline specific elective courses, DSEs in each 5th and 6th semester. These two courses are termed as DSE-A and DSE-B. In 5th semester the courses are DSE A1 and DSE B1. Similarly, DSE A2 and DSE B2 are the subjects for 6th Semester.

Detail plans with credits in parentheses are given in following table (XXX for GE will be cleared in the third table).

Honours Course: Credit Distribution

Courses	Semester 1	Semester 2	Semester 3	Semster 4	Semester 5	Semester 6
CC	PHSA-CC-1 (6)	PHSA-CC-3 (6)	PHSA-CC-5 (6)	PHSA-CC-8 (6)	PHSA-CC-11 (6)	PHSA-CC-13 (6)
	PHSA-CC-2 (6)	PHSA-CC-4 (6)	PHSA-CC-6 (6)	PHSA-CC-9 (6)	PHSA-CC-12 (6)	PHSA-CC-14 (6)
			PHSA-CC-7 (6)	PHSA-CC-10 (6)		
GE	XXXGE1 (6)	XXXGE2 (6)	XXXGE2 (6)	XXXGE4 (6)		
SEC			PHSA-SEC A (2)	PHSA-SEC B (2)		
DSE					PHSA-DSE-A1 (6)	PHSA-DSE-A2 (6)
					PHSA-DSE-B1 (6)	PHSA-DSE-B2 (6)
AECC	AECC -1 (2)	AECC-2 (2)				
Total Credit	20	20	26	26	24	24
Number	400	400	500	500	400	400

Thus a general stuents completes $20 \times 2+26 \times 2+24 \times 2 = 40 + 52 + 48 = 140$ Credits in his/her course. The total marks for which student will appear in examination are given below. All the core courses have practical module. Therefore, both theory and practical examination will be held for these courses. Some SEC and AECC2 have projects. All these projects must be completed and submitted for evaluation within the stipulated semester. However, the DSE courses do not have any practical module. In these courses the students will appear in tutorial instead of practical examination.

Distribution of Honours Courses

The fourteen (14) Core papers are compulsory. Students persuing Advanced (i.e., Honours) Course need to take two (2) Skill enhancement Courses one in each of 3rd and 4th Semesters and four Discipline Specific Elective two in each 5th and 6th Semester. The details of the course divisions along with the subjects are given below.

Table 1: The Course distribution of Honours Course

Semester	Core Courses			SEC	DSE A	DSE B
Semester	**CC-1**	**CC-2**				
1	Mathematical Methods 1	Mechanics				
Semester	**CC-3**	**CC-4**				
2	Electricity & Magnetism	Waves & Optics				
Semester	**CC-5**	**CC-6**	**CC-7**	**SEC A-1**		
3	Mathematical Methods II	Thermal Physics	Modern Physics	Scintific Writing Or **SEC A-2** Renewable Energy		
Semester	**CC-8**	**CC-9**	**CC-10**	**SEC B-1**		
4	Mathematical Methods III	Analog Electronics	Quantum Mechanics	Arduino Or **SEC B-2** Electrical Circuits Network Skill		
Semester	**CC-11**	**CC-12**			**DSE A1**	**DSE B1**
5	Electromagnetic Theory	Statistical Physics			Advanced Mathmatical Methods Or Laser & fiber optics	Astronomy & Astrophysics Or Nuclear Physics
Semester	**CC-13**	**CC-14**			**DSE A2**	**DSE B2**
6	Digital Electronics	Solid State Physics			Nanomaterials Or Advanced Classical Dynamics	Communication Electronics Or Advanced Statistical Mechanics

Distribution of Generic Elective

Student will take two generic elective coureses and need to cover only two module for each of them. Therefore, a student read a particluar subject in two semesters only. Four different modules are prescribed for four semesters in all subjects and they are named accordingly. i.e.,

- Semester 1 GE 1
- Semester 2 GE 2
- Semester 3 GE 3
- Semester 4 GE 4

Therefore, a student who will choose chemistry in second semester his/her module will be CEMG-GE2. Among the first four semesters student should take one subject in any two semesters and in the rest two semesters he/she need to take the other one as Generic Elective. Let us denote these two subjects as 111G & 222G. The possible combinations of generic electives are shown in the following table.

Combination	GE1	GE2	GE3	GE4
1	111G	222G	222G	111G
2	222G	111G	111G	222G
3	111G	111G	222G	222G
4	222G	222G	111G	111G
5	111G	222G	111G	222G
6	222G	111G	222G	111G

Honours: Semester 1

CC1 and CC2

CC1	Mathemtical Physics 1	Theory	Practical
	Credit 6	Credit 4	Credit 2
		Classes 60	Classes 60
CC2	Mechanics	Theory	Practical
	Credit 6	Credit 4	Credit 2
		Classes 60	Classes 60

1.1 Mathematical Physics I

1.1.1 Mathematical Physics I (Theory)

Paper: PHS-A-CC-1-1-TH	**Credits:4**

1. **Calculus** **20 Lectures**

(a) Recapitulation: Limits, continuity, average and instantaneous quantities, differentiation. Plotting functions. Intuitive ideas of continuous, differentiable, etc. functions and plotting of curves.

(b) Convergence of infinite series: Convergence of power series . Idea of interval of convergence . Different convergence tests of power series: D'alembert's ratio test, Cauchy's root test, Integral test. Alternating series test. Absolute and conditional convergence. Taylor series of one variable, Maclaurin series. Approximation errors.

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

(d) Calculus of functions of more than one variable: Partial derivatives, exact and inexact differentials. Integrating factor with simple illustration. Taylor series of two variable functions, Maxima, minima, saddle point evaluation of two variable functions using Taylor series. Constrained Maximization using Lagrange Multipliers.

2. **Vector Algebra and Vector Calculus** **25 Lectures**

(a) Recapitulation of Vector Algebra. Idea of linear independence, completeness, basis and representation of vectors. Properties of vectors under rotations. Scalar product and its invariance under coordinate rotations. Vector product, Scalar triple product and their interpretation in terms of area and volume respectively.

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

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

(d) Orthogonal Curvilinear Coordinates. Derivation of Gradient, Divergence, Curl and Laplacian in Spherical and Cylindrical Coordinate Systems.

3. Matrices **15 Lectures**

(a) Addition and Multiplication of Matrices. Null Matrices. Diagonal, Scalar and Unit 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.

(b) Eigen-values and Eigenvectors (Degenerate and non-degenerate). Cayley-Hamiliton Theorem. Diagonalization of Matrices. Solutions of Coupled Linear Ordinary homogeneous Differential Equations. Functions of a Matrix.

Reference Books

1. Calculus and Analytic Geometry , Thomas and Finney, Pearson Education India
2. Mathematical methods in the Physical Sciences, M. L. Boas, 2005, Wiley
3. Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, F.E. Harris, 2013, 7th Edn., Elsevier
4. Essential Mathematical Methods, K.F.Riley and M.P.Hobson, 2011, Cambridge Univ. Press
5. Higher Enginering Mathematics, B. S. Grewal, Khanna Publisher
6. Differential Equations, George F. Simmons, 2007, McGraw Hill
7. Vector Analysis and an introduction to TENSOR ANALYSIS, S. Lipschutz, D. Spellman, M. R. Spiegel, Schaum's Outline Series, Tata Mc Graw Hill Education Private Limited, edition 2009
8. Matrix Methods: An Introduction , R. Bronson, 1991, Academic Press
9. A Students Guide to Vectors and Tensors, D. Fleisch, 2012, Cambridge University Press

Additional Reference Books

1. Calculus: Early Transcendentals, J. Stewart, Cengage India Private Limited
2. Calculus volume 1 and 2, T. Apostol, Wiley.
3. An introduction to ordinary differential equations, E.A. Coddington, 2009, PHI
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. Mathematics for Physics and Physicists, W.Appel, 2007, Princeton University Press
11. Piskunov, N., Differential and Integral Calculus, CBS
12. Play with Graphs, Amit M. Agarwal, Arihant Publisher

1.1.2 Mathematical Physics - I (Practical)

Paper: PHS-A-CC-1-1-P	**Credits: 2**

1. Introduction to plotting graphs with Gnuplot **3 Lectures + 6 Classes**

(a) **Plotting 2D graphs:** both functions and data files. Changing plot range, plot style: the options- with points (w p), with dots (w d), with lines (w l), with linespoints (w lp), linetype (lt), linewidth (lw). Using the set command for samples, xrange, yrange, xlabel , ylabel, title etc. The *using* and *every* options.
(b) User defined functions [Including the use of ternary operator (? :) for piece-wise defined functions.]
(c) Fitting data files using gnuplot.
(d) Polar and parametric plots.
[Graphs to be saved by using GUI - The "export" protocol is not needed.]

2. Introduction to programming in python:
(a) Introduction **3 Lectures + 5 Classes**

- Using the python interpreter as a calculator
- Variable and data types (int, float, complex, list, tuple, string, the type() function)
- Basic mathematical operations
- Compound statements in python
  - *Conditionals*
    if:
    elf:
    else:
  - *Loops* for: , while:
  - *User defined functions* def: [return statement, default values for arguments, keyword arguments]
- Importing modules with math and cmath as examples
- Using online help
- Basic idea of namespaces-local and global
- Python scripts, I/O operations (including opening and writing to files)

(b) The python iterables data type **5 Lectures + 10 Classes**

- **List:**defining lists,reading and changing elements from lists, slicing (with discussion on the difference between **ll**=**mm** and **ll**=**mm[:]**, concatenation, list comprehension.

  - built in functions involving lists: range(), len(), sum(), min(), max()
  - list methods: append(), extend(), count(), index(), sort(), insert(), pop(), remove(), reverse()

- **Tuples:** Contrast and compare with lists, packing/unpacking using tuples (including **a,b**=**b,a** to swap variables)
- **Strings:** defining strings, the use of single, double or triple quotes as string delimiters, len(),indexing, slicing, string concatanation, some string methods: strip(), split(), join(), find(), count(), replace(), string formatting in python (using the % operator

(c) Problems and applications **8 Lectures + 20 Classes**

Problem 0: Observe and interpret the result of the following two scripts

```
i=0
a=1
while a>0:
        i=i+1
        a=a/2
print i
```

```
i=0
a=1
b=1
while a+b > b:
        i=i+1
        a=a/2
print i
```

Problem 1. Root finding for a single variable (basic theory and algorithm)

- Bisection method
- Newton-Raphson Method

Problem 2. Sorting of lists (algorithm, flowchart and code)

- Bubble sort
- Selection sort

Problem 3. ODE in one and two dimensions using Euler algorithm (output to be saved in data files and gunuplot to be used to plot graphs)

- Capacitor charging/discharging
- Simulating a half-wave rectifier with a capacitor filter
- Particle dynamics in 1D

Problem 4. Matrix operations using list of lists

- Matrix Addition
- Matrix Multiplication
- Transpose of a Matrix

Reference Books

1. Gnuplot in Action understanding data and Graphs, Phillipp K. Janert
2. Scientific Computing in Python. Abhijit Kar Gupta, Techno World

3. Physics in Laboratory including python Programming (Semester I), Mandal, Chowdhury, Das, Das, Santra Publication

Additional Reference Books

1. Introduction to Numerical Analysis, S.S. Sastry, 5th Edn. , 2012, PHI Learning Pvt. Ltd
2. Numerical Methods, Arun Kr Jalan, Utpal Sarkar, Univerisity Press
3. Numerical Mathematical Analysis, J. B. Scarborough, OXFORD and IBH Co. Pvt. Ltd.
4. Elementary Numerical Analysis, K.E. Atkinson, 3rd Edn., 2007, Wiley India Edition
5. An Introduction to computational Physics, T.Pang, 2nd Edn., 2006,Cambridge Univ. Press
6. Learning with Python-how to think like a computer scientist, J. Elkner, C. Meyer, and A. Downey, 2015, Dreamtech Press
7. Gnuplot 5, Lee Phillips, Alogus Publishing, edition 2012.
8. Python Programming, Satyanarayana, Radhika Mani, Jagdesh, Univerisity Press
9. Python 2.1 Bible Dave Brueck, Stephen Tanner, Hungry Minds Inc, New York
10. Computatioal Physics problem solving with Computers, Landau, Paez, Bordeianu etextbook in Python 3rd Edition

1.2 Mechanics

1.2.1 Mechanics (Theory)

Paper: PHS-A-CC-1-2-TH	Credits: 4

1.Fundamentals of Dynamics **12 Lectures**

(a) Review of Newtons Laws: Mechanistic view of the Universe. Concepts of Inertial frames, force and mass.Galilean transformations and Gallilean invariance. Solution of the equations of motion (E.O.M.) in simple force fields in one, two and three dimensions using cartesian, cylindrical polar and spherical polar coordinate systems.

(b) Dynamics of systems of particles: Difficulty of solving the E.O.M. for systems of particles. Newton's third Law. External and Internal forces. Momentum and Angular Momentum of a system. Torque acting on a system. Conservation of Linear and Angular Momentum. Centre of mass and its properties. Two-body problem.

(c) Variable mass system: motion of rocket.

2. Work and Energy **8 Lectures**

(a) Work Kinetic Energy Theorem. Conservative Forces: Force as the gradient of a scalar field. concept of Potential Energy. Other equivalent definitions of a Conservative Force. Conservation of Energy.

(b) Qualitative study of one dimensional motion from potential energy curves. Stable and Unstable equilibrium.

(c) Energy of a system of particles.

3. Gravitation and Central Force Motion **10 Lectures**

(a) Central Force. Reduction of the two body central force problem to a one body problem. Setting up the E.O.M. in plane polar coordinates.

(b) Differential equation for the path. Motion under an Inverse square force. Newton's Law of Gravitation. Inertial and gravitational mass. Kepler's Laws. Satellite in circular orbit and applications. Weightlessness.

(c) Gravitational potential energy. Potential and field due to spherical shell and solid sphere.

4. Non-Inertial Systems **12 Lectures**

Non-inertial frames and idea of fictitious forces. E.O.M with respect to a uniformly accelerating frame. E.O.M with respect to a uniformly rotating frame - Centrifugal and Coriolis forces. Laws of Physics in a laboratory on the surface of the earth.

5. Rotational Dynamics **12 Lectures**

(a) The Rigid Body: Constraints defining the rigid body. Degrees of freedom for a rigid body;

(b) Relation between Angular momentum and Angular Velocity: Moment of Inertia Tensor. Calculation of moment of inertia for rectangular, cylindrical and spherical bodies.

(c) Equation of motion for rotation about a fixed axis. Principal Axes transformation. Transformation to a body fixed frame. E.O.M for the rigid body with one point fixed (Euler's equations of motion). Torque free motion.Kinetic energy of rotation.

6. Fluid Motion **6 Lectures**

Kinematics of Moving Fluids: Idea of compressible and incompressible fluids, Equation of continuity; streamline and turbulent flow, Reynold's number. Euler's Equation. The special case of fluid statics $\vec{F} = \vec{\nabla}p$. Simple applications (e.g: Pascal's law and Archimedes principle). Bernoulli's Theorem.

Reference Books

1. An introduction to mechanics, D. Kleppner, R.J. Kolenkow, 1973, McGraw- Hill
2. Feynman Lectures, Vol. I, R.P.Feynman, R.B.Leighton, M.Sands, 2008, Pearson Education
3. Classical Mechanics and General Properties of Matter. S.N. Maiti and D.P. Raychaudhuri, New Age
4. Introduction to Classical Mechanics, R. G. Takwale and P.S.Puranik, Tata McGraw-Hill Publishing Company Ltd.
5. Theory and Problems of Theoretical Mechanics, M. R. Spiegel, Mc Grow Hill Education
6. Classical Mechanics , R.D. Gregory, 2006, Cambridge University Press
7. Introduction to Classical Mechanics With Problems and Solutions , D. Morin, Cambridge University Press

Additional Reference Books

1. Mechanics,Berkeley Physics, vol.1, C.Kittel, W.Knight, et.al. 2007, Tata McGraw-Hill. Physics
2. Mechanics,Resnick, Halliday and Walker 8/e. 2008, Wiley
3. Analytical Mechanics, G.R. Fowles and G.L. Cassiday. 2005, Cengage Learning
4. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole

5. Classical Dynamics of Particles and Systems. S.T. Thornton and J. B. Marion, 2009, Brooks/Cole
6. Mechanics , K. Symon, 2016, Pearson Education India
7. Classical Mechanics , Kibble and Berkshire, Imperial College Press
8. Classical Mechanics , J.M. Finn, 2010, Laxmi Publications
9. Mechanics, D.S. Mathur, S. Chand and Company Limited, 2000
10. University Physics. F.W Sears, M.W Zemansky, H.D Young 13/e, 1986, Addison Wesley

1.2.2 Mechanics (Practical)

Paper PHS-A-CC-1-2-P	**Credits: 2**

General Topics

1. Measurements of length (or diameter) using vernier caliper, screw gauge and traveling microscope.

2. Idea of systematic and random errors introduced in different instruments.

List of Practicals

1. To determine the Moment of Inertia of a metallic cylinder / rectangular bar about an axis passing through the C.G. and to determine the Modulus of Rigidity of the suspension wire.

2. To determine the Moment of Inertia of a Flywheel.

3. To determine the Young modulus, modulus of rigidity and Poisson ratio of the material of a wire by Searle's dynamic method.

4. To determine the value of g using Bar Pendulum.

5. To determine the height of a building (or a suitable vertical height) using sextant.

6. Determination of Young's modulus of the material of a beam by the method of flexure.

Reference Books

1. Practical Physics, G.L. Squires, 2015, 4th Edition, Cambridge University Press
2. B.Sc. Practical Physics, C.L. Arora, S Chand and Company Limited
3. Physics in Laboratory, Mandal, Chowdhury, Das, Das, Santra Publication
4. Advanced Practical Physics Vol 1, B. Ghosh, K. G. Majumder, Sreedhar Publisher

Additional Reference Books

1. Practical Physics, P.R. Sasi Kumar, PHI Learning Private Limited
2. B.Sc. Practical Physics, Harnem Singh, P.S. Hemne, S Chand and Company Limited
3. Engineering Practical Physics, S.Panigrahi & B.Mallick, 2015, Cengage Learning India Pvt. Ltd

Honours: Semester 2

CC3 and CC4

CC3	Electricity and Magnetism	Theory	Practical
	Credit 6	Credit 4	Credit 2
		Classes 60	Classes 60
CC4	Waves and Optics	Theory	Practical
	Credit 6	Credit 4	Credit 2
		Classes 60	Classes 60

2.1 Electricity and Magnetism

2.1.1 Electricity and Magnetism (Theory)

Paper: PHS-A-CC-2-3-TH **Credits: 4**

1. Dirac delta function and it's properties **3 Lectures**

Dirac delta function: definition of dirac delta function. Delta function as limit of different representations. Properties of delta function. Three dimensional delta function. Proof of the relation $\nabla.(\frac{\hat{r}}{r^2}) = 4\pi\delta^3(\vec{r})$.

2. Electrostatics **12 Lectures**

(a) Coulombs law, principle of superposition, electrostatic field. Electric field and charge density, surface and volume charge density, charge density on the surface of a conductor. Force per unit area on the surface.

(b) Divergence of the Electrostatic field, flux, Gauss's theorem of electrostatics, applications of Gauss theorem to find Electric field due to point charge, infinite line of charge, uniformly charged spherical shell and solid sphere, plane charged sheet, charged conductor.

(c) Curl of the Electrostatic Field. Conservative nature of electrostatic field, Introduction to electriostatic potential, Calculation of potential for linear, surface and volume charge distributions, potential for a uniformly charged spherical shell and solid sphere. Calculation of electric field from potential.

3. Dielectric properties of matter **6 Lectures**

Electric dipole moment, electric potential and field due to an electric dipole, force and Torque on a dipole. Electric Fields inside matter, Electric Polarisation, bound charges, displacement density vector, relation between $\vec{E}$, $\vec{P}$ and $\vec{D}$. Gauss's theorem in dielectrics, linear Dielectric medium, electric succeptibility and permittivity. Electrostatic boundary conditions for $\vec{E}$ and $\vec{D}$.

4. Method of Images **4 Lectures**

Laplace's and Poisson equations. Uniqueness Theorems. Method of Images and its application to: Plane Infinite metal sheet, Semi-infinite dielectric medium and metal Sphere.

5. Electrostatic Energy **3 Lectures**

Electrostatic energy of system of charges. Electrostatic energy of a charged sphere. Energy per unit volume in electrostatic field.

6. The Magnetostatic Field **10 Lectures**

(a) Biot-Savart's law. Application of Biot-Savart's law to determine the magnetic field of a straight conductor, circular coil. Force on a moving point charge due to a magnetic field: Lorentz force law. Force between two straight current carrying wires.

(b) Divergence of the magnetic field and its solenoidal nature. Magnetic vector potential, calculation for simple cases.

(c) Curl of the magnetic field. Ampere's circuital law. Its application to (1) Infinite straight wire, (2) Infinite planar surface current, and (3) Infinite Solenoid.

7. Magnetic properties of matter **7 Lectures**

(a) Potential and field due to a magnetic dipole. Magnetic dipole moment. Force and torque on a magnetic dipole in a uniform magnetic field.

(b) Magnetization, Bound currents. The magnetic intensity $\vec{H}$. Relation between $\vec{B}$, $\vec{H}$ and $\vec{M}$. Linear media. Magnetic Susceptibility and Permeability. Boundary conditions for $\vec{B}$ and $\vec{H}$. Brief introduction of dia-, para- and ferro-magnetic materials. B-H curve and hysteresis.

8. Electro-magnetic induction **7 Lectures**

Ohms law and definition of E.M.F. Faraday's laws of electromagnetic induction, Lenz's law. Self-Inductance and Mutual Inductance. Reciprocity Theorem. Introduction to Maxwell's Equations. Charge conservation. Displacement current and resurrection of Equation of Continuity.

9. Electrical circuits **8 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

Reference Books

1. Feynman Lectures Vol.2, R.P.Feynman, R.B.Leighton, M. Sands, 2008, Pearson Education
2. Introduction to Electrodynamics, D.J. Griffiths, 3rd Edn., 1998, Benjamin Cummings
3. Electricity and Magnetism, D.Chattopadhyay and P.C.Rakshit, New Central Book Agency, 2011
4. Fundamentals of Electricity and Magnetism, B. Ghosh, Books and Allied (P) Ltd., 4th edition, 2015.

Additional Reference Books

1. Electricity, Magnetism and Electromagnetic Theory, S. Mahajan and Choudhury, 2012, Tata McGraw Hill
2. Electricity and Magnetism, Edward M. Purcell, 1986 McGraw-Hill Education
3. Elements of Electromagnetics, M.N.O. Sadiku, 2010, Oxford University Press
4. Classical Electromagnetism, Jerrold Franklin, Pearson Education

5. Electricity and Magnetism, J.H.Fewkes & J.Yarwood. Vol. I, 1991, Oxford Univ. Press
6. Electricity and Magnetism, D. C. Tayal, Himalayan Publisher

2.1.2 Electricity and Magnetism (Practical)

Paper: PHS-A-CC-2-3-P	**Credit: 2**

General Topics

- Potentiometric measurement technique of voltage, advantage over the use of voltmeter
- idea of potential lead and current lead of low resistance
- idea of the order of value of the resistance per unit length of Carey foster Bridge with the value of resistance used for measurement, the expected accuracy
- use of multimeter in different modes
- frequency response for CR circuit
- details of ballistic galvanometer
- variation of mutual inductance for angle between primary and secondary coil

List of Practicals

1. To determine an unknown Low Resistance using Potentiometer.

2. To determine an unknown Low Resistance using Carey Foster's Bridge.

3. 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.

4. To study the ac characteristics of a series RC Circuit. Study as low/high pass filter. Calculation of capacitance from current reactance graph.

5. To study mutual inductance between two coils .

6. Determination of horizontal component of the Earth's magnetic field.

Reference Books

1. Practical Physics Vol 1, Vol 2, B. Ghosh, K. G. Majumder, Sreedhar Publisher
2. An Advanced Course in Practical Physics, D. Chattopadhyay, P.C. Rakshit, New Central Book Agency (P) Ltd

Additional Reference Books

1. Practical Physics, P.R. Sasi Kumar, PHI Learning Private Limited

2. B.Sc. Practical Physics, Harnem Singh, P.S. Hemne, S Chand and Company Limited
3. B.Sc. Practical Physics, C.L. Arora, S Chand and Company Limited
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

2.2 Waves and Optics

2.2.1 Waves and Optics (Theory)

Paper: PHS-A-CC-2-4-TH	**Credit:4**

1. Oscillations **8 Lectures**
Differential equation of Simple Harmonic Oscillation and its solution. Kinetic energy, potential energy, total energy and their time average values. Damped oscillation. Forced oscillations: Transient and steady states; Resonance, sharpness of resonance; power dissipation and Quality Factor.

2. Superposition of Harmonic Oscillations **4 Lectures**
(a) Superposition of Two Collinear Harmonic oscillations having equal frequencies and different frequencies (Beats).
(b) Superposition of Two Perpendicular Harmonic Oscillation for phase difference $\delta = 0, \frac{\pi}{2}, \pi$: Graphical and Analytical Methods, Lissajous Figures with equal and unequal frequency and their uses.

3. Wave motion **4 Lectures**
Plane and Spherical Waves. Longitudinal and Transverse Waves. Plane Progressive (Traveling) Waves. Wave Equation for travelling waves . Particle and Wave Velocities. (Solution of spherical wave equation may be assumed)

4. Superposition of Harmonic Waves **9 Lectures**
(a) Velocity of Transverse Vibrations of Stretched Strings, Standing (Stationary) Waves in a String: Fixed and Free Ends. Analytical Treatment. Changes with respect to Position and Time. Energy of Vibrating String. Transfer of Energy. Normal Modes of Stretched Strings. (form of the solution of wave equation may be assumed). Plucked and Struck Strings.
(b) Superposition of N Harmonic Waves. Phase and Group Velocities.

5. Wave optics **4 Lectures**
(a) Electromagnetic nature of light. Definition and properties of wave front. Huygens Principle.
(b) Temporal and Spatial Coherence.

6. Interference **10 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.

7. Interferometers **5 Lectures**
(a) 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.

(b)Multiple beam interferometry, Fabry-Perot interferometer.

8. Diffraction **16 Lectures**

(a) Fraunhofer diffraction: Single slit. Circular aperture (solution may be assumed), Resolving Power of a telescope. Double slit. Multiple slits. Diffraction grating. Resolving power of grating. Rayleigh criterion for resolution.

(b) 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.

Reference Books

1. The Physics of Vibrations and Waves, H. J. Pain, 2013, John Wiley and Sons
2. Advanced Acoustics, D. P. Roychowdhury, Chayan Publisher
3. Waves and Oscillations, N. K. Bajaj, Tata McGrow Hill
4. Optics, 4th Edn., Eugene Hecht, Pearson Education Limited, 2014
5. Optics, Ajoy Ghatak, 2008, Tata McGraw Hill

Additional Reference Books

1. Waves: Berkeley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGraw-Hill
2. Fundamentals of Optics, F.A. Jenkins & H.E. White, 1981, McGraw- Hill
3. Introduction to Optics, F.L. Pedrotti, L.S. Pedrotti, L.M. Pedrotti, Pearson Education
4. Principles of Optics, Max Born & Emil Wolf, 7th Edn., 1999, Pergamon Press
5. Fundamental of Optics, A. Kumar, H.R. Gulati and D.R. Khanna, 2011, R. Chand Publications
6. A textbook of Optics; N Subramanyam, B. Lal and M.N.Avadhanulu; S.Chand. Publishing

2.2.2 Waves and Optics (Practical)

Paper: PHS-A-CC-2-4-TH	**Credit: 2**

General topic

- Construction and measurment process in Spectrometer
- Theory of Schuster's focusing

List of Practicals

1. To determine the frequency of an electric tuning fork by Melde's experiment and verify $\lambda^2 - T$ law.

2. To study the variation of refractive index of the Material of a prism with wavelengths and hence the Cauchy constants using mercury/helium source.

3. To determine wavelength of sodium light using Fresnel Biprism.

4. To determine wavelength of sodium light/radius of plano convex lens using Newton's Rings.

5. To determine the thickness of a thin paper by measuring the width of the interference fringes produced by a wedge-shaped Film.

6. Measurement of the spacing between the adjacent slits in a grating by measuring sinθ vs graph of a certain order of grating spectra.

Reference Books

1. B.Sc. Practical Physics, C.L. Arora, S Chand and Company Limited
2. Advanced Practical Physics, Vol 1, B. Ghosh, K.G.Majumdar, Shreedhar Publishers
3. An Advanced Course in Practical Physics, D. Chattopadhyay, P.C. Rakshit, New Central Book Agency (P) Ltd

Additional Reference Books

1. Practical Physics, P.R. Sasi Kumar, PHI Learning Private Limited
2. B.Sc. Practical Physics, Harnem Singh, P.S. Hemne, S Chand and Company Limited

Honours: Semester 3

CC 5, CC 6, CC 7, SEC A

CC 5	Mathematical Physics II	Theory	Practical
	Credit 6	Credit 4	Credit 2
		Classes 60	Classes 60
CC 6	Thermal Physics	Theory	Practical
	Credit 6	Credit 4	Credit 2
		Classes 60	Classes 60
CC 7	Modern Physics	Theory	Practical
	Credit 6	Credit 4	Credit 2
		Classes 60	Classes 60
SEC A 1	Scientific Writing	Theory	Project
	Credit 2	Credit 1	Credit 1
		Classes 15	Classes 15
SEC A 2	Renewable Energy	Theory	
	Credit 2	Credit 2	
		Classes 30	

3.1 Mathematical Physics II

3.1.1 Mathematical Physics II (Theory)

Paper: PHS-A-CC-3-5-TH **Credit:4**

1. Fourier Series **10 Lectures**

(a) 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. Applications. Summing of Infinite Series. Term-by-Term differentiation and integration of Fourier Series. Parseval Identity.

2. Frobenius Method and Special Functions **20 Lectures**

Singular Points of Second Order Linear Differential Equations and their importance. Power series solution of 2nd order differential equation. Frobenius method and its applications to differential equations. Legendre, Bessel, Hermite Differential Equations. Properties of Legendre Polynomials: Rodrigues Formula, Generating Function, Orthogonality. Simple recurrence relations. Expansion of function in a series of Legendre Polynomials. Multipole expansion in Electrostatics. Bessel Functions of the First Kind: Generating Function, simple recurrence relations. Zeros of Bessel Functions ($J_0(x)$ and $J_1(x)$) and Orthogonality. Airy's disc for Fraunhofer diffraction through circular aperture.

3. Some Special Integrals **4 Lectures**

Beta and Gamma Functions and Relation between them. Expression of Integrals in terms of Gamma Functions. Error Function (Probability Integral).

4. Integrals Transforms **10 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, 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.

5. Introduction to probability **6 Lectures**

Independent random variables: Sample space and Probability distribution functions. Binomial, Gaussian, and Poisson distribution with examples. Mean and variance.

6. Partial Differential Equations **10 Lectures**

Solutions to partial differential equations using separation of variables: Solutions of Laplace's equation in problems with cylindrically and spherically symmetric boundary conditions. Examples from Electrostatics. Wave equation and its solution for vibrational modes of a stretched string, rectangular and circular membranes. Diffusion Equation.

Reference Books

1. Mathematical Methods for Physicists: Arfken, Weber, 2005, Harris, Elsevier
2. Fourier Analysis by M.R. Spiegel, 2004, Tata McGraw-Hill
3. Differential Equations, George F. Simmons, 2006, Tata McGraw-Hill
4. Differential Equations, S.L. Ross, 2007, Wiley
5. Mathematical Physics, P.K. Chattopadhyay,2014, New Academic Science
6. Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press
7. Fourier Series and Boundary Value Problems , J.W. Brown and R.V. Churchill, 2017, McGraw Hill Education
8. Introduction to Mathematical Physics, Charlie Harper, PHI Learning Pvt. Ltd.

Additional Reference Books

1. Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole
2. Mathematical Methods of Physics. J. Mathews and R.L. Walker, 2004, Pearson
3. Engineering Mathematics, S.Pal and S.C. Bhunia, 2015, Oxford University Press
4. Mathematical methods for Scientists and Engineers, D.A. McQuarrie, 2003, Viva Books
5. Mathematics for Physicists, P. Dennery and A.Krzywicki, 1967, Dover Publications.
6. Elementary Differential Equations and Boundary Value Problems, W.E. Boyce and R.C. Diprima, 2009, Wiley
7. Fourier Series, G.P. Tolstov, R. A. Silverman, 1976, Dover Publications Inc
8. A Students Guide to Fourier Transforms: With Applications In Physics And Engineering, J.F. James, 2011, Cambridge University Press
9. An Introduction to Partical Differential Equations for Science Students, G Stephenson, ELBS and Longman
10. Partial Differential Equations for Scientists and Engineers, S.J. Farlow, 1993, Dover Pub

3.1.2 Mathematical Physics II (Practical)

Paper: PHS-A-CC-3-5-P	**Credit: 2**

1. Introduction to numpy and scipy

- **the numpy array** **3 Lectures + 9 Classes**
  - properties: size, shape, ndim, dtype
  - creating arrays
    - zeros, one(), full(), fill()
    - arange(),linspace(),logspace()
    - identity(), eye()
    - astype()
  - indexing and slicing arrays (view versus copy)
  - important array methods
    - reshape(), ravel(), flatten()
    - hstack() and vstack()
  - Element wise functions:native numpy functions,the vectorise() method
  - Aggregate functions
    np.sum(),np.prod(),np.mean(),np.std(),np.var(),np.min(),np.max(), np.argmin(), np.argmax()
- **Using numpy for matrix operators (the 2D numpy array)** **2 Lectures + 6 Classes**
  - addition, multiplication(dot)
  - Gauss elemination (using partial pivoting)(numpy code)

    * for evaluating the determinant
    * for solving linear equation
  - the numpy linalg module
    * solving equations
    * diagonalisation

- **Scientific Applications**
  - **Interpolation** **2 Lectures + 6 Classes**
    * Lagrange Interpolation
    * Newton Forward Interpolation
      Using both numpy and scipy.interpolate(for visualization of the results use mathplotlib)
      -basic numerical analysis theory to be explained.
  - **Numerical Integration:(for both functions and equi-spaced data)** **4 Lectures + 8 Classes**
    * Trapezoidal rule
    * Simpson's one-third rule
      Using both numpy and scipy.integrate.quad(), scipy.integrate.trapz(), scipy.intgrate.simps()
      -basic numerical analysis theory to be explained.
    * Numerical Integration by n-point Gaussian Quadrature method. [Basic theory and numpy code - nodes and weights to be read from files, Integration by scipy.integrate.quad().]
  - **Solution of ODE** **2 Lectures + 3 Classes**
    * Solution of 1st order and 2nd order ordinary differential equation using 4th order Runge Kutta (RK4) algorithm [algorithm and numpy code - detailed theory not required]
  - **Curve fitting** **2 Lectures + 3 Classes**
    * with numpy polinomials
    * with user defined functions using scipy.optimize module

2. Introduction to mathplotlib (Using the pyplot submodule) **3 Lectures + 7 Classes**

- figure, axes, subplot
- plot(), scatter(), show()
- labels, legends, titles, styles, ticks
- dynamically updating curves
- saving graphs

Reference Books

1. Numerical Methods, Arun Kr Jalan, Utpal Sarkar, Univeristy Press
2. Scientific Computing in Python. Abhijit Kar Gupta, Techno World
3. Physics in Laboratory including python Programming (Semester III), Mandal, Chowdhuri, Das, Das, Santra Publication

4. mathplotlib Plotting Cookbook, Alexandre Devert, PACKT Publishing

5. Programming for Computation-Python, Svein Linge, Hans Petter Lantangen, Springer

6. Numerical Python, Robert Johansson, Apress Publication

Additional Reference Books

1. Introduction to Numerical Analysis, S.S. Sastry, 5th Edn. , 2012, PHI Learning Pvt. Ltd

2. Elementary Numerical Analysis, K.E. Atkinson, 3rd Edn., 2007, Wiley India Edition

3. An Introduction to computational Physics, T.Pang, 2nd Edn., 2006,Cambridge Univ. Press

4. Computatioal Physics problem solving with Computers, Landau, Paez, Bordeianu etextbook in Python 3rd Edition

3.2 Thermal Physics

3.2.1 Thermal Physics (Theory)

Paper: PHS-A-CC-3-6-TH	**Credit:4**

1.Introduction to Thermodynamics **25 Lectures**

(a) Zeroth and First Law of Thermodynamics: Extensive and intensive Thermodynamic Variables, Thermodynamic Equilibrium, Zeroth Law of Thermodynamics & Concept of Temperature. Concept of Work & Heat, State Functions, Internal Energy and First Law of Thermodynamics. Its differential form, 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 Coefficient.

(b) Second Law of Thermodynamics: Reversible and Irreversible process with examples. Conversion of Work into Heat and Heat into Work. Heat Engines. Carnot's Cycle, Carnot engine & efficiency. Refrigerator & coefficient of performance, 2nd Law of Thermodynamics: Kelvin-Planck and Clausius Statements and their Equivalence.

(c) Carnot's Theorem. Applications of Second Law of Thermodynamics: Thermodynamic Scale of Temperature and its Equivalence to Perfect Gas Scale.

(d) Entropy: Concept of Entropy, Clausius Theorem. Clausius Inequality, Second Law of Thermodynamics in terms of Entropy. Entropy of a perfect gas. Principle of Increase of Entropy. Entropy Changes in Reversible and Irreversible processes with examples. Entropy of the Universe. Principle of Increase of Entropy. Temperature-Entropy diagrams for Cycle. Third Law of Thermodynamics. Unattainability of Absolute Zero.

2. Thermodynamic Potentials **15 Lectures**

(a) 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.

(b) Maxwell's Thermodynamic Relations. Derivations and applications of Maxwell's Relations: (1) Clausius Clapeyron equation, (2) Values of C_P-C_V, (3) TdS Equations, (4) Joule-Kelvin coecient for Ideal and Van der Waal Gases, (5) Energy equations, (6) Change of Temperature during Adiabatic Process. Joule's Experiment. Free Adiabatic Expansion of a Perfect Gas.

(c) Joule-Thomson Porous Plug Experiment: Joule- Thomson Effect for Real and Van der Waal Gases. Temperature of Inversion. Joule Thomson Cooling.

3. Kinetic Theory of Gases **15 Lectures**

(a) 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.

(b) 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.

(c) Real Gases: Behavior of Real Gases: Deviations from the Ideal Gas Equation. The Virial Equation. Andrew's Experiments on CO_2 Gas. Critical Constants. Continuity of Liquid and Gaseous State. Vapour and Gas. Boyle Temperature. Van der Waal's Equation of State for Real Gases. Values of Critical Constants. Law of Corresponding States. Comparison with Experimental Curves. P-V Diagrams.

4. Conduction of Heat **5 Lectures**

Thermal conductivity, diffusivity. Fourier's equation for heat conduction its solution for rectilinear flow of heat.

Reference Books

1. Heat and Thermodynamics, M.W. Zemansky, Richard Dittman, 1981, McGraw-Hill
2. Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Sears & Salinger. 1988, Narosa
3. Concepts in Thermal Physics, S.J. Blundell and K.M. Blundell, 2nd Ed., 2012, Oxford University Press
4. Thermodynamics , E. Fermi, 2007 , Sarat Book House
5. Basic Thermodynamics, E. Guha, 2010, Narosa
6. Kinetic theory of gases , Loeb, Radha Publishing House
7. A Treatise on Heat, Meghnad Saha, and B.N. Srivastava, 1969, Indian Press

Additional Reference Books

1. Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer
2. Thermodynamics and an introduction to thermostatistics, H. B. Callen, 1985, Wiley
3. Thermal Physics, A. Kumar and S.P. Taneja, 2014, R. Chand Publications
4. Elements of Classical Thermodynamics A.B. Pippard , 1957, Cambridge University Press
5. Equilibrium Thermodynamics, C.J. Adkins, 1983, Cambridge University Press
6. Principles of Thermodynamics , M. Kaufman, 2002, CRC Press

3.2.2 Thermal Physics (Practical)

Paper: PHS-A-CC-3-6-P	**Credit: 2**

List of Practicals

1. Determination of the coefficient of thermal expansion of a metallic rod using an optical lever.

2. Calibration of a thermocouple by direct measurement of the thermo-emf using potentiometer and the constants. [one end in ice and another end at water bath which to be heated.

3. To determine the Coefficient of Thermal Conductivity of a bad conductor by Lee and Charlton's disc method.

4. To determine the boiling point of a liquid using Platinum Resistance Thermometer (PRT).

5. To determine Temperature Coefficient of Resistance using Carey Foster bridge.

Reference Books

1. Advanced Practical Physics, Vol 1, B. Ghosh, K. G. Majumder, Sreedhar Publication
2. An Advanced Course in Practical Physics, D. Chattopadhyay, P.C. Rakshit, New Central Book Agency (P) Ltd

3.3 Modern Physics

3.3.1 Modern Physics (Theory)

Paper: PHS-A-CC-3-7-TH	**Credit:4**

1. Radiation and its nature **15 Lectures**

(a) Blackbody Radiation, Planck's quantum hypothesis, Planck's constant (derivation of Planck formula is not required). Photoelectric effect and Compton scattering - light as a collection of photons. Davisson-Germer experiment. De Broglie wavelength and matter waves. Wave-particle duality. Wave description of particles by wave packets. Group and Phase velocities and relation between them. Probability interpretation: Normalized wave functions as probability amplitudes.

(b) Two-slit experiment with photons and electrons. Linear superposition principle as a consequence.

(c) Position measurement, gamma ray microscope thought experiment. Heisenberg uncertainty principle (Statement with illustrations). Impossibility of a particle following a trajectory.

2. Basics of Quantum Mechanics **15 Lectures**

(a) Quantum measurements: Deterministic vs probabilistic view points. States as normalised vectors (normalised wave functions). Dynamical variables as linear Hermitian operators (position, momentum, angular momentum, and energy as examples).

(b) Schrödinger equation as a first principle. Probabilistic interpretation of wavefunction and equation of continuity (in 1D). Time evolution of wavefunction and $\exp(iHt/\hbar)$ as the evolution operator. Stationary states. Eigenvalue equation.

(c) Application to one dimensional systems: Boundary conditions on wave functions. Particle in an infinitely rigid box: energy eigenvalues and eigenfunctions, normalization. Quantum dot. Quantum mechanical tunnelling across a step potential & rectangular potential barrier, α-decay as an example.

(d) Simultaneous measurements: Compatible and incompatible observables and their relation to commutativity. Heisenberg's uncertainty relation for a pair of incompatible observables. Illustration of the ideas using $[x_i, p_j]$ and $[L_i, L_j]$.

3. Nuclear Structure **10 Lectures**

(a) 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.

(b) Nature of nuclear force, NZ graph.

(c) Nuclear Models: Liquid Drop model. semi-empirical mass formula and binding energy. Nuclear Shell Model. Magic numbers.

4. Interaction with and within nucleus **12 Lectures**

(a) Radioactivity: 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.

(b) 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)

5. Lasers **8 Lectures**

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 action.

Reference Books

1. Feynman Lectures Vol.3, R.P.Feynman, R.B.Leighton, M. Sands, 2008, Pearson Education
2. Basic Quantum Mechanics, A.K.Ghatak , 2004, Macmillan
3. Quantum Mechanics, A Textbook for Undergraduates, M. C. Jain, Prentice-Hall of Indial Private Limited
4. Introduction to Quantum Mechanics, David J. Griffiths, 2005, Pearson Education
5. Quantum Physics, Stephen Gasiorowicz, John Wiley & Sons, Inc.
6. Nuclear Physics, Irving Kaplan, Oxford & Publishing Co. Pvt. Ltd
7. Nuclear Physics, An Introduction, S.B. Patel, New Age International (P) Ltd. Publishers
8. Laser Physics and Spectroscopy, P.N.Ghosh, Levant Books, India, 2016

Additional Reference Books

1. Primer of Quantum Mechanics; M. Chester; John Wiley & Sons, 1987
2. Physics for scientists and Engineers with Modern Physics, Jewett and Serway, 2010, Cengage Learning
3. Modern Physics, G.Kaur and G.R. Pickrell, 2014, McGraw Hill
4. Quantum Physics, Berkeley Physics, Vol.4
5. Nuclear Physics, S.N.Ghosal; S. Chand Publishing
6. Nuclear Physiscs, Principles and Applications, John Lilley, John Wiley India
7. Atom, Laser and Spectroscopy, S.N. Thakur, D.K. Rai, PHI Learning Private Ltd
8. Laser and NON Linear Optics, B.B. Laud, New Age International (P) Ltd. Publishers
9. Modern Physics, J.R. Taylor, C.D. Zaratos, M.A. Dubson, 2004, PHI Learning
10. Schaum's outline, Theory and Problems of Modern Physics, R. Gautreau and W. Savin, 2nd Edn, Tata McGraw-Hill Publishing Co. Ltd
11. Theory and Problems of Modern Physics, E.H.Wichman, 1971, Tata McGraw-Hill Co
12. Basic ideas and concepts in Nuclear Physics, K.Heyde, 3rd Edn., Institute of Physics Pub
13. Six Ideas that Shaped Physics: Particle Behave like Waves, T.A.Moore, 2003, McGraw Hill

3.3.2 Modern Physics (Practical)

Paper: PHS-A-CC-3-7-P	**Credit: 2**

List of Practicals

1. Measurement of Plank constant using LED

2. Verification of Stefan's law of radiation by the measurement of voltage and current of a torch bulb glowing it beyond draper point.

3. Determination of e/m of electrons by using bar magnet.

4. To study the photoelectric effect: variation of photocurrent versus intensity and wavelength of light.

5. To show the tunneling effect in tunnel diode using I-V characteristics.

Reference Books

1. B.Sc. Practical Physics, C.L. Arora, S. Chand And Company Limited
2. Practical Physics Vol 1, Vol 2, B. Ghosh, K. G. Majumder, Sreedhar Publisher

SEC A-1 (Technical Skill)

3.4 Scientific Writing (Project type)

3.4.1 Scientific Writing (Theory)

Paper: PHS-A SEC-B-TH	**Credits: 1**

1. Introduction to LaTeX **2 Lectures**
The difference between WYSIWYG and WYSIWYM. Preparing a basic LaTeX file. Compiling LaTeX file.

2. Document classes : **1 Lectures**
Different type of document classes, e.g., article, report, book etc.

3. Page Layout **2 Lectures**
Titles, Abstract, Chapters, Sections, subsections, paragraph, verbatim, References, Equation references, citation.

4. List structures: **1 Lectures**
Itemize, enumerate, description etc.

5. Representation of mathematical equations **5 Lectures**
Inline math, Equations, Fractions, Matrices, trigonometric, logarithmic, exponential functions, line-surface-volume integrals with and without limits, closed line integral, surface integrals, Scaling of Parentheses, brackets etc.

6. Customization of fonts **1 Lectures**
Bold fonts, emphasise, mathbf, mathcal etc. Changing sizes Large, Larger, Huge, tiny etc.
7. Writing tables **2 Lectures**
Creating tables with different alignments, placement of horizontal, vertical lines.

8. Figures **1 Lectures**
Changing and placing the figures, alignments

Packages : amsmath,amssymb, graphics, graphicx, Geometry, algorithms, color, Hyperref etc. Use of Different LaTeX commands and environments, Changing the type style, symbols from other languages. special characters.

Note: Software required: LaTeX in Linux and MikTeX in Windows. Preferred editor Kile/emacs in Linux and TeXStudio in Windows.

Reference Book

1. LaTeX- A Document Preparation System , Leslie Lamport , 1994, Addison-Wesley
2. LaTeXTutorials A PRIMER, Indian TeXuser group, E. Krishnan
3. Practical LaTeX, George Gratzer, Springer
4. Official LaTeXsite : `https://www.latex-project.org/`

5. The Not So Short Introduction to LaTeX: `http://mirror.iopb.res.in/tex-archive/info/lshort/english/lshort.pd`
6. LaTeXWikibook `https://en.wikibooks.org/wiki/LaTeX`
7. TeXLive `http://www.tug.org/texlive/`

3.4.2 Scientific Writing (Project)

Paper: PHS-A SEC-B-PR	**Credits: 1**

List of some sample Projects

1. Writing articles/ research papers/reports

2. Writing mathematical derivation

3. Writing Resume

4. Writing any documentation of a practical done in laboratory with results, tables graphs.

5. Writing graphical analysis taking graphs plotted in gnuplot

SEC A-2 (Knowledge Skill)

3.5 Renewable energy and Energy Harvesting (Theory)

Paper: PHS-A SEC-B-TH	**Credits: 2**

1. Fossil fuels and Alternate Sources of energy **5 Lectures**

Fossil fuels and nuclear energy, their limitation, need of renewable energy, non-conventional energy sources. An overview of developments in Ocean shore Wind Energy, Tidal Energy, Wave energy systems, Ocean Thermal Energy Conversion, solar energy, biomass, biochemical conversion, biogas generation, geothermal energy tidal energy, Hydroelectricity.

2. Solar energy **5 Lectures**

Solar energy, its importance, storage of solar energy, solar pond, non-convective solar pond, applications of solar pond and solar energy, solar water heater, flat plate collector, solar distillation, solar cooker, solar green houses, solar cell, absorption air conditioning. Need and characteristics of photovoltaic (PV) systems, PV models and equivalent circuits, role of maximum power point tracking for harvesting maximum energy and sun tracking systems.

3. Wind Energy harvesting **4 Lectures**

Fundamentals of Wind energy, Wind Turbines and different electrical machines in wind turbines, Power electronic interfaces, and grid interconnection topologies. (only idea of synchronisation, current injection, islanding etc with utility grid)

4. Ocean Energy **4 Lectures**

Ocean Energy Potential against Wind and Solar, Wave Characteristics and Statistics, Wave energy Devices. Tide characteristics and Statistics, Tide Energy Technologies, Ocean Thermal Energy, Osmotic Power, Ocean Bio-mass.

5. Geothermal Energy **2 Lectures**

Geothermal Resources, Geothermal Technologies.

6. Hydro Energy **2 Lectures**

Hydropower resources, hydropower technologies, environmental impact of hydro power sources.

7. Piezoelectric Energy harvesting **3 Lectures**

Introduction, Physics and characteristics of piezoelectric effect, materials and mathematical description of piezoelectricity, Piezoelectric parameters and modeling piezoelectric generators, Piezoelectric energy harvesting applications.

8. Electromagnetic Energy Harvesting **3 Lectures**

(a) Linear generators, physics mathematical models, recent applications
(b) Carbon captured technologies, cell, batteries, power consumption.
(c) Environmental issues and Renewable sources of energy, sustainability.

9. Fuel cell **2 Lectures**

Introduction, Design principle and operation of fuel cell, Types of fuel cells, conversion efficiency of fuel cell, application of fuel cells

Reference Books

1. Non-conventional energy sources, G.D Rai, Khanna Publishers, New Delhi

Additional Reference Books

1. Solar energy, M.P. Agarwal, S Chand and Co. Ltd
2. Solar energy, Suhas P Sukhative, Tata McGraw Hill Publishing Company Ltd
3. Renewable Energy, Power for a sustainable future, Godfrey Boyle, Oxford University Press, in association with The Open University
4. Solar Energy: Resource Assesment Handbook, Dr. P Jayakumar, 2009
5. Photovoltaics, J.Balfour, M.Shaw and S. Jarosek, Lawrence J Goodrich (USA)

Honours: Semester 4

CC 8, CC 9, CC 10, SEC B

CC 8	Mathematical Physics III	Theory	Practical
	Credit 6	Credit 4	Credit 2
		Classes 60	Classes 60
CC 9	Analog Electronics	Theory	Practical
	Credit 6	Credit 4	Credit 2
		Classes 60	Classes 60
CC 10	Quantum Mechanics	Theory	Practical
	Credit 6	Credit 4	Credit 2
		Classes 60	Classes 60
SEC B 1	Arduino	Theory	Project
	Credit 2	Credit 1	Credit 1
		Classes 15	Classes 15
SEC B 2	Electrical Circuits &	Theory	
	Network Skill	Credit 2	
	Credit 2	Classes 30	

4.1 Mathematical Physics III

4.1.1 Mathematical Physics III (Theory)

Paper: PHS-A-CC-4-8-TH	**Credit: 4**

1. Complex Analysis **20 Lectures**

(a) Brief Revision of Complex Numbers and their Graphical Representation. Euler's formula, 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. only single valued integrals; simple poles on and off the real axis.

2. Variational calculus in Physics **20 Lectures**

Functionals. Basic ideas of functionals. Extremization of action as a basic principle in mechanics. Lagrangian formulation. Euler's equations of motion for simple systems: harmonic 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.

3. Special theory of Relativity **20 Lectures**

(a) Michelson-Morley Experiment and its outcome. Postulates of Special Theory of Relativity. Lorentz Transformations. Simultaneity and order of events. Lorentz contraction. Time dilation. Relativistic transformation of velocity. Relativistic Dynamics. Variation of mass with velocity. Massless Particles. Mass-energy Equivalence. Transformation of Energy and Momentum.

(b) A short introduction to tensors Covariant and contravariant vectors. Contraction. Covariant, contravariant, and mixed tensors of rank-2, transformation properties. The metric tensor (flat space-time only). Raising and lowering of indices with metric tensors. (Consistent use of convention $\rightarrow$ diag(1,-1,-1,-1).)

(c) Relativity in Four Vector Notation: Four-vectors, Lorentz Transformation and Invariant interval, Space-time diagrams. Proper time and Proper velocity. Relativistic energy and momentum - Four momentum. Conservation of four momentum and applications to collisions. Minkowski Force.

Reference Books

1. Complex Variables, Schuam's Outline Series, 2nd ed, M.R. Spiegel, S. Lipschutz, J.J. Schiller, D. Spellman, McGraw Hill Private Ltd.
2. Complex Variables and Applications, J.W. Brown and R.V. Churchill, 7th Ed. 2003, Tata McGraw-Hill
3. Classical Mechanics , N.C. Rana and P. Joag, McGraw Hill Education
4. Classical Mechanics, Goldstein, Poole & Safco, Pearson Education
5. Introduction to Special Relativity, R. Resnick, 2010, John Wiley and Sons
6. Theoretical Physics 4, Special Theory of Relativity, Wolfgang Nolting, Springer
7. Introduction to Electrodynamics, D.J. Griffiths, 3rd Ed., Pearson Education

Additional Reference Books

Books on Complex Variables

1. Complex Variables, A.S.Fokas and M.J.Ablowitz, 8th Ed., 2011, Cambridge Univ. Press
2. Complex Variables, A.K. Kapoor, 2014, Cambridge Univ. Press
3. Complex analysis , D.G. Zill and P.D. Shanahan, 2015 Jones and Bartlett

Books on variational principle and mechanics

1. Classical Mechanics: Systems of Particles and Hamiltonian Dynamics. W. Greiner, 2004, Springer
2. Classical Mechanics. J.R. Taylor, 2005, University Science Books
3. Classical Mechanics, Goldstein, Pearson Education

4. Mechanics: Volume 1, Landau & Lifshitz, Butterworth-Heinemann
5. The Variational Principles of Mechanics, C. Lanczos , 1986, Dover Publications Inc
6. Classical Mechanics, A course of Lectures, A.K. Raychaudhuri, 1983, Oxford University Press

Books on relativity

1. Relativity - The Special and General Theory, A. Einstein, Methuen and Co. Ltd., 1920
2. Special Relativity (MIT Introductory Physics). A.P. French, 2018, CRC Press
3. Special Relativity: For the Enthusiastic Beginner , D. Morin, 2017, Createspace Independent Pub
4. The Special Theory of Relativity, Banerji and Banerjee 2nd Ed., PHI Learning Private Ltd.
5. Introduction to Special Relativity , J.H. Smith, 2003, Dover Publications Inc
6. The Special Theory of Relativity , D. Bohm, 2006, Routledge
7. It‘s About Time Understanding Einstein‘s Relativity, N.D. Mermin, Princeton University Press
8. Classical Electrodynamics, J.D. Jackson, 2007, Wiley

4.1.2 Mathematical Physics III (Practical)

Paper: PHS-A-CC-4-8-P	**Credit: 2**

1. Exploring Gaussian Integrals and the delta function **3 Lectures + 8 Classes**

- Numerically handling improper integrals over infinite intervals
- Numerically verifying the Gaussian integral result

$$\int_{-\infty}^{\infty} \exp\left(-ax^2 + bx + c\right) = \sqrt{\frac{\pi}{a}} \exp\left(\frac{b^2}{4a} + c\right)$$

- Verifying that the convolution of two Gaussian function is a Gaussian
- Verifying that $\int_{a-x_1}^{a+x_2} \delta(x-a) f(x)\, dx = f(a)$ using different limiting representation of $\delta(x)$.

2. Solution of Differential Equation **3 Lectures + 6 Classes**
First order and 2nd order ODE by scipy.integrate.odeint().

3. Special functions **3 Lectures + 6 Classes**
Use of special functions taken from scipy.special. Plotting and verification of the properties of special functions. Orthogonality relations and recursion relations. Examples,
(a) $zJ'_\nu(z) + \nu J_\nu(z) = zJ_{\nu-1}(z)$
(b) $\left(1-x^2\right) P'_n(x) + (n+1)\, xP_n(x) - (n+1)\, P_{n+1}(x)$
(c) $\int_{-\infty}^{\infty} P_n(x)\, P_m(x)\, dx = \frac{2}{2n+1}\delta_{mn}$

4. Solution of some basic PDEs **5 Lectures + 20 Classes**

(a) Boundary value problems. Finite discrete method with fixed step sizes. Idea of stability. Application to simple physical problems.

(b) Laplace equation $\frac{\partial^2\phi}{\partial x^2} + \frac{\partial^2\phi}{\partial y^2} = 0$, on a square grid with specified potential at the boundaries.

(c) Wave equation in 1+1 dimension: $\frac{\partial^2\phi}{\partial t^2} = \lambda\frac{\partial^2\phi}{\partial x^2}$. Vibration of a string with ends fixed with given initial configurations: $\phi(x,0)$ and $\frac{\partial\phi}{\partial t}(x,0)$.

(d) Heat equation in 1+1 dimension, $\frac{\partial u}{\partial t} = \alpha\frac{\partial^2 u}{\partial x^2}$ with specified value of temperature at the boundaries with given initial temperature at the boundaries with given initial temperature profile.

5. Fourier Series **2 Lectures + 4 Classes**

Evaluate the Fourier coefficients of a given periodic function using scipy.integrate.quad(). Examples: square wave, triangular wave, saw-tooth wave. Plot to see a wave form from scipy.signal and the constructed series along with.

Reference Books

1. Numerical Analysis, Mathematics of Scientific Computing, David Kincaid, Ward Cheney, Reprint First Indian Edition 2013, American Mathematical Society
2. Numerical Methods for Engineers, 2nd Edition, D.V. Griffiths and I.M. Smith, , Chapman & Hall/CRC, Special Indian Edition
3. An Introduction to computational Physics, T.Pang, 2nd Edn., 2006,Cambridge Univ. Press
4. Scientific Computing in python, Avijit Kar Gupta, Techno World
5. Computational Physics problem solving with Computers, Landau, Paez, Bordeianu etextbook in Python 3rd Edition
6. Computational Methods for physcs, Joel Franklin, Cembridge University Press
7. Programming for Computation-Python, Svein Linge, Hans Petter Lantangen, Springer
8. Numerical Python, Robert Johansson, Apress Publication

4.2 Analog Electronics

4.2.1 Analog Systems and Applications (Theory)

Paper: PHS-A-CC-4-9-TH	**Credits: 4**

1. Circuits and Network **4 Lectures**

Discrete components, Active & Passive components, 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.

2. Semiconductor Diodes and application **8 Lectures**

(a) 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.

(b) Rectifier Diode: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers, Calculation of Ripple Factor and Rectification Efficiency, L and C filter. Circuit and operation of clipping and clamping circuit.

(c) Principle and structure of

- LEDs
- Photodiode
- Solar Cell
- Varactor diode

3. Bipolar Junction transistors and biasing **10 Lectures**

(a) n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. Physical Mechanism of Current Flow. Current gains α and β, Relations between them. Active, Cut-off and saturation Regions. DC Load line and Q-point.

(b) Transistor Biasing and Stabilization Circuits; Fixed Bias, collector to base bias, emitter or self bias, 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.

4. Field Effect transistors **5 Lectures**

JFET and MOSFET (both depletion and enhancement type) as a part of MISFET. Basic structure & principle of operations and their characteristics. Pinch off, threshold voltage and short channel effect.

5. Regulated power supply **3 Lecture**

Load regulation and line regulation. Zener diode as a voltage regulator. The problem with the zener regulator circuit. Requirement of feedback and error amplifier. Study of series regulated power supply using pass and error transistor assisted by zener diode as a reference voltage supplier.

6. Amplifiers **5 Lectures**

Transistor amplifier; CB, CE and emitter follower circuit and their uses. Load Line analysis of Transistor amplifier. Classification of Class A, B & C Amplifiers with respect to placement to Q point. Frequency response of a CE amplifier. The role of series and parallel capacitors for cut off frequencies. The idea about the value of coupling and bypass capacitor with respect to lower cut-off frequencies. Miller capacitance and its role in higher cut-off frequency.

7. Feedback amplifiers and OPAMP **15 Lectures**

(a) Effects of Positive and Negative Feedback. Voltage series, current series, voltage shunt and current shunt feedback and uses for specific amplifiers. Estimation of Input Impedance, Output Impedance, Gain, Stability, Distortion and Noise for voltage series feedback

(b) Operational Amplifiers (Black Box approach): Characteristics of an Ideal and Practical Op-Amp. (IC 741) Open-loop and Closed-loop voltage Gain. Frequency Response. CMRR. Slew Rate and concept of Virtual ground.

(c) Application of OPAMP:

D.C. Application:

- Inverting and non-inverting amplifiers
- Inverting and non inverting Adder

- Differentiator as Subtractor
- Logarithmic & anti logarithmic amplifiers
- Error amplifier
  - Comparator
  - Schmidt Trigger

A.C. Application:

- Differentiator
- Integrator

8. Multivibrator: **5 Lectures**

Transistor as a switch, Explanation using CE output characteristics. Calculation of component values for a practical transistor switch. Transistor switching times, use of speed up capacitor (Physical explanation only) Construction and operation, using wave shapes of collector coupled Bistable, Monostable andAstable Multivibrator circuits, Expression for time period.

9.Oscillators **5 Lectures**

Sinusoidal Oscillators: Barkhausen's Criterion for self-sustained oscillations. RC Phase shift oscillator, Wein Bridge oscillator, determination of feedback factor and frequency of oscillation. Reactive network feedback oscillators: Hartley's & Colpitt's oscillators. Relaxation oscillator using OPAMP.

Reference Books

1. Circuits and Networks, Analysis and Synthesis, A Sudhakar, Shyammohan S Palli, Tata McGraw Hill Education Private Ltd.
2. Solid State Electronic Devices, B.G.Streetman & S.K.Banerjee, 6th Edn.,2009, PHI Private Ltd.
3. Fundamental Principles of Electronics, B Ghosh, 2nd ed, 2008, Books & Allied (P) Ltd.
4. Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata McGraw Hill Education Private Ltd.
5. Electronics: Fundamentals and Applications, J.D. Ryder,2004, Prentice Hall India Private Ltd.
6. Learning OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition,2000, Prentice Hall India Private Ltd.

Additional Reference Books

1. Electronic Devices and Circuit Theory, R.L. Boylestad, L. Nashelsky, PHI Private Ltd.
2. Microelectronic circuits, A.S. Sedra, K.C. Smith, A.N. Chandorkar, 2014, 6th Edn., Oxford University Press
3. Electronic circuits: Handbook of design & applications, U.Tietze, C.Schenk,2008, Springer

4. Semiconductor Devices: Physics and Technology, S.M. Sze, 2nd Ed., 2002, Wiley India
5. Microelectronic Circuits, M.H. Rashid, 2nd Edition, Cengage Learning
6. Electronic Devices, Thomas L. Floyd, 7/e 2008, Pearson India
7. Microelectronics, Jacob Millman, Arvin Grabel, Tata McGRAW Hill
8. Electronic Devices and Circuits, S. Salivahanan, N. Suresh Kumar, McGraw Hill Education Private Ltd.

4.2.2 Analog Systems and Applications (Practical)

Paper: PHS-A-CC-4-9-P	**Credits: 2**

List of Practicals

1. To study the reverse characteristics of Zener diode and study the load and line regulation.

2. To study the static characteristics of BJT in CE Conguration.

3. To design and study the frequency response of the BJT amplifier in CE mode.

4. Construction of a series regulated power supply from an unregulated power supply.

5. To study OPAMP: inverting amplifer, non inverting amplier, adder, substractor, comparator, Schmitt trigger, Integrator, differentiator, relaxation oscillator.

6. To design a Wien bridge oscillator for given frequency using an op-amp.

Reference Books

1. Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-Graw Hill
2. Advanced Practical Physics (volume II), B. Ghosh , Shreedhar Publication
3. An Advanced Course in Practical Physics, D. Chattopadhyay, P.C. Rakshit, New Central Book Agency (P) Ltd
4. Laboratory Manual for Operational Amplifiers and Linear ICs, David A. Bell, Prentice Hall of India Pvt Ltd.

.

4.3 Quantum Mechanics

4.3.1 Quantum Mechanics (Theory)

Paper: PHS-A-CC-4-10-TH	**Credit: 4**

1. **Wavepacket description** **5 Lectures**
Description of a particle using wave packets. Spread of the Gaussian wave-packet for a free particle in one dimension. Fourier transforms and momentum space wavefunction. Position-Momentum uncertainty.

2. **General discussion of bound states in an arbitrary potential** **8 Lectures**
Continuity of wave function, boundary condition and emergence of discrete energy levels. Application to one dimensional square well potential of finite depth.

3. **Quantum mechanics of simple harmonic oscillator** **6 Lectures**
Setting up the eigenvalue equation for the Hamiltonian. Energy levels and energy eigenfunctions in terms of Hermite polynomials (Solution to Hermite differential equation may be assumed). Ground state, zero point energy & uncertainty principle.

4. **Quantum theory of hydrogen-like atoms** **8 Lectures**
Reduction of a two body problem to a one body problem. The time independent Schrodinger equation for a particle moving under a central force, the Schrodinger equation in spherical polar coordinates. Separation of variables. Angular equation and orbital angular momentum. Spherical Harmonics (Solution to Legendre differential equation may be assumed). Radial equation for attractive coulomb interaction - Hydrogen atom. Solution for the radial wavefunctions (Solution to Laguerre differential equation may be assumed). Shapes of the probability densities for ground & first excited states. Orbital angular momentum quantum numbers l and m; s, p, d shells.

5. **Generalized Angular Momenta and Spin** **10 Lectures**
(a) Generalized angular momentum. Electron's magnetic Moment and Spin Angular Momentum. $\mathbf{J} = \mathbf{L} + \mathbf{S}$. Gyromagnetic Ratio and Bohr Magneton and the g factor. Energy associated with a magnetic dipole placed in magnetic field. Larmor's Theorem. Stern-Gerlach Experiment.
(b) Addition of angular momenta - statement only. Allowed values of angular momentum.

6. **Spectra of Hydrogen atom and its fine structure** **5 Lectures**
(a) Formula for first order nondegenerate perturbative correction to the eigenvalue statement only.
(b) Spin-orbit interaction and relativistic correction to the kinetic energy and Darwin term.
(c) Fine structure of the hydrogen atom spectrum (No rigorous derivation is required).

7. **Atoms in Electric & Magnetic Fields** **8 Lectures**
(a) Zeeman Effect: Normal and Anomalous Zeeman Effect (Formula for first order perturbative correction to the eigenvalue to be assumed). (b) Paschen Back effect & Stark effects (Qualitative Discussion only).

8. **Many electron atoms** **10 lectures**

(a) Identical particles. Symmetric & Antisymmetric Wave Functions. Pauli's Exclusion Principle. Hund's Rule. Periodic table.

(b) Fine structure splitting. L-S and J-J coupling scheme. Spectral Notations for Atomic States and Term symbols. Spectra of Alkali Atoms (Na etc.).

Reference Books

1. Introduction to Quantum Mechanics, D.J. Griffiths, 2nd Ed. 2005, Pearson Education
2. Quantum Mechanics, Robert Eisberg and Robert Resnick, 2nd Edn., 2002, Wiley.
3. A Text book of Quantum Mechanics, P.M.Mathews and K.Venkatesan, 2nd Ed., 2010, McGraw Hill Private Ltd.

Additional Reference Books

1. Quantum Mechanics, Leonard I. Schiff, 3rd Edn. 2010, Tata McGraw Hill
2. Quantum Mechanics, G. Aruldhas, 2nd Edn. 2002, PHI Learning of India
3. Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and Bartlett Learning
4. Quantum Mechanics for Scientists & Engineers, D.A.B. Miller, 2008, Cambridge University Press
5. Quantum Mechanics, Eugen Merzbacher, 2004, John Wiley and Sons, Inc
6. Quantum Mechanics, Walter Greiner, 4th Edn., 2001, Springer

.

4.3.2 Quantum Mechanics (Practical)

Paper: PHS-A-CC-4-10-P	**Credit:2**

1. Finding eigenstates solving transcendental equation **3 Lectures + 6 Classes**

To find eigenvalues of the bound state particle of mass in a one dimensional potential well by solving the transcendental equation that appears as the eigenvalue condition (graphs are to be plotted for appropriate guess values, scipy root searching package may be used) and to plot the eigenfunctions.

2. Use of shooting algorithm **7 Lectures + 20 Classes**

Shooting algorithm for solving bound state problems (solving the ode using both Euler and Numerov algorithms) : conversion to dimensionless variable, eigenvalues and eigenvectors of the ground and first excited states.

- in one dimension (for example, the Harmonic oscillator, the Morse potential, the triangular well etc.)
- the s wave radial equation for a particle moving in a central potential, $\frac{d^2U(r)}{dr^2} = A(r)U(r)$ where $A(r) = \frac{2m}{\hbar^2}[V(r) - E]$
  some Examples
  - ☐ $V(r) = -\frac{e^2}{r}$
  - ☐ $V(r) = -\frac{e^2}{r}e^{-r/a}$

☐ $V(r) = \frac{1}{2}kr^2 + \frac{1}{3}br^3$

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

3. Time Evaluation of Wave Packet **6 Lectures + 18 Classes**

- Time evolution of a wave packet moving in free space by the numerical solution of the time dependent Scrödinger equation.
- Solving the TDSE to study Barrier penetration and tunneling for an initially Gaussian wavepacket.

Reference Books

1. An Introduction to computational Physics, T.Pang, 2nd Edn., 2006,Cambridge Univ. Press
2. Scientific Computing in Python, Abhijit Kar Gupta, Techno World
3. Computational Physics problem solving with Computers, Landau, Paez, Bordeianu etextbook in Python 3rd Edition
4. Computational Methods for physcs, Joel Franklin, Cembridge University Press
5. Computational Quantum Mechanics, Joshua Izaac, Jingbo Wang, Springer

SEC B -1 (Technical Skill)

4.4 Arduino (Project type)

4.4.1 Arduino

Paper PHS-A-SEC-B-TH	Credit 1

1. Introduction to Arduino **2 Lectures**
Brief history of the Arduino; open-source electronics prototyping.

2. Basic ideas **3 Lectures**
Basic ideas of Arduino, Familiarize the Arduino board, Setting up the arduino board. Installation of IDE in PC/ laptop for Arduino programming(Sketch)

3. Arduino Programming: **10 Lectures**
(a) Program structure:
data types, variables and constants, operators, control statements, loops, functions, string.
(b) Interfacing:
serial communication, digital and analog input/output, getting input from sensors(e.g. temperature sensor, ultrasonic sensor etc)

Books and references

1. Arduino Cookbook, Michael Margolis, O'Reilly Media (2011)
2. Getting Started with Arduino, Massimo Banzi, O'Reilly Media(2009)
3. Arduino as a tool for physics experiments, Giovanni Organtini 2018 J. Phys.: Conf. Ser. 1076 012026
4. `https://www.arduino.cc/en/Guide/HomePage`
5. Physics Today 66, 11, 8 (2013); `https://doi.org/10.1063/PT.3.2160`
6. The Physics Teacher 52, 157 (2014); `https://doi.org/10.1119/1.4865518`

4.4.2 Practical Projects

Paper PHS-A-SEC-B-PR	**Credit 1**

1. LED Blinking and fading.

2. Measurement of voltages (Below 5 V and above).

3. Interfacing 7 Segment display.

4. Construction of thermometer using LM35 or Others.

5. Construct the experimental set up for studying simple pendulum and hence determine the acceleration's due to gravity.

6. Construct data logger for studying charging and discharging of RC circuit.

NOTE: Software required: Arduino Integrated Development Environment, Hardware required: Arduino Uno

SEC B -2 (Knowledge Skill)

4.5 Electrical Circuits and Network skills (Theory)

PHS-A SEC-B -TH	**Credit 2**

1. DC generator : **10 Lectures**

(a) EMF generated in the armature for simplex lap and wave winding, concept of pole, Methods of Excitation, Armature reaction, Dc motor : Torque equation of D.C motor, speed& torque Operating Characteristics of separately excited, Shunt, Series &Compound motors with emphasis on application areas.

(b) Three phase generator, concept of stator and rotor, star and delta connections – their current voltage relationships (both line and phase current & voltage).

2. Transformer : **5 Lectures**

Types of transformer, basic emf equation, no load current, leakage inductance, Magnetising current and equivalent circuit of single phase transformer on no-load and on load, idea of star/star, star/delta, delta/star, and zig-zag connection of 3 phase transformer, 3 phase to 2 phase transformation, Scott T connection.

3. AC motor **6 Lectures**

(a) Single phase AC motor – double field revolving theory, slip-speed characteristics,

(b) Construction of 3 phase induction motor and its action using rotating field theory, equivalent circuit of induction motor, Speed control by V/f control of induction motor (block diagram only).

4. Measurements and faults **9 Lectures**

(a) Measurement of three phase power by two and three wattmeter method,theory of induction type wattmeterand its use as energy meter in domestic house. Megger.

(b) Unsymmetrical faults in distribution system, Common switchgear equipments like relay, circuit breakers and fuses, Simple oil circuit breaker and SF6 circuit breaker, Construction of protective relay in distribution bus-bar system, Block diagram of a utility distribution sub-station.

Reference Books

1. Text book on Electrical Technology (vol 1 & 2), Thereja and Thereja

2. Power System, V. K. Meheta

3. Electrical Machines, S. K. Bhattacharya

Honours: Semester 5

CC 11, CC 12, DSE A1, DSE B1

CC 11	Electromagnetic Theory Credit 6	Theory	Practical
		Credit 4	Credit 2
		Classes 60	Classes 60
CC 12	Statistical Physics Credit 6	Theory	Practical
		Credit 4	Credit 2
		Classes 60	Classes 60
DSE A 1	(a) Advanced Mathematical Methods Or (b) Laser and Fiber Optics Credit 6	Theory	Tutorial
		Credit 5	Credit 1
		Classes 75	Classes 15
DSE B 1	(a) Astronomy and Astrophysics Or (b) Nuclear and particle Physics Credit 6	Theory	Tutorial
		Credit 5	Credit 1
		Classes 75	Classes 15

5.1 Electromagnetic Theory

5.1.1 Electromagnetic Theory (Theory)

Paper: PHS-A-CC-5-11-TH	**Credit: 4**

1.Maxwell Equations **12 Lectures**

Review of Maxwell's equations. 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.

2. 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.

3. 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, Reflection & Transmission coefficients, Brewster's law. Total internal reflection, evanescent waves. Metallic reflection (normal Incidence).

4. Polarization **7 Lectures**

Description of Linear, Circular and Elliptical Polarization. Propagation of E.M. Waves in birefringent medium.

5. Polarization in uniaxial crystals **15 Lectures**

Uniaxial and Biaxial Crystals. Light Propagation in Uniaxial Crystal. Double Refraction. Polarization by Double Refraction. Nicol Prism. Ordinary & extraordinary refractive indices. Phase Retardation Plates: Quarter-Wave and Half-Wave Plates. Production & analysis of polarized light. Babinet Compensator and its Uses.

6. Rotatory polarization **6 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 and biquartz polarimeters.

Reference Books

1. Introduction to Electrodynamics, D.J. Griffiths, 3rd Ed., Pearson Education
2. Optics, E. Hecht, 2016, Pearson Education
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

Additional Books for Reference

1. Electromagnetic field Theory, R.S. Kshetrimayun, 2012, Cengage Learning
2. Engineering Electromagnetic, Willian H. Hayt, 8th Edition, 2012, McGraw Hill
3. Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer
4. Electromagnetic Fields & Waves, P.Lorrain & D.Corson, 1970, W.H.Freeman & Co
5. Electromagnetics, J.A. Edminster, Schaum Series, 2006, Tata McGraw Hill
6. Electromagnetic field theory fundamentals, B. Guru and H. Hiziroglu, 2004,Cambridge University Press
7. Advanced Engineering Electromagnetics , C.A. Balanis, 2012, John Wiley & Sons
8. Electromagnetic Field Theory, Bo Thide, 2011, Dover Publications
9. Optical Electronics, Ajoy Kumar Ghatak , K. Thyagarajan, Cambridge University Press
10. Problems And Solutions In Electromagnetics, Ajoy Ghatak K. Thyagarajan R. K. Varshney, Viva Books

5.1.2 Electromagnetic Theory (Practical)

Paper: PHS-A-CC-5-11-P	**Credit: 2**

List of Practicals

1. To determine Brewster's angle for air-glass interface using a prism.

2. To study Fresnels law by the reflection on the surface of a prism.

3. To verify the Malus law using a pair of polaroids.

4. To study the specific rotation of optically active solution using polarimeter.

5. To determine dispersive power and resolving power of a plane diffraction grating

Reference Books

1. Advanced Practical Physics (Vol 1 & Vol 2), B. Ghosh, K. G. Majumder, Sreedhar Publication

5.2 Statistical Physics

5.2.1 Statistical Physics (Theory)

Paper: PHS-A-CC-5-12-TH	**Credit: 4**

1. Classical Statistical Mechanics **25 Lectures**

(a) Macrostate & Microstate, Elementary Concept of Ensemble and Ergodic Hypothesis (statement only). Phase Space.

(b) Microcanonical ensemble, Postulate of Equal a-priori probabilities. Boltzmann hypothesis: Entropy and Thermodynamic Probability.

(c) Canonical ensemble, Partition Function, Thermodynamic Functions of an Ideal Gas, Classical Entropy Expression, Gibbs Paradox. Equivalence of microcanonical and canonical ensemble.

(d) Sackur Tetrode equation, Law of Equipartition of Energy (with proof) Applications to Specific Heat and its Limitations. Thermodynamic Functions of a Two-Energy Level System. Negative Temperature.

(e) Grand canonical ensemble. Application of ideal gas using grand canonical ensemble. chemical potential.

2. Systems of Identical particles **6 Lectures**

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 (for a pair of particles only). Bosons and Fermions. Symmetric and Antisymmetric wave functions. state counting for bosons and fermions.

3. Bose-Einstein Statistics **12 Lectures**

B-E distribution law. Thermodynamic functions of a strongly degenerate Bose Gas, Bose Einstein condensation and properties of liquid He IV (qualitative description only).

4. Radiation: classical and quantum aspects **7 Lectures**

(a) Spectral Distribution of Black Body Radiation. Rayleigh-jeans law, UV catastrophe, Planck's Quantum Postulates. Planck's Law of Blackbody Radiation: Experimental Verification. Deduction of Rayleigh- Jeans Law, Stefan-Boltzmann Law, Wien's Displacement law from Planck's law.

(b) Bose derivation of Planck's law. Radiation as a photon gas and Thermodynamic functions of photon gas. chemical potential of photon gas.

5. Fermi-Dirac Statistics **10 Lectures**

Fermi-Dirac Distribution Law. Thermodynamic functions of strongly Degenerate Fermi Gas, Fermi Energy, Electron gas in a Metal, Specific Heat of Metals due to electrons.

Reference Books

1. Introductory Statistical Mechanics , R. Bowley and M. Sanchez, 2007, Oxford Science Publications.
2. Statistical Physics, Berkeley Physics Course, F. Reif, 2008, Tata McGraw- Hill Publishing Company Ltd.
3. Concepts in Thermal Physics, S.J. Blundell and K.M. Blundell, 2nd Ed., 2012, Oxford University Press
4. Statistical Physics, F. Mandl, 2014, Wiley India Pvt. Ltd.
5. An Introduction to Thermal Physics, D.V. Schroeder, 2014, Pearson Education, India
6. Thermal Physics, Garg, Bansal, Ghosh, Tata McGraw- Hill Publishing Company Ltd.

Additional Reference Books

1. Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2nd Ed.,1996, Oxford University Press
2. Statistical and Thermal Physics, S. Lokanathan and R.S. Gambhir. 1991, Prentice Hall
3. Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Francis W. Sears and Gerhard L. Salinger, 1986, Narosa
4. Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer
5. An Introduction to Statistical Mechanics & Thermodynamics, R.H. Swendsen, 2012, Oxford Univ. Press
6. Statistical Mechanics an elementary outline, A. Lahiri, 2008, Universities Press
7. Intermediate Statistical Mechanics. J. Bhattacharjee and D. Banerjee, 2017, World Scientific (HBA)
8. An Introductory Course of Statistical Mechanics. P.B. Pal,2008, Narosa
9. Thermal Physics, Kittel and Kroemer, 1980, W. H. Freeman
10. Elementary Statistical Physics , Kittel, 2004, Dover Publications
11. Thermodynamics and Statistical Mechanics, W. Greiner, 2001, Springer

5.2.2 Statistical Mechanics (Practical)

Paper: PHS-A-CC-5-12-P	**Credit: 2**

1. Study of Random Numbers and Time series **5 Lectures + 15 Classes**

Introduction to the numpy.random() module

- Histogram (by matplotlib.pyplot.hist) and autocorrelation function of a given time series.
- Generating exponential variates from uniform variate using transformation
- Gaussian variate from uniform variate using central limit theorem.
- Study of histogram and moments of random sequences of different probability density using numpy.random.

2. Applications of Random Numbers **8 Lectures + 20 Classes**

- Coin tossing. Fit with binomial distribution.
- Nuclear Decay: Simulation assuming a constant decay probability per unit time.
- Random Walk:
  - In 1D and in 2D (Square grid)
  - Plot of r.m.s. value of end to end distance as a function of time step
  - fitting and finding of exponent
- Monte Carlo Integration

3. Scaling and plots, exponents and parameters: **4 Lectures + 8 Classes**

Laws and distributions from Statistical Mechanics
Some Problems

- Maxwell-Boltzmann distribution
- Bose-Einstein distribution
- Fermi-Dirac distribution
- Plot of specific Heat of Solids
  - Dulong-Petit law
  - Einstein distribution function
  - Debye distribution function for high temperature and low temperature and compare them for these two cases

Reference Books

1. Introduction to Modern Statistical Mechanics, D. Chandler, Oxford University Press, 1987

2. Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer
3. Statistical and Thermal Physics with computer applications, Harvey Gould and Jan Tobochnik, Princeton University Press, 2010
4. Scientific Computing in Python. Abhijit Kar Gupta, Techno World
5. Computatioal Physics problem solving with Computers, Landau, Paez, Bordeianu etextbook in Python 3rd Edition
6. Computational Methods for physcs, Joel Franklin, Cembridge University Press

DSE A1 (a)

5.3 Advanced Mathematical Methods (Theory)

Paper: PHS-A-DSE-A1-TH	**Credits: 5 (+1 for Tutorial)**

1. Linear Algebra and Vector Space **30 Lectures**

(a) Abstract systems. Binary operations and relations. Introduction to Groups and Fields. Vector spaces over real and complex fields. Subspaces. Homomorphism and isomorphism of Vector Spaces. Linear independence and dependence of vectors. Completeness of a set of vectors. Basis and dimension of a vector space.

(b) Inner product space. Norm (defined in terms of inner product). Orthogonality. Orthonormal basis. Gram-Schmidt orthogonalisation - proof that an orthonormal basis always exists. Schwarz inequality. Linear functionals on a vector space. Addition and multiplication by scalars on linear functionals. Dual space. Bra and ket vectors and the bra-ket notation. Dual basis. Construction of bra from ket and vice-versa.

(c) Linear operators. Consequences of linearity: Action of an operator on the whole space in terms of its action on the basis vectors. Representation of linear operators by matrices. Transformation of representations under change of basis. Algebra of linear operators. Singular and non-singular operators (with examples). The adjoint or hermitian conjugate of an operator. Hermitian, orthogonal and unitary operators with examples. Projection operators.

(d) Eigenvalues and eigenvectors of an operator - non-degenerate and degenerate cases. Hermitian and unitary operators; reality and unimodularity of eigenvalues. Condition of diagonalizability. Normal operators. Commuting operators and simultaneous eigenstates for non-degenerate and degenerate eigenvalues. Complete sets of commuting operators.

(e) Tensor products of inner product spaces. Tensor products of vectors and operators.

2. Tensors **20 Lectures**

(a) Introduction of the Levi-Civita symbol and its uses in deriving the vector identities. The summation convention.

(b) Cartesian tensors in 3-d: Definition of a tensor, tensor algebra, sum, difference, and outer product of two tensors. Contraction, quotient law, symmetric and antisymmetric tensors. Krönecker tensor. Isotropic tensors. Tensorial Character of Physical Quantities. Examples of index contraction: triple products of vectors, divergence of tensors. Construction of the moment of inertia tensor I_{ij}, its properties, principal moments and axes of inertia, parallel and perpendicular axis theorem, relation of I_{ij} with scalar moment of inertia. Metric tensor in cartesian and curvilinear coordinates. Introduction to stress tensor.

(c) Tensors in $3+1$ dimensional space-time: Definition in terms of Lorentz transformation, Metric tensor in Minkowski space-time and invariant interval, contravariant and covariant tensors, contraction of tensors (example: four-divergence and equation of continuity, mass-energy relationship). Introduction to $F^{\mu\nu}$ and evaluation of its components from the definition of electric and magnetic fields, Lorentz transformation of $\mathbf{E}$ and $\mathbf{B}$, $\partial_\mu F^{\mu\nu} = j^\nu$ as Maxwell's equations with a source term. (Introduction of dual tensor not needed.)

3. Group Theory **25 Lectures**

(a) Definition of groups with examples. Uniqueness of identity and inverse. Discrete groups (Z_n, symmetry and permutation groups) and continuous groups ($O(n)$, $SO(n)$, $U(n)$, $SU(n)$). Abelian and non-abelian groups.

(b) Discrete groups: Multiplication table, rearrangement theorem. Conjugacy relations and classes. Subgroups. Homomorphism (example: Z_2 with Z_4) and isomorphism (example: 3-object permutation group S_3 with symmetry group of an equilateral triangle C_3) of groups. Matrix representations of groups: Reducible and irreducible representations.

(c) Lie groups and Lie algebras: Compactness, continuous connection to identity, representation by unitary matrices. Generators and their representation by hermitian matrices. Algebra of generators. Jacobi identity for generators. Non-abelian Lie groups and structure constants, their properties. Abelian invariant subalgebras and semisimple Lie groups. Real and complex representations. Fundamental and adjoint representations.

(d) $SU(2)$: Algebra, fundamental and adjoint representations. Connection with the angular momentum algebra. Decomposition of a higher dimensional representation into irreducible representations: spin singlet and triplet states as example of $\mathbf{2} \otimes \mathbf{2} = \mathbf{3} \oplus \mathbf{1}$. Combination of two angular momentum states and Clebsch-Gordan coefficients.

(e) $SO(3)$: Identification as the group of 3-d rotation, algebra, homomorphism with $SU(2)$.

Tutorial: In tutorial section, problems in the theory classes should be discussed. Problems and solutions regarding the theory course may be discussed.

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. Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press
4. Mathematics for Physicists, P. Dennery and A. Krzywicki, 1967, Dover Publications
5. Linear Algebra, S. Lipschutz and M.L.Lipson, Schaums Outline Series, 2009 McGraw Hill
6. Introduction to Electrodynamics, D.J. Griffiths, 3rd Ed., Pearson Education
7. Classical Electrodynamics, J.D. Jackson, 2007, Wiley
8. Elements of Group Theory for Physicists by A. W. Joshi, 1997, John Wiley
9. Lie Algebras in Particle Physics, H.Georgi, 2009

Additional Reference Books

1. Linear Algebra and Its Applications, G. Strang, 2005, Cengage Learning
2. Introduction to Mathematical Physics: Methods & Concepts: Chun Wa Wong, 2012, Oxford University Press
3. Introduction to Matrices and Linear Transformations, D.T. Finkbeiner, 1978, Dover Pub
4. Schaums Outline of Tensor Calculus , D. Kay, 2011, McGraw-Hill Education
5. Introduction to Tensor Calculus and Continuum Mechanics, J.H. Heinbockel, 2001, Trafford Publishing

6. An Introduction to Tensor Calculus and Relativity, D.F.Lawden, 2013, Literary Licensing, LLC

7. Group Theory and its Applications to Physical Problems by Morton Hamermesh, 1989, Dover

8. Group Theory in Physics, Volume I & II, J.F.Cornwell, Academic Press, 1984

9. Group Theory In Physics, W.K. Tung, 1985, World Scientific Publishing Co Pvt. Ltd.

DSE A1 (b)

5.4 Laser and Fiber Optics (Theory)

Paper: PHS-A-DSE-A2-TH	**Credits: 5 (+1 for Tutorial)**

1.Einstein coefficients and Rate equations **20 Lectures**

Historical background of laser, Einstein coefficients and stimulated light amplification: population inversion. Three level & four level lasers: Rate equation, condition for population inversion and threshold condition. minimum amount of pump power.

2. Basic properties of laser **4 Lectures**

Coherence, directionality, monochromaticity, brightness.

3. Resonantors **8 Lectures**

Optical resonators. Different configurations of optical resonators. stability condition (no derivation required) and stability diagram for optical resonators. Cavity lifetime. The Quality factor.

4. Transient effect **5 Lectures**

Transverse and Longitudinal mode selection. Principle of Q-switching and Mode locking. Different methods of Q-switching : electro-optic Q-switching, Pockels cell .

5. Basic Laser Systems **7 Lectures**

(i) Gas Laser

- He-Ne laser
- CO_2 Laser

(ii) Solid state laser

- Ruby Laser
- Nd:YAG laser
- Semiconductor laser

(iii) Liquid laser: Dye laser.

6. Practical properties and uses of laser **5 Lectures**

(a) The Line-shape function. Various Line broadening mechanisms: collisional broadening , Natural broadening, Doppler broadening.

(b) Basic idea of Laser cooling and trapping.

7. Fiber optics **12 Lectures**

Optical fiber, coherent bundle, Numerical aperture. Attenuation of optical fibers. Ray paths , Ray paths in a homogeneous medium, in square law media. Pulse dispersion in parabolic index medium and in planar step index waveguide. Modes of a planar waveguide: TE and TM modes. Physical understanding of modes, Optical fibers: Guided modes of step-index and graded index fibers. Applications of optical fibers in Communication and Sensing.

8. Holography **4 Lectures**

Principle of Holography. Recording and Reconstruction Method. Theory of Holography between two plane waves. Point source holograms.

9. Introductory Nonlinear Optics **10 Lectures**

Origin of nonlinearity, susceptibility tensor, phase matching, second harmonic generation, Sum frequency generation, Difference frequency generation, Sum and Difference Frequency generation, for second-order nonlinear optical medium. Nonlinear susceptibility of a classical anharmonic oscillator in case of noncentrosymmetric medium.

Tutorial: In tutorial section, problems in the theory classes should be discussed. Problems and solutions regarding the theory course may be discussed.

Reference Books

1. Lasers: Theory and Applications , A. Ghatak & K. Thyagarajan
2. Principles of Lasers , O. Svelto, 2009, Springer
3. Laser Physics, M. Sargant, M. Scully & W. Lamb , 1974, Westview Press
4. Introduction to Fiber Optics, A. Ghatak, 1998, Cambridge University Press
5. Introduction to Modern Optics, G. Fowles, 1989, Dover Publications
6. Optics, E. Hecht & A. Ganesan, 2009, Pearson Prentice Hall
7. Nonlinear Optics, R. Boyd, 2008, Academic Press

DSE B1 (a)

5.5 Astronomy and Astrophysics (Theory)

Paper: PHS-A-DSE-A2-TH	Credits: 5 (+1 for Tutorial)

1. Tools of Astronomy **15 Lectures**

(a) Contents of our Universe: basic introduction of stars, galaxies, clusters, interstellar medium, black holes, our own galaxy Milky Way.

(b) Mass, length, time and magnitude scales in astronomy.

(c) Interaction of light and matter fundamentals of radiative transfer (emission, absorption, radiative transfer equation, mean free path, optical depth), thermal radiation and thermodynamic equilibrium (Kirchhoff's law of thermal emission, Boltzmann and Saha equation, thermodynamics of black body radiation, concept of local thermodynamic equilibrium.

(d) Observational tools for multi-wavelength astronomy - telescope as a camera, optical telescopes (refracting and refrecting telescopes), radio telescopes, astronomical instruments and detectors, observations at other wavelengths (infrared, ultraviolet, X-ray and Gamma ray astronomy), all-sky surveys.

2. Stars and stellar systems **25 Lectures**

(a) Properties of stars (distance, brightness, size, mass, temperature, luminosity).

(b) Measurement of stellar parameters: distance parallax, Cepheid variables, nova and supernovae, red shift), stellar spectra, spectral lines, the Hertzsprung-Russell diagram, luminosity and radius, binary system and mass determination, scaling relation on the Main Sequence.

(c) Basic equation of stellar structure hydrostatic equilibrium and the virial theorem, radiative and convective energy transport inside stars, nuclear energy production. Equation of state, opacity, Derivation of scaling relations.

(d) Formation and evolution of stars star formation, pre-main-sequence collapse (gravitational instability and mass scales, collapse of spherical cloud, contraction onto the Main Sequence, Brown Dwarfs), evolution of high-mass and low-mass stars (core and shell hydrogen burning, helium ignition), late-stage evolution of stars, evolution of Sun-like stars and solar system.

(e) End stages of stars white dwarfs (electron-degeneracy pressure, mass-radius relation), neutron stars (mass limit of neutron stars, neutron stars observable as pulsars), black holes as end point of stellar evolution, supernovae.

3. Galaxies and the Universe **10 Lectures**

(a) Milky Way galaxy: components, morphology and kinematics of the Milky way, the galactic center, spiral arms.

(b) Classification and morphology of galaxies - quiet and active galaxies, types of active galaxies, Active Galactic Nuclei (AGN) and Quasars, accretion by supermassive black holes.

4. Cosmology **25 Lectures**

(a) Newtonian cosmology, Olber's paradox, Hubble's law and the expanding Universe, scale factor and comoving coordinate.

(b) Standard cosmology, the Friedmann equations from Newtonian cosmology, fluid equation , equation of state for matter, dust etc. from basic thermodynamics, cosmological redshift, dark matter, dark energy and the accelerating universe, tests and probes of Big Bang cosmology (the Cosmic Microwave Background, primordial nucleosynthesis).

Tutorial: In tutorial section, problems in the theory classes should be discussed. Problems and solutions regarding the theory course may be discussed.

Reference Books

1. An Introduction to Modern Astrophysics, B.W. Carroll & D.A. Ostlie, Addison-Wesley Publishing Co
2. Introductory Astronomy and Astrophysics, M. Zeilik and S.A. Gregory, 4 th Edition, Saunders College Publishing
3. Astrophysics in a Nutshell (Basic Astrophysics), Dan Maoz, Princeton University Press
4. An Invitation to Astrophysics, T. Padmanabhan, World Scientic Publishing Co
5. Foundations of Astrophysics, Barbara Ryden and Bradley M. Peterson, Addison Wesley

Additional Reference Books

1. Astronomy and Astrophysics, A. B. Bhattacharya, S. Joardar, R. Bhattacharya, Overseas Press (India) Pvt. Ltd

2. Astrophysics for Physicists, Arnab Rai Choudhuri, Cambridge University Press
3. Introduction to Astronomy and Cosmology, Ian Morison, John Wiley & Sons Ltd
4. Theoretical Astrophysics, Volume III: Galaxies and Cosmology, T. Padmanabhan, Cambridge University Press

DSE B1 (b)

5.6 Nuclear and Particle Physics (Theory)

Paper: PHS-A-DSE-A2-TH	**Credits: 5 (+1 for Tutorial)**

1. Introduction **5 Lectures**
Recapitulation of general properties of nuclei, nuclear models and radioactivity.

2. Nuclear Reactions **10 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).

3. Interaction of Nuclear Radiation with matter **15 Lectures**
Energy loss due to ionization (Bethe- Block formula), energy loss of electrons, Cerenkov radiation. Gamma ray interaction through matter, photoelectric eect, Compton scattering, pair production, neutron's interaction with matter.

4. Detector for Nuclear Radiations **15 Lectures**
Gas detectors: estimation of electric eld, 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.

5. Particle Accelerators **15 Lectures**
Accelerator facility available in India, Different type of accelerators

- Van-de Graaf generator (Tandem accelerator)
- Linear accelerator
- Cyclotron
- Betatron
- Synchrotrons

6. Particle Physics **15 Lectures**
Fundamental particles and their families. Fundamental particle-interactions and their basic features. Gellmann Nishijima formula. Quark structure of hadrons. 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.

Tutorial: In tutorial section, problems in the theory classes should be discussed. Problems and solutions regarding the theory course may be discussed.

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 Elementary Particles, D. Griffiths, John Wiley & Sons
4. Basic ideas and concepts in Nuclear Physics - An Introductory Approach by K. Heyde (IOP- Institute of Physics Publishing, 2004)
5. Radiation detection and measurement, G.F. Knoll (John Wiley & Sons, 2000)
6. Nuclear Physics, Irving Kaplan, Oxford & IBH Publishing Co. Pvt. Ltd.

Additional Reference Books

1. Introduction to the physics of nuclei & particles, R.A. Dunlap. (Thomson Asia, 2004)
2. Introduction to High Energy Physics, D.H. Perkins, Cambridge Univ. Press
3. Quarks and Leptons, F. Halzen and A.D. Martin, Wiley India, New Delhi
4. Physics and Engineering of Radiation Detection, Syed Naeem Ahmed (Academic Press, Elsevier, 2007)
5. Particle and Nuclei, Povh, Rith, Scholz, Zetsche, 6th Ed., Springer
6. Introduction to Nuclear and Particle Physics, A. Das and T. Ferbel, World Scientific
7. Theoretical Nuclear Physics, J.M. Blatt & V.F.Weisskopf (Dover Pub.Inc., 1991)

Honours: Semester 6

CC 13, CC 14, DSE A2, DSE B2

CC 13	Digital Electronics Credit 6	Theory Credit 4 Classes 60	Practical Credit 2 Classes 60
CC 14	Solid State Physics Credit 6	Theory Credit 4 Classes 60	Practical Credit 2 Classes 60
DSE A 2	(a) Nanomaterials Or (b) Advanced Classical dynamics Credit 6	Theory Credit 5 Classes 75	Tutorial Credit 1 Classes 15
DSE B 2	(a) Communication Electronics Or (b) Advanced Statistical Mechanics Credit 6	Theory Credit 5 Classes 75	Tutorial Credit 1 Classes 15

6.1 Digital Systems and Applications

6.1.1 Digital Systems and Applications (Theory)

Paper: PHS-A-CC-6-14-TH **Credits: 4**

1. Integrated Circuits **5 Lectures**

Principle of Design of monolithic Chip. Advantages and drawbacks of ICs. Scale of integration: SSI, MSI, LSI and VLSI (basic idea and definitions only w.r.t. micron/submicron feature length).

2. Number System **7 Lectures**

Binary Numbers. Decimal to Binary and Binary to Decimal Conversion. BCD, Octal and Hexadecimal numbers. Signed and unsigned number representation of binary system. Representation of negative number. 1's Complement and 2's Complement method of subtraction.

3. Digital Circuits **16 Lectures**

(a) Difference between Analog and Digital Circuits. Introduction of switching algebra, Huntington's postulates. Combinational logic, Truth table. Introduction of basic logic functions AND, OR and NOT. Implementation of OR, AND, NOT Gates (realization using Diodes and Transistor). De Morgan's Theorems. NAND and NOR Gates as

Universal Gates. XOR and XNOR Gates and application as Parity Checkers. Circuit representation of gates (both Usual and IEEE symbols). Introduction to different logics like DTL, TTL, MOS and CMOS. MOS and CMOS inverter circuit. NAND/NOR circuit using MOS logic.

(b) Product term and sum term in logical expression. Sum of Product and Product of Sum and mixed expression. Minterm and Maxterm in the expressions. Conversion between truth table and logical expression. Simplification of logical expression using Karnaugh Map.

4. Implementation of different circuits **6 Lectures**

Half and Full Adders. Subtractors, 4-bit binary adder/Subtractor. Combinational logic circuits using PAL/PLA, use of IC 7483 as adder and subtractor.

5. Data processing circuits **5 Lectures**

Basic idea of Multiplexers, De-multiplexers, Decoders, Encoders.

6. Sequential Circuits: **6 Lectures**

Introduction to Next state present state table, excitation table and truth table for Sequential circuits. SR, D, and JK Flip-Flops. Clocked (Level and Edge Triggered) Flip-Flops. Preset and Clear operations. Race condition in SR and Race-around conditions in JK Flip-Flop. M/S JK Flip-Flop, T type FF.

7. Registers and Counters **6 Lectures**

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

(b) Counters (4 bits): Asynchronous counters: ripple counter, Decade Counter. Synchronous Counter, Ring counter.

8. Computer Organization **6 Lectures**

Input/Output Devices. Data storage (idea of RAM and ROM, EPROM). Computer memory. Memory organization & addressing. Memory Interfacing. Memory Map.

9. Data Conversion **3 Lectures**

A/D (Ladder and weighted resistance) and D/A conversion circuit

Reference Books

1. Digital Circuits, Part I & II, D. Raychaudhuri, Eureka Publisher
2. Digital Logic and Computer Design, M. Morris Mano, Pearson Education
3. Digital Principles and Applications, A.P. Malvino, D.P. Leach and Saha, 7th Ed., 2011, Tata McGraw Hill
4. Electronic devices & circuits, S. Salivahanan & N.S. Kumar, 2012, Tata Mc-Graw Hill
5. Fundamental of Digital Circuits, A. Anand Kumar, Prentice Hall India Learning Pvt. Ltd.
6. Digital Systems, Principles and Applications, R. Tocci, N. S. Widemer, Prentice Hall India Learning Pvt. Ltd.
7. Modern Digital Electronics, R. P. Jain, Tata McGrow Hill Publishing Company
8. Digital Electronics An Introduction to Theory and Practice, Prentice Hall India Learning Pvt. Ltd.
9. Digital Computer Electronics, A. Malvino & Jerald Brown, Tata McGrow Hill Publishing Company.

6.1.2 Digital Systems and Applications (Practical)

Paper: PHS-A-CC-6-14-P	**Credits: 2**

List of Practicals

1. To design OR & AND logic with diode and resistor. Basic logic gates with Transistors. To verify the logics by any type of universal gate NAND/NOR.

2. Construction of half adder and full adder

3. Construction of SR, D, JK FF circuits using NAND gates.

4. Construction of 4 bit shift registers (serial & parallel) using D type FF IC 7476.

5. Construction of 4×1 Multiplexer using basic gates and IC 74151.

Reference Books

1. Advanced Practical Physics, B. Ghosh, K. G. Majumder, Sreedhar Publication
2. An Advanced Course in Practical Physics, D. Chattopadhyay, P.C. Rakshit, New Central Book Agency (P) Ltd

6.2 Solid State Physics

6.2.1 Solid State Physics (Theory)

Paper: PHS-A-CC-6-13-TH	**Credits: 4**

1. Crystal Structure **12 Lectures**

(a) 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. Laue and Bragg's Law and their equivalance. Atomic and Geometrical Structure Factor. Basic idea of crystal indexing: examples with SC, BCC, FCC structure.

2. Elementary Lattice Dynamics **10 Lectures**

(a) Lattice Vibrations and Phonons: Linear Monatomic 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.

3. Magnetic Properties of Matter **8 Lectures**

Dia, Para, Ferri and Ferromagnetic Materials. Classical Langevin Theory of Dia and Paramagnetic Domains. Quantum Mechanical Treatment of Paramagnetism (using parition function). Curie's law, Weiss's Theory of Ferromagnetism and Ferromagnetic Domains. Discussion of B-H Curve. Hysteresis and Energy Loss.

4. Dielectric Properties of Materials **8 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.

5.Drude's theory **4 Lectures**

Free electron gas in metals, effective mass, drift current, mobility and conductivity, Hall effect in metals. Thermal conductivity. Lorentz number, limitation of Drude's theory.

6.Elementary band theory **12 Lectures**

Kronig Penny model. Band Gap. effective mass and effective mass tensor. Conductor, Semiconductor (P and N type) and insulator. Conductivity of Semiconductor, mobility, Hall Effect. Measurement of conductivity (4 probe method) & Hall coefficient.

7. Superconductivity **6 Lectures**

Experimental Results. Critical Temperature. Critical magnetic field. Meissner effect. Type I and type II Superconductors, London's Equation and Penetration Depth. Isotope effect.

Reference Books

1. Introduction to Solid State Physics, Charles Kittel, 8th Edition, 2004, Wiley India Pvt. Ltd.
2. Solid-state Physics, H. Ibach and H. Luth, 2009, Springer Solid State Physics, Rita John, 2014, McGraw Hill
3. Elementary Solid State Physics, 1/e M. Ali Omar, 1999, Pearson India
4. Solid State Physics and Electronics, A.B.Gupta and N.Islam, Books and Allied (P) Ltd
5. Solid State Physics, M.A. Wahab, 2011, Narosa Publications

Additional Reference Books

1. Elements of Solid State Physics, J.P. Srivastava, 4th Edition, 2015, Prentice- Hall of India
2. Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw Hill
3. Solid State Physics, N.W. Ashcroft and N.D. Mermin, 1976, Cengage Learning
4. The Oxford Solid State Basics, S.H. Simon, 2017, Oxford University Press
5. Solid-State Physics: Introduction to the Theory , J.D. Patterson and B.C. Bailey, 2018 , Springer
6. Solid State Physics, G. Grosso, 2005, Elsevier India
7. Basic Solid State Physics , A. Raychaudhuri, 2014, Sarat Book House
8. Solid State Physics, M.S.Rogalski and S.B. Palmer, 2018, CRC Press

6.2.2 Solid State Physics (Practical)

Paper: PHS-A-CC-5-12-P	**Credits: 2**

List of Practicals

1. To study BH hysteresis of ferromagnetic material

2. To determine dielectric constant of different materials (solid and liquid) using fixed frequency alternating source.

3. Measurement of variation of resistivity in a semiconductor and investigation of intrinsic band gap using linear four probe.

4. Measurement of hall voltage by four probe method

5. To study temperature coefficient of a semiconductor (NTC thermistor) and construction of temperature controller with comperator and relay switch.

6. Measurement of magnetic susceptibility of solids

Reference Books

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

DSE A2 (a)

6.3 Nano Materials and Applications (Theory)

Paper: PHS-A-DSE-A2-TH	Credits: 5 (+1 for Tutorial)

1. 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 connement: Applications of Schrodinger equation: Infinite potential well, potential step, potential box, quantum confinnement of carriers in 3D, 2D, 1D nanostructures and its consequences.

2. Synthesis of Nanostructure Materials **15 Lectures**

(a) Top down and Bottom up approach, Photolithography. Ball milling. Gas phase condensation.
(b) Vacuum deposition

- Physical vapor deposition (PVD)
- Thermal evaporation
  - Electron beam evaporation
  - Pulsed Laser deposition
- Chemical vapor deposition (CVD)
- MBE growth of quantum dots

(c) Chemical Synthesis

- Chemical bath deposition
- Electro deposition
- Spray pyrolysis
- Hydrothermal synthesis
- Sol-Gel synthesis

- Preparation through colloidal methods

3. Characterization **10 Lectures**

(a) X-Ray Diffraction. Optical Microscopy. Scanning Electron Microscopy (SEM). Transmission Electron Microscopy (TEM). Atomic Force Microscopy (AFM). Scanning Tunneling Microscopy (STM).

4. Optical Properties **15 Lectures**

(a) 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.

5. Electron Transport **10 Lectures**

(a) Carrier transport in nanostrucutures. Coulomb blockade effect, thermionic emission, tunneling and hoping conductivity. Defects and impurities: Deep level and surface defects.

6. Applications **15 Lectures**

(a) 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).

Tutorial: In tutorial section, problems in the theory classes should be discussed. Problems and solutions regarding the theory course may be discussed.

Reference Books

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

DSE A2 (b)

6.4 Advanced Classical Dynamics (Theory)

Paper: PHS-A-DSE-A2-TH	**Credits: 5 (+1 for Tutorial)**

1. Calculus of Variations **30 Lectures**

(a) Definition of a functional : Idea of a functional as a definite integral. Examples: shortest distance between two points in a plane, on a sphere, Brachistochrone problem. Fermat's principle.

(b) Extremization of the Lagrangian to obtain the equation of motion, i.e. the Euler Lagrange equation.

(c) Calculus of variations in presence of constraints: Lagrange's equation for the first kind using undetermined multipliers. Applications using simples examples: block moving on a fixed and freely movable frictionless inclined plane, particle sliding along a cylinder and losing contact etc.

(c) Lagrangian and its formulation for a non-inertial frame; appearance of the centrifugal force and the Coriolis' force from the Lagrangian picture. Lagrangian for charged particle in electromagnetic field and Lorentz force law.

(d) Symmetries and Conservation laws. Virial theorem in classical mechanics.

(e) Formulation of Hamiltonian Mechanics. Basic idea of Poisson bracket and its properties. Hamilton's EOM using Poisson bracket.

2.Small Oscillations **10 Lectures**

Minima of potential energy 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 3 identical masses connected in a linear fashion to 2 - identical springs.

3. Rigid Body Motion **10 Lectures**

Idea of rigid body in terms of constraints and degrees of freedom. Combination of translation and rotation as a general motion. Rotation of rigid body about an arbitrary axis; angular momentum, angular velocity, moments of inertia, products of inertia, kinetic energy. Principal axis transformation.

4. Nonlinear Dynamics **25 Lectures**

(a) Definition of a dynamical system. Casting Newton's equation for a particle in the dynamical system form. Autonomous and non autonomous system through examples: free, forced and damped oscillators. Idea of conservative dissipative and anti dissipative systems. Discussion of Mathieu, Duffing, and van der Pol oscillator in this context.

(b) Idea of fixed points in one dimensional problems. Flows. Linear stability analysis. Classification of fixed points through simple examples: both geometrical and linear stability analysis approach should be emphasized.

(c) Canonical forms and their discussions. Associated phase diagrams. Physical examples.

(d) Two dimensional systems and their analysis from the point of view of linear stability. Periodic obits in the form of center and limit cycles. Their stability. Examples: Lotka Volterra (predator-prey), Duffing and Van der Pol oscillator.

(e) One dimensional maps. Idea of fixed point of a map through iterations. Stability of the fixed point and the cobweb plot.Tent and Bernoulli maps. Their graphical representation. Idea of a period two orbit.

Tutorial: In tutorial section, problems in the theory classes should be discussed. Problems and solutions regarding the theory course may be discussed.

Reference Books

1. Classical Mechanics: A Course of Lectures. A.K. Raychaudhuri, 1983, Oxford University Press
2. Mechanics, L. D. Landau and E. M. Lifshitz, 1976, Pergamon
3. Classical Mechanics, P.S. Joag, N.C. Rana, , McGraw Hill
4. Classical Mechanics, H.Goldstein, C.P. Poole, J.L. Safko, 3rd Edn. 2002, Pearson Education
5. Introduction to Classical Mechanics With Problems and Solutions , D. Morin, 2008, Cambridge University Press
6. Nonlinear Dynamics and Chaos, S.H. Strogatz, Levant Books, Kolkata, 2007
7. Introduction to dynamics , Perceival & Richards, 1983 , Cambridge University Press

8. Introduction to Chaos: Physics and Mathematics of Chaotic phenomena: H. Nagashima & Y. Baba , 1998, CRC Press

9. **Also see book references in core courses of classical mechanics.

DSE B2 (a)

6.5 Communication Electronics (Theory)

Paper: PHS-A-DSE-A1-TH	**Credits: 5 (+1 for Tutorial)**

1. Electronic communication **10 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

2. Analog Modulation **15 Lectures**

(a) Amplitude Modulation, mathematical analysis for modulation index, frequency spectrum and power in AM Generation of AM (Emitter Modulation), Diode/square law modulator, Amplitude Demodulation (diode detector), Balanced modulator for DSB, Concept of Single side band generation and detection, concept of vestigial side band.

(b) Frequency Modulation (FM) and Phase Modulation (PM), modulation index and frequency spectrum, Transistor/FET reactance modulator, equivalence between FM and PM, Generation of FM using VCO, FM detector : slope detector, Balanced slope detector, Idea of Phase discriminator and ratio detector, Qualitative idea of IF and Super heterodyne receiver.

3. Analog Pulse Modulation **10 Lectures**

Channel capacity, Sampling theorem, Basic Principles- PAM, PWM, PPM, modulation and detection technique for PAM only, Multiplexing – FDM and TDM and its application in communication.

4. Digital Pulse Modulation **15 Lectures**

Need for digital transmission, Sampling and Shanon's criteria, Quantization and Encoding, Quantisation error, non-uniform quantisation, Impulse sampling, Natural sampling and flat top sampling, Pulse Code Modulation (PCM), Differential PCM , Digital Carrier Modulation Techniques, Concept of Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK).

(b) Idea of 8-PSK, QPSK, BPSK, use of Constellation diagram (idea only), Delta modulation. Concept of companding- A law and µ law. Line Coder: Unipolar and bipolar RZ & NRZ, Manchester format.

5. Introduction to Communication and Navigation systems: **25 Lectures**

(a) Satellite Communication: 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.

(b) Mobile Telephony System _ 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).

Tutorial: In tutorial section, problems in the theory classes should be discussed. Problems and solutions regarding the theory course may be discussed.

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
8. Communication System by Sanjay Sharma, S.K. Kataria and Sons
9. Electronic Communication: Modulation and Transmission by Schoenbeck, Prentice Hall India Learning Private Limited

DSE B2 (b)

6.6 Advanced Statistical Mechanics (Theory)

Paper: PHS-A-DSE-B2-TH	**Credits: 5 (+1 for Tutorial)**

1. Review of classical statistical mechanics **25 Lectures**

(a) Idea of phase space, classical Liouville theorem, different enseembles. Evaluation of thermodynamic parameters using microcanonical ensemble for (i) harmonic oscillator, (ii) classical ideal gas (Sackur Tetrode Equation), (iii) paramagnets. Partition function and thermodynamic parameters evaluation for other simple examples. Anharmonic oscillator: mean energy ,mean position, specific heat using canonical ensemble, idea of thermal expansion of solids. Virial theorem and equipartion theorem . Energy fluctuatiuon in canonical ensemble.

(b) Grand canonical ensemble, various thermodynamic parametrs in grand canonical ensemble. Chemical potential for classical ideal gas. Saha ionization equation.Density and energy fluctuation in grand canonical ensemble. Equivalence of different ensembles.

2. Quantum statistical mechanics **10 Lectures**

Density matrix formulation. Random phase approximattion. Ensemble average for micro, canonical and grand canonical ensemble. Density matrix Examples: electron in magnetic field, free particle, harmonic oscillator. Distribution function of identical particles: bosons and fermions.

3.Ideal Bose systems and Fermi systems **20 Lectures**

Ideal bose gas. Thermodynamic relations, equation of state. bose-einstein condensation,: evaluation of various thermodynamic parameters . chemical potential for bose gas. Ideal fermi gas: thermodynamic relations.equation of state. Pauli paramagnetism, degenerate and non-degenerate fermi gas. Relativistic fermi gas. White dwarf and chandrasekhar mass limit.

4. Ising model **10 Lectures**

Ising model : Bragg-Williams theory and relation with binary alloy.

5.Non-equilibrium statistical mechanics **10 Lectures**

Equilibrium time scales, irreversibility and role of fluctuation; coarse grained description. Random walk : calculation of occupation probability.

Tutorial: In tutorial section, problems in the theory classes should be discussed. Problems and solutions regarding the theory course may be discussed.

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. Concepts in Thermal Physics, S.J. Blundell and K.M. Blundell, 2nd Ed., 2012, Oxford University Press
4. An Introductory Course of Statistical Mechanics. P.B. Pal,2008, Narosa
5. Statistical Mechanics an elementary outline, A. Lahiri, 2008, Universities Press
6. Statistical Mechanics, K. Huang, J Wiley India

Additional Reference Books

1. An Introduction to Thermal Physics, D.V. Schroeder, 2014, Pearson Education, India
2. Intermediate Statistical Mechanics. J. Bhattacharjee and D. Banerjee, 2017, World Scientific (HBA)
3. A Modern Course in Statistical Physics, L. Reichl, 2016, Wiley-VCH
4. Equilibrium Statistical Mechanics , G.F. Mazenko, 2000, Wiley VCH
5. Elements of Nonequilibrium Statistical Mechanics , V. Balakrishnan, 2008, CRC Press
6. Principles of Condensed Matter Physics , P.M. Chaikin & T.C. Lubensky , 2000, Cambridge University Press
7. **Also see reference books in statistical mechanics core course.

Question patterns in different examinations for Honours Course in Physics

The number allotted for each course is 100. The marks distributions are given previously. The duration of examinations and details of marks distribution are given in the following table.

Examination		Conducted by	Center	Total Marks	Marks Division: Question	Marks Division: Marks	Total Question to be allotted	Time allotted
Internal Assessment		College	Home	10 Marks	10×2=20 (scaled down to 10)		15 Question	1 Hour
CC-Theory		University	Away	50 marks	$5 \times 2 = 10$		7 Questions	2 Hours
					$4 \times 10 = 40$		6 Questions	
CC-Practical		University	Away	30 marks	LWB	5		3 Hours
					Viva	5		
					Experiment	20		
GE-Theory		University	Away	50 marks	$5 \times 2 = 10$		7 Questions	2 Hours
					$4 \times 10 = 40$		6 Questions	
GE-Practical		College	Home	30 marks	LWB	5		3 Hours
					Viva	5		
					Experiment	20		
DSE-Theory		University	Away	65 marks	$5 \times 2 = 10$		7 Questions	3 Hours
					$3 \times 5 = 15$		5 Questions	
					$4 \times 10 = 40$		6 Questions	
DSE-Tutorial		College	Home	15 marks	****			
SEC (Theory)		University	Away	80 marks	$10 \times 2 = 20$		12 Questions	3 Hours
					$4 \times 5 = 20$		6 Questions	
					$4 \times 10 = 40$		6 Questions	
SEC	Th	University	Away	20 marks	$10 \times 2 = 20$		12 MCQ type	30 minute
(Project type)	Proj	College	Home	60 marks				

**** Students must be given a set of problems/assignments (at least 2). On the basis of regularity of submission and evaluation of assignments by the respective Teacher credits should be awarded to the students.

Part II

Physics Syllabus : General Course

Basic Course Structure for General Course (B.Sc. Programme)

Students of B.Sc. General or B.Sc. Programme should take three subjects in their carriculum. In first four semester students will take one core course, CC from each subject in each semester. We refer to the subjects as 111, 222 & 333. As a general student the subject code will be 111G, 222G, 333G. e.g., a student who had opted Physics, Chemistry and Mathematics his/her subject codes will be PHSG, CEMG, and MTMG. Thus 111 ≡PHS, 222 ≡CEM and 333 ≡MTM. Skill Enhancement Course, SEC must be opted in 3rd, 4th and 5th, 6th Semesters. SEC A is meant for odd (i.e., 3rd & 5th) Semesters and SEC B is meant for even (i.e., 4th & 6th) Semesters. Student will take two SEC A courses from two subjects in 3rd and 5th semesters and similarly he/she will take two SEC B courses from the same two subjects in 4th and 6th semesters. i.e., in each semester student will study one SEC. The details for choice of SEC is given later.

The core course (CC) are absent in 5th and 6th Semesters. Student should take Discipline specific elective courses, DSE there. DSE-A and DSE-B are for 5th and 6th Semesters respectively. Student will chose one DSE-A from each subject in 5th semester and similarly DSE-B from each subject in 6th Semester.

The DSE courses are so arranged that a student can choose practical based DSE or theoretical DSE as type A and B.

Detail plans with credits are given in following table (XXX for SEC will be cleared in fourth table).

General Course: Credit Distribution

Courses	Semester 1	Semester 2	Semester 3	Semster 4	Semester 5	Semester 6
CC	111G-CC-1 (6)	111G-CC-2 (6)	111G-CC-3 (6)	111G-CC-4 (6)		
	222G-CC-1 (6)	222G-CC-2 (6)	222G-CC-3 (6)	222G-CC-4 (6)		
	333G-CC-1 (6)	333G-CC-2 (6)	333G-CC-3 (6)	333G-CC-4 (6)		
SEC			XXXG-SEC A (2)	XXXG-SEC B (2)	XXXG-SEC A (2)	XXXG-SEC B (2)
DSE					111G-DSE-A (6)	111G-DSE-B (6)
					222G-DSE-A (6)	222G-DSE-B (6)
					333G-DSE-A (6)	333G-DSE-B (6)
AECC	AECC -1 (2)	AECC-2 (2)				
Total Credit	20	20	20	20	20	20
Number	400	400	400	400	400	400

The term in the parentheses represents credit of a course. Thus a general stuents completes $20 \times 6 = 120$ Credits in his/her course. In each semeser the student appear for four 100 marks paper. However, if student will take a course with practical module then the practical examination also will be there.

Physics courses for general students (B.Sc. Programme)

In physics all the core courses have practical.There are two types of SEC are there one is project type and other is theoretical paper. The DSE also of two types. In one type of DSE there is practical module and other type of DSE comprises of theoretical part only.

The courses offered in Physics general are given in the next Table.

General Course: Physics Modules distribution

Semester	Core Course	SEC-A	SEC-B	DSE-A	DSE-B
Semester-1	CC1/GE1 Mechanics				
Semester-2	CC2/GE2 Electricity & Magnetism				
Semester-3	CC3/GE3 Thermal Physics	SEC A-1 Scientific Writing Or SEC A-2 Renewable Energy			
Semester-4	CC4/GE4 Waves & Optics		SEC B-1 Arduino Or SEC B-2 Electrical Circuit & Network Skill		
Semester-5		SEC A-1 Scientific Writing Or SEC A-2 Renewable Energy		DSE-A(1) Analog Electronics Or DSE-A(2) Modern Physics	
Semester-6			SEC B-1 Arduino Or SEC B-2 Electrical Circuit & Network Skill		DSE-B(1) Digital Electronics Or DSE-B(2) Nuclear Physics

.

Choice of Skill Enhancement Course (SEC)

According to the CSR for CBCS it was mentioned that

One paper from Group A, i.e., SEC A of each of the two subjects to be chosen in the third and fifth semester; one papaer from Group B, i.e., SEC B of each of the two core subjects to be chosen in the fourth and sixth semester.

The stuedents take three subjects as core in B.Sc. Programme. For SEC he/she took pic up any two subjects among these three core subjects. Thus, three possible combinations are

- 111G & 222G
- 111G & 333G
- 222G & 333G

Again for a specific choice there are several distributions. Let us take for the subject combinations of 111G and 222G.

Combination	3rd Semester	4th Semester	5th Semester	6th Semester
1	111G SEC A	111G SEC B	222G SEC A	222G SEC B
2	111G SEC A	222G SEC B	222G SEC A	111G SEC B
3	222G SEC A	222G SEC B	111G SEC A	111G SEC B
4	222G SEC A	111G SEC B	111G SEC A	222G SEC B

To be specific if any one have opted Physics and Mathematics for SEC then the combinations are

Combination	3rd Semester	4th Semester	5th Semester	6th Semester
1	PHSG SEC A	PHSG SEC B	MTMG SEC A	MTMG SEC B
2	PHSG SEC A	MTMG SEC B	MTMG SEC A	PHSG SEC B
3	MTMG SEC A	MTMG SEC B	PHSG SEC A	PHSG SEC B
4	MTMG SEC A	PHSG SEC B	PHSG SEC A	MTMG SEC B

In Physics carriculum two SEC courses are given, one is for knowledge skill (theory type) other is for technical skill (project type). The evaluation process for knowledge skill SEC courses is theoretical examination (of 80 marks) and the skill based SEC will be evaluated through a project (of 60 marks) and an examination containing MCQ type questions (of 20 marks).

Choice of Discipline Specific Elective Course (DSE)

According to the CSR for CBCS it was mentioned that

A student shall have to study 6 DSE courses strictly on 3 subjects, opted for pursuing core courses, taking exactly two courses from each subject. Such a student shall have to study the carriculum of DSE of the subject concerned as specified for the relevent semester, i.e., DSE-A in the 5th Semester and DSE-B in 6th Semester.

Since, the students have taken three subjects as the core subjects they need to take one DSE A course from all those subjects in 5th Semester and one DSE B course from all those subjects in 6th Semster. The available DSE A courses and DSE B courses are mentioned in each subjects. Thus, the options are mentioned below

5th Semester	6th Semester
111G-DSE A	111G-DSE B
222G-DSE A	222G-DSE B
333G-DSE A	333G-DSE B

In Physics carriculum two DSE A courses are mentioned in 5th Semester and two DSE B courses are given in 6th Semester. DSE A(1) and DSE B(1) have both theory and practical components. Therefore, two examinations i.e., theory (for 50 marks) and practical (for 30 marks) will be held for these DSE courses. The second type DSE, i.e., DSE A(2) and DSE B(2) are of theory type. There will be theoretical examinations (for 80 marks) only for these DSE courses.

Choice of Generic Elective Subjects for Honours students

Students who will take **Honours** Course in subject other than physics may take **physics as a generic elective upto 4th semester** along with another subject. In that situation the student will have to study Physics general in any two semesters only.

In each semester there is a single core course offered for B.Sc. general students. The same coureses will be treated as generic elective subjects for them. That is why the courses are referred to as CC/GE in each semester. Students have to accept the course running in that semester in which they had decided to take physics general.

The Honours student can take Physics as Generic elective in any following combinations.

Combination	GE1	GE2	GE3	GE4
1	PHSG	OG	OG	PHSG
2	OG	PHSG	PHSG	OG
3	PHSG	PHSG	OG	OG
4	OG	OG	PHSG	PHSG
5	PHSG	OG	PHSG	OG
6	OG	PHSG	OG	PHSG

Here, PHSG represents generic elective from Physics and OG represents the other subject which is opted by the student as second generic subject.

Therefore, the SEC or DSE mentioned in previous sections are not for the students continuing Honours course in the subject other than Physics.

General: Semester 1

CC1/GE1

CC 1/GE 1	Mechanics	Theory	Practical
	Credit 6	Credit 4	Credit 2
		Classes 60	Classes 60

1.1 Mechanics

1.1.1 Mechanics (Theory)

Paper: PHS-G-CC-1-1-TH	**Credits: 4**

1. Mathematical Methods **15 Lectures**

(a) Vector Algebra: Addition of vectors and multiplication by a scalar. Scalar and vector products of two2 vectors, vector triple product. Representation of vectors in terms of basis vectors.

(b) Vector Analysis: Derivatives of a vector with respect to a parameter. Gradient, divergence and Curl. Vector integration, line, surface and volume integrals of vector fields. Gauss divergence theorem and Stoke's theorem of vectors (Statement only) and their significances.

(c) Ordinary Differential Equations: 1st order homogeneous differential equations. 2nd order homogeneous and inhomogeneous differential equations with constant coefficients.

2. Introduction to Newtonian Mechanics **5 Lectures**

(a) Laws of Motion: Idea of space time for Newtonian Mechanics, frames of reference, Newton's Laws of motion. Dynamics of a system of particles. Conservation of momentum. Centre of Mass.

(b) Work-energy theorem. Conservative forces. Concept of Potential Energy. Conservation of energy.

3. Rotational Motion **10 Lectures**

Rotation of a rigid body about a fixed axis. Angular velocity and angular momentum. Moment of Inertia. Calculation of moment of inertia for rectangular, cylindrical and spherical bodies. Torque. Conservation of angular momentum.

4. Central force and Gravitation **10 Lectures**

(a) Motion of a particle in a central force field. Conservation of angular momentum leading to restriction of the motion to a plane and constancy of areal velocity. Kepler's Laws (statement only). Newton's Law of Gravitation. Satellite in circular orbit and applications. Geosynchronous orbits. Basic idea of global positioning system (GPS).

5. Oscillations **9 Lectures**

Simple harmonic motion. Differential equation of SHM and its solutions. Kinetic and Potential Energy, Total Energy and their time averages. Damped oscillations. Forced oscillations with harmonic forces.

6. Elasticity **6 Lectures**

(a) Hooke's law, elastic moduli, relation between elastic constants, Poisson's Ratio, Expression for Poisson's ratio in terms of elastic constants.

(b) Twisting couple on a cylinder. Determination of Rigidity modulus by static torsion. Torsional pendulum.

(c) Bending of beams, Cantilever.

(d) Work done in stretching and work done in twisting a wire.

7. Surface Tension **5 Lectures**

Molecular theory of surface tension, surface energy, comparison between surface tension and surface energy, variation of surface tension with temperature, application to spherical drops and bubbles Synclastic and anticlastic surface, excess of pressure, capilary rise of liquid.

Reference Books

1. A Handbook of Degree PHYSICS (Vol I), C. R. Dasgupta, Asok Kumar Das, Book Syndicate Private Limited
2. University Physics. FW Sears, MW Zemansky and HD Young13/e, 1986. Addison Wesley
3. Physics, Resnick, Halliday & Walker 9/e, 2010, Wiley.
4. Engineering Mechanics, Basudeb Bhattacharya, 2nd ed, 2015, Oxford University Press
5. Physics for Degree Students (For B.Sc. 1st Year); C.L. Arora & P.S. Hemme; S.Chand Publishing

1.1.2 Mechanics (Practical)

Paper: PHS-G-CC-1-1-P	**Credits: 2**

General Topics

1. Measurements of length (or diameter) using vernier caliper, screw gauge and traveling microscope.

2. Idea of systematic and random errors introduced in different instruments.

List of Practicals

1. Determination of Moment of inertia of cylinder/bar about axis by measuring the time period, of the cradle and with body of known moment of Inertia.

2. Determination of Y modulus of a metal bar of rectangular cross section by the method of exure.

3. Determination of rigidity modulus of wire by measuring the time period of torsional oscillation of a metal cylinder attached to it.

4. Determination of Moment of Inertia of a flywheel.

5. Determination gravitational acceleration, g using bar pendulum.

Reference Books

1. A handbook of Degree PRACTICAL PHYSICS (Vol 1), Dasgupta, Das, Paul, Book Syndicate Private Limited
2. Porikshagare Podarthovidya, Das, Das, Santra Publication
3. Practical Physics, P.R. Sasi Kumar, PHI Learning Private Limited
4. B.Sc. Practical Physics, Harnem Singh, P.S. Hemne, S Chand and Company Limited
5. B.Sc. Practical Physics, C.L. Arora, S Chand and Company Limited
6. Advanced Practical Physics, Vol 1, B. Ghosh, K.G.Majumdar, Shreedhar Publishers

General: Semester 2

CC2/GE2

<table>
<tr><td rowspan="3">CC 2/ GE 2</td><td>Electricity and Magnetism</td><td>Theory</td><td>Practical</td></tr>
<tr><td rowspan="2">Credit 6</td><td>Credit 4</td><td>Credit 2</td></tr>
<tr><td>Classes 60</td><td>Classes 60</td></tr>
</table>

2.1 Electricity and Magnetism

2.1.1 Electricity and Magnetism (Theory)

Paper: PHS-G-CC-2-2-TH	**Credits: 4**

1. Essential Vector Analysis **5 Lectures**

(a) Vector Algebra: Addition of vectors and multiplication by a scalar. Scalar and vector products of two vectors.

(b) Vector Analysis: Gradient, divergence and Curl. Vector integration, line, surface and volume integrals of vector fields. Gauss'divergence theorem and Stoke's theorem of vectors (Statement only) and their significances.

2. Electrostatics **25 Lectures**

(a) Coulombs law, principle of superposition, electrostatic field. Electric field and charge density, surface and volume chargev density, charge density on the surface of a conductor. Force per unit area on the surface.

(b) Electric dipole moment, electric potential and field due to an electric dipole, force and Torque on a dipole. Electric Fields inside matter, Electric Polarisation, bound charges, displacement density vector, linear Dielectric medium, electric Succeptibility and Permittivity.

(c) Divergence of the Electrostatic field, flux, Gauss's theorem of electrostatics, applications of Gauss theorem to find Electric field due to point charge, infinite line of charge, uniformly charged spherical shell and solid sphere, plane charged sheet, charged conductor. Gauss's theorem in dielectrics.

(d) Curl of the Electrostatic Field. Conservative nature of electrostatic field, Introduction to electriostatic potential, Calculation of potential for linear, surface and volume charge distributions, potential for a uniformly charged spherical shell and solid sphere. Calculation of electric field from potential. Energy per unit volume in electrostatic field.

3. Magnetism **15 Lectures**

(a) Introduction of magnetostatics through Biot-Savart's law. Application of Biot Savart's law to determine the magnetic field of a straight conductor, circular coil, solenoid carrying current. Force between two straight current carrying wires. Lorentz force law.

(b) Divergence of the magnetic field, Magnetic vector potential.

(c) Curl of the magnetic field. Ampere's circuital law. Determination of the magnetic field of a straight current carrying wire. Potential and field due to a magnetic dipole. Magnetic dipole moment. Force and torque on a magnetic dipole.

(d) Magnetic fields inside matter, magnetization, Bound currents. The magnetic intensity H. Linear media. Magnetic susceptibility and Permeability. Brief introduction of dia, para and ferro-magnetic materials.

4. Electromagnetic Induction **5 Lectures**

Faraday's laws of electromagnetic induction, Lenz's law, self and mutual inductance, L of single coil, M of two coils.

5. Electrodynamics **10 Lectures**

Maxwell's Equations, Equation of continuity of current, Displacement current, electromagnetic wave propagation through vacuum and isotropic dielectric medium, transverse nature of EM waves, Poynting vector, decay of charge in conducting medium.

Referrence Books

1. A Handbook of Degree PHYSICS (Vol II), C. R. Dasgupta, Asok Kumar Das, Book Syndicate Private Limited
2. Electricity and Magnetism, Edward M. Purcell, 1986, McGraw-Hill Education
3. Electricity and Magnetism, D C Tayal, 1988, Himalaya Publishing House
4. Electricity and Magnetism; R.Murugeshan; S. Chand Publishing

2.1.2 Electricity and Magnetism (Practical)

Paper: PHS-G-CC-2-2-P	**Credits: 2**

List of Practicals

1. Determination of unknown resistance by Carey Foster method.
2. Measurement of a current flowing through a register using potentiometer.
3. Determination of the horizontal components of earths magnetic field.
4. Conversion of an ammeter to a voltmeter.
5. Conversion of a voltmeter to an Ammeter.

Reference Books

1. A handbook of Degree PRACTICAL PHYSICS (Vol 2), Dasgupta, Das, Paul, Book Syndicate Private Limited
2. Practical Physics, P.R. Sasi Kumar, PHI Learning Private Limited
3. B.Sc. Practical Physics, Harnem Singh, P.S. Hemne, S Chand and Company Limited

4. B.Sc. Practical Physics, C.L. Arora, S Chand and Company Limited

5. Practical Physics, B. Ghosh, K.G.Majumdar, Shreedhar Publishers

General: Semester 3

CC3/GE3, SEC A

CC 3/ GE 3	Thermal Physics	Theory	Practical
	Credit 6	Credit 4	Credit 2
		Classes 60	Classes 60
SEC A 1	Scientific Writing	Theory	Project
	Credit 2	Credit 1	Credit 1
		Classes 15	Classes 15
SEC A 2	Renewable Energy	Theory	
	Credit 2	Credit 2	
		Classes 30	

3.1 Thermal Physics and Statistical Mechanics

3.1.1 Thermal Physics and Statistical Mechanics (Theory)

Paper: PHS-G-CC-3-3-TH	**Credits: 4**

1. Laws of Thermodynamics **18 Lectures**

(a) 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 Coeficients, Reversible and irreversible processes.

(b) Second law and Entropy, Carnot's cycle & Carnot's theorem, Entropy changes in reversible & irreversible processes, Entropy-temperature diagrams.

(c) Third law of thermodynamics, unattainability of absolute zero.

2. Thermodynamical Potentials **9 Lectures**

Enthalpy, Gibbs, Helmholtz and Internal Energy functions, Maxwell's relations and applications: Joule-Thompson Effect, Clausius- Clapeyron Equation, Expression for (C_P and C_V). TdS equations.

3. Kinetic Theory of Gases **10 Lectures**

Derivation of Maxwell's law of distribution of velocities and its experimental verication, 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.

4. Theory of Radiation **8 Lectures**

(a) 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.

5. Statistical Mechanics **15 Lectures**

Phase space, Macrostate and Microstate. Ensemble, Ergodic hypothesis. Entropy and Thermodynamic probability, Boltzmann hypothesis. Maxwell-Boltzmann law of distribution of velocity. Quantum statistics (qualitative discussion only). Fermi-Dirac distribution law (statement only), electron gas as an example of Fermi gas. Bose-Einstein distribution law (statement only), photon gas as an example of Bose gas. Comparison of three statistics.

Reference Books

1. A Handbook of Degree PHYSICS (Vol III), C. R. Dasgupta, Asok Kumar Das, Book Syndicate Private Limited
2. Thermal Physics, A. B. Gupta, H. P. Roy, Books and Allied (P) Ltd

3.1.2 Thermal Physics and Statistical Mechanics (Practical)

Paper: PHS-G-CC-3-3-P	**Credits: 2**

List of Practicals

1. Determination of the coefficient of thermal expansion of a metalic rod using an optical lever.

2. Verication of Stefan's law of radiation by the measurement of voltage and current of a torch bulb glowing it beyond draper point.

3. To determine Thermal coefficient of Resistance using Carey forster bridge.

4. To determine the Coefficient of Thermal Conductivity of a bad conductor by Lee and Charlton's disc method.

5. Determination of the pressure coefficient of air using Jolly's apparatus.

Reference Books

1. Practical Physics, P.R. Sasi Kumar, PHI Learning Private Limited
2. B.Sc. Practical Physics, Harnem Singh, P.S. Hemne, S Chand and Company Limited
3. B.Sc. Practical Physics, C.L. Arora, S Chand and Company Limited
4. Advanced Practical Physics, B. Ghosh, K.G.Majumdar, Shreedhar Publishers

SEC A-1 (Technical Skill)

3.2 Scientific Writing (Project type)

3.2.1 Scientific Writing (Theory)

Paper: PHS-A SEC-B-TH	**Credits: 1**

1. Introduction to LaTeX **2 Lectures**
The difference between WYSIWYG and WYSIWYM. Preparing a basic LaTeX file. Compiling LaTeX file.

2. Document classes : **1 Lectures**
Different type of document classes, e.g., article, report, book etc.

3. Page Layout **2 Lectures**
Titles, Abstract, Chapters, Sections, subsections, paragraph, verbatim, References, Equation references, citation.

4. List structures: **1 Lectures**
Itemize, enumerate, description etc.

5. Representation of mathematical equations **5 Lectures**
Inline math, Equations, Fractions, Matrices, trigonometric, logarithmic, exponential functions, line-surface-volume integrals with and without limits, closed line integral, surface integrals, Scaling of Parentheses, brackets etc.

6. Customization of fonts **1 Lectures**
Bold fonts, emphasise, mathbf, mathcal etc. Changing sizes Large, Larger, Huge, tiny etc.

7. Writing tables **2 Lectures**
Creating tables with different alignments, placement of horizontal, vertical lines.

8. Figures **1 Lectures**
Changing and placing the figures, alignments

Packages : amsmath, amssymb, graphics, graphicx, Geometry, algorithms, color, Hyperref etc. Use of Different LaTeX commands and environments, Changing the type style, symbols from other languages. special characters.

Note: Software required: LaTeX in Linux and MikTeX in Windows. Preferred editor Kile/emacs in Linux and TeXStudio in Windows.

Reference Book

1. LaTeX- A Document Preparation System, Leslie Lamport, 1994, Addison-Wesley
2. LaTeXTutorials A PRIMER, Indian TeXuser group, E. Krishnan
3. Practical LaTeX, George Gratzer, Springer
4. Official LaTeXsite : `https://www.latex-project.org/`

5. The Not So Short Introduction to LaTeX: `http://mirror.iopb.res.in/tex-archive/info/lshort/english/lshort.pd`
6. LaTeX Wikibook `https://en.wikibooks.org/wiki/LaTeX`
7. TeXLive `http://www.tug.org/texlive/`

3.2.2 Scientific Writing (Project)

Paper: PHS-A SEC-B-PR	**Credits: 1**

List of some sample Projects

1. Writing articles/ research papers/reports

2. Writing mathematical derivation

3. Writing Resume

4. Writing any documentation of a practical done in laboratory with results, tables, graphs.

5. Writing graphical analysis taking graphs from outside.

SEC A-2 (Knowledge Skill)

3.3 Renewable energy and Energy Harvesting (Theory)

Paper: PHS-A SEC-B-TH	**Credits: 2**

1. Fossil fuels and Alternate Sources of energy **5 Lectures**

Fossil fuels and nuclear energy, their limitation, need of renewable energy, non-conventional energy sources. An overview of developments in Ocean shore Wind Energy, Tidal Energy, Wave energy systems, Ocean Thermal Energy Conversion, solar energy, biomass, biochemical conversion, biogas generation, geothermal energy tidal energy, Hydroelectricity.

2. Solar energy **5 Lectures**

Solar energy, its importance, storage of solar energy, solar pond, non-convective solar pond, applications of solar pond and solar energy, solar water heater, flat plate collector, solar distillation, solar cooker, solar green houses, solar cell, absorption air conditioning. Need and characteristics of photovoltaic (PV) systems, PV models and equivalent circuits, role of maximum power point tracking for harvesting maximum energy and sun tracking systems.

3. Wind Energy harvesting **4 Lectures**

Fundamentals of Wind energy, Wind Turbines and different electrical machines in wind turbines, Power electronic interfaces, and grid interconnection topologies. (only idea of synchronisation, current injection, islanding etc with utility grid)

4. Ocean Energy **4 Lectures**

Ocean Energy Potential against Wind and Solar, Wave Characteristics and Statistics, Wave energy Devices. Tide characteristics and Statistics, Tide Energy Technologies, Ocean Thermal Energy, Osmotic Power, Ocean Bio-mass.

5. Geothermal Energy **2 Lectures**

Geothermal Resources, Geothermal Technologies.

6. Hydro Energy **2 Lectures**

Hydropower resources, hydropower technologies, environmental impact of hydro power sources.

7. Piezoelectric Energy harvesting **3 Lectures**

Introduction, Physics and characteristics of piezoelectric effect, materials and mathematical description of piezoelectricity, Piezoelectric parameters and modeling piezoelectric generators, Piezoelectric energy harvesting applications.

8. Electromagnetic Energy Harvesting **3 Lectures**

(a) Linear generators, physics mathematical models, recent applications
(b) Carbon captured technologies, cell, batteries, power consumption.
(c) Environmental issues and Renewable sources of energy, sustainability.

9. Fuel cell **2 Lectures**

Introduction, Design principle and operation of fuel cell, Types of fuel cells, conversion efficiency of fuel cell, application of fuel cells

Reference Books

1. Non-conventional energy sources, G.D Rai, Khanna Publishers, New Delhi
2. Solar energy - M P Agarwal - S Chand and Co. Ltd
3. Solar energy - Suhas P Sukhative Tata McGraw - Hill Publishing Company Ltd.
4. Renewable Energy, Power for a sustainable future, Godfrey Boyle, Oxford University Press, in association with The Open University
5. Solar Energy: Resource Assesment Handbook, Dr. P Jayakumar, 2009
6. Photovoltaics, J.Balfour, M.Shaw and S. Jarosek, Lawrence J Goodrich (USA)

General: Semester 4

CC4/GE4, SEC B

CC 4/ GE 4	Waves and Optics	Theory	Practical
	Credit 6	Credit 4	Credit 2
		Classes 60	Classes 60
SEC B 1	Arduino	Theory	Project
	Credit 2	Credit 1	Credit 1
		Classes 15	Classes 15
SEC B 2	Electrical Circuits &	Theory	
	Network Skill	Credit 2	
	Credit 2	Classes 30	

4.1 Waves and Optics

4.1.1 Waves and Optics (Theory)

Paper: PHS-G-CC-4-4-TH — **Credits: 4**

1. Accoustics — **10 Lectures**

(a) Review of SHM, damped & forced vibrations: amplitude and velocity resonance. Fourier's Theorem amd its application for some waveforms e.g., Saw tooth wave, triangular wave, square wave. Intensity and loudness of sound. Intensity levels, Decibels.

2. Superposition of vibrations — **5 Lectures**

(a) Superposition of Two Collinear Harmonic oscillations having equal frequencies and different frequencies (Beats).

(b) Superposition of Two Perpendicular Harmonic Oscillation for phase difference $\delta = 0, \frac{\pi}{2}, \pi$: Graphical and Analytical Methods, Lissajous Figures with equal and unequal frequency and their uses.

3. Vibrations in String — **8 Lectures**

(a) Wave equation in streched string and its solutions. Boundary conditions for plucked and struck strings. Expression of amplitude for both the cases (no derivation), Young's law, Ideal of harmonics. Musical scales and notes.

4. Introduction to wave Optics **2 Lectures**
Definition and Properties of wave front. Huygens Principle, Electromagnetic nature of light.

5. Interference **15 Lectures**
Superposition of two waves with phase difference, distribution of energy, formation of fringes, visibility of fringes.Division of amplitude and division of wavefront. Young's Double Slit experiment. Lloyd's Mirror and Fresnel's Biprism. Phase change on reflection: Stoke's treatment. Interference in Thin Films: parallel and wedge-shaped lms. Fringes of equal inclination (Haidinger Fringes); Fringes of equal thickness (Fizeau Fringes). Newton's Rings: measurement of wavelength and refractive index. Michelson's Interferometer (a) Idea of form of fringes (no theory needed), Determination of wavelength, Wavelength dierence, Refractive index.

6. Diffraction **10 Lectures**
(a) Fraunhofer diffraction Single slit; Double Slit. Multiple slits and Diffraction grating.
(b) Fresnel Diraction: Half-period zones. Zone plate.

7. Polarization **10 Lectures**
Transverse nature of light waves. Plane polarized light, production and analysis. Circular and elliptical polarization. Optical activity.

Reference Books

1. Advanced Acoustics, D. P. Roychowdhury, Chayan Publisher
2. Waves and Oscillations, N. K. Bajaj, Tata McGrow Hill
3. A textbook of Optics; N Subramanyam, B. Lal and M.N.Avadhanulu; S.Chand. Publishing
4. Optics, B. Ghosh, Sreedhar Publications

4.1.2 Waves and Optics (Practical)

Paper: PHS-G-CC-4-4-P	**Credits: 2**

List of Practicals

1. Determination of the focal length of a concave lens by auxiliary lens method.
2. Determination of the frequency of a tuning fork with the help of sonometer.
3. Determination of radius of curvature of plano convex lens/wavelength of a monochromatic or quasi monochromatic light using Newtons ring.
4. Measurement of thickness of a paper from a wedge shaped film.
5. Measurement of specific rotation of active solution (e.g., sugar solution) using polarimeter.

Reference Books

1. Practical Physics, P.R. Sasi Kumar, PHI Learning Private Limited
2. B.Sc. Practical Physics, Harnem Singh, P.S. Hemne, S Chand and Company Limited
3. B.Sc. Practical Physics, C.L. Arora, S Chand and Company Limited
4. Advanced Practical Physics, Vol 1 & 2, B. Ghosh, K.G.Majumdar, Shreedhar Publishers

SEC B -1 (Technical Skill)

4.2 Arduino (Project type)

4.2.1 Arduino

Paper PHS-A-SEC-B-TH	**Credit 1**

1. Introduction to Arduino **2 Lectures**
Brief history of the Arduino; open-source electronics prototyping.

2. Basic ideas **3 Lectures**
Basic ideas of Arduino, Familiarize the Arduino board, Setting up the arduino board. Installation of IDE in PC/ laptop for Arduino programming(Sketch)

3. Arduino Programming: **10 Lectures**
(a) Program structure:
data types, variables and constants, operators, control statements, loops, functions, string.
(b) Interfacing:
serial communication, digital and analog input/output, getting input from sensors(e.g. temperature sensor, ultrasonic sensor etc)

Books and references

1. Arduino Cookbook, Michael Margolis, O'Reilly Media (2011)
2. Getting Started with Arduino, Massimo Banzi, O'Reilly Media(2009)
3. Arduino as a tool for physics experiments, Giovanni Organtini 2018 J. Phys.: Conf. Ser. 1076 012026
4. `https://www.arduino.cc/en/Guide/HomePage`
5. Physics Today 66, 11, 8 (2013); `https://doi.org/10.1063/PT.3.2160`
6. The Physics Teacher 52, 157 (2014); `https://doi.org/10.1119/1.4865518`

4.2.2 Practical Projects

Paper PHS-A-SEC-B-PR	**Credit 1**

1. LED Blinking and fading.

2. Measurement of voltages (Below 5 V and above).

3. Interfacing 7 Segment display.

4. Construction of thermometer using LM35 or Others.

5. Construct the experimental set up for studying simple pendulum and hence determine the acceleration's due to gravity.

6. Construct data logger for studying charging and discharging of RC circuit.

NOTE: Software required: Arduino Integrated Development Environment, Hardware required: Arduino Uno

SEC B -2 (Knowledge Skill)

4.3 Electrical Circuits and Network skills (Theory)

PHS-A SEC-B -TH	Credit 2

1. DC generator : 10 Lectures

(a) EMF generated in the armature for simplex lap and wave winding, concept of pole, Methods of Excitation, Armature reaction, Dc motor : Torque equation of D.C motor, speed& torque Operating Characteristics of separately excited, Shunt, Series &Compound motors with emphasis on application areas.

(b) Three phase generator, concept of stator and rotor, star and delta connections – their current voltage relationships (both line and phase current & voltage).

2. Transformer : 5 Lectures

Types of transformer, basic emf equation, no load current, leakage inductance, Magnetising current and equivalent circuit of single phase transformer on no-load and on load, idea of star/star, star/delta, delta/star, and zig-zag connection of 3 phase transformer, 3 phase to 2 phase transformation, Scott T connection.

3. AC motor 6 Lectures

(a) Single phase AC motor – double field revolving theory, slip-speed characteristics,

(b) Construction of 3 phase induction motor and its action using rotating field theory, equivalent circuit of induction motor, Speed control by V/f control of induction motor (block diagram only).

4. Measurements and faults 9 Lectures

(a) Measurement of three phase power by two and three wattmeter method,theory of induction type wattmeterand its use as energy meter in domestic house. Megger.

(b) Unsymmetrical faults in distribution system, Common switchgear equipments like relay, circuit breakers and fuses, Simple oil circuit breaker and SF6 circuit breaker, Construction of protective relay in distribution bus-bar system, Block diagram of a utility distribution sub-station.

Reference Books

1. Text book on Electrical Technology (vol 1 & 2), Thereja and Thereja
2. Power System, V. K. Meheta
3. Electrical Machines, S. K. Bhattacharya

General: Semester 5

DSE A, SEC A (Same as Semester 3)

SEC A 1	Scientific Writing Credit 2	Theory	Project
		Credit 1	Credit 1
		Classes 15	Classes 15
SEC A 2	Renewable Energy Credit 2	Theory	
		Credit 2	
		Classes 30	
DSE A 1	Analog Electronics Credit 6	Theory	Practical
		Credit 4	Credit 2
		Classes 60	Classes 60
DSE A 2	Modern Physics Credit 6	Theory	Tutorial
		Credit 5	Credit 1
		Classes 75	Classes 15

DSE-A(1)

5.1 Analog Electronics

5.1.1 Analog Electronics(Theory)

Paper: PHS-G-DSE-A-TH	**Credits: 4**

1. Circuits and Network **6 Lectures**

Discrete components, Active & Passive components, 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.

2. Semiconductor Devices **20 Lectures**

(a) Semiconductor Diodes: P and N type semiconductors. Barrier Formation in PN Junction Diode. Qualitative Idea of Current Flow Mechanism in Forward and Reverse Biased Diode. PN junction and its characteristics. Static and Dynamic Resistance.

Principle and structure of

- Light Emitting Diode

- Photo Diode
- Solar Cell

(b) Application of Diode: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers, Ripple Factor and Rectification Eciency. Basic idea about capacitor filter. (b) Zener Diode and Voltage Regulation.

(c) Bipolar Junction transistors: n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Congurations. Active, Cut-off & Saturation regions. Current gains α and β. Relations between them. Load Line analysis of Transistors. DC Load line & Q- point. Voltage Divider Bias Circuit for CE Amplier. Class A, B & C Ampliers.

3. Regulated Power Supply **4 Lectures**

Difference between regulated and unregulated power supply. Load regulation and line regulation. Zener as voltage regulator. Principle of series regulated power supply, IC controlled regulated power supply.

4. Field Effect transistors **5 Lectures**

Construction, operation, characteristics,and parameters of junction FET. MOSFET (both depletion and enhancement type) as a part of MISFET. Basic structure & principle of operations and their characteristics. Pinch off, threshold voltage and short channel effect. Comparison of JFFET and MOSFET.

4. Feedback Amplifiers **5 Lecutures**

Necessity of negative feedback for stability. Voltage series, voltage shunt, current series and current shunt feedback. Change in input impedance, output impedence, voltage gain for a voltage series feedback in a voltage amplifer.

5. Operational Ampliers **15 Lectures**

(a) Characteristics of an Ideal and Practical Op-Amp (IC 741), Open loop and closed loop Gain. CMRR, concept of Virtual ground.

Applications of Op-Amps

- Inverting and non-inverting Ampliers
- Inverting Adder
- Subtractor
- Differentiator
- Integrator
- Zero crossing detector

6. Sinusoidal Oscillators: **5 Lectures**

Barkhausen's Criterion for Self-sustained Oscillations. Wien bridge oscillator.

Reference Books

1. Electronic Principle, Albert Malvino, 2008, Tata Mc-Graw Hill.
2. Electronics: Fundamentals and Applications, D. Chattopadhyay, P.C. Rakshit, New Age Publication

5.1.2 Analog Electronics (Practical)

Paper: PHS-G-DSE-A-P	Credits: 2

List of Practicals

1. Veryfication of Thevenin and Norton's theorem, super position theorem and maximum power transfer theorem for resistive network fed by D.C. power supply.

2. Study the emitter characteristics of a photo transistor illuminated by LED.

3. To study the characteristics of a Transistor in CE conguration.

4. Construction of a regulated power supply using LM 317 IC.

5. To study OPAMP: inverting amplifer, non inverting amplier, adder, substractor.

Reference Books

1. Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-Graw Hill.
2. Practical Physics, B. Ghosh, Sreedhar Publication

DSE A (2)

5.2 Modern Physics

5.2.1 Modern Physics (Theory)

Paper: PHS-G-DSE-A-TH	Credits: 5 (+1 for Tutorial)

1. Radiation and its nature **22 Lectures**

(a) Blackbody Radiation, Planck's quantum hypothesis, Planck's constant (derivation of Planck formula is not required). Photoelectric effect and Compton scattering - light as a collection of photons. Davisson-Germer experiment. De Broglie wavelength and matter waves. Wave-particle duality. Wave description of particles by wave packets. Group and Phase velocities and relation between them. Probability interpretation: Normalized wave functions as probability amplitudes.

(b) Two-slit experiment with photons and electrons. Linear superposition principle as a consequence.

(c) Position measurement, gamma ray microscope thought experiment. Heisenberg uncertainty principle (Statement with illustrations). Impossibility of a particle following a trajectory.

2. Foundation of Quantum Mechanics **28 Lectures**

(a) Schrödinger equation as a first principle. Probabilistic interpretation of wavefunction and equation of continuity (in 1D). Time evolution of wavefunction and $\exp(iHt/\hbar)$ as the evolution operator. Stationary states. Eigenvalue equation.

(b) Postulates of Quantum Mechanics: States as normalized wavefunctions. Dynamical variables as linear Hermitian operators (position, momentum, angular momentum, and energy as examples). Expectation values of operators and their time evolution. Ehrenfest theorem.

(c) Application to one dimensional systems, Boundary conditions on wave functions.

- Particle in an infinitely rigid box ($x = 0$ to $x = a$), energy states, wave function and its normalisation.
- Particle in front of a step potential, reflection coefficient.

3. Special Theory of Relativity **15 Classes**

(a) Michelson-Morley experiment. Lorentz transformation. Time dilation and length contraction. Velocity addition rule.

(b) Relativistic dynamics. Elastic collision between two particles. Idea of relativistic momentum and relativistic mass. Mass-energy equivalence.

4. Lasers **10 Lectures**

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 action.

Tutorial: In tutorial section, problems in the theory classes should be discussed. Problems and solutions regarding the theory course may be discussed.

Reference Books

1. Concepts of Modern Physics, Arthur Beiser, 2002, McGraw-Hill
2. Modern Physics; R.Murugeshan & K.Sivaprasath; S. Chand Publishing
3. Introduction to Special Relativity, R. Resnick, 2005, John Wiley and Sons
4. Theory and Problems of Modern Physics, Schaum's outline, R. Gautreau and W. Savin, 2nd Edn, Tata McGraw-Hill Publishing Co. Ltd
5. An Introduction to Lasers, M. N. Avadhanulu (Author), P. S. Hemne, S. Chand Publication

General: Semester 6

DSE B, SEC B (Same as Semester 4)

SEC B 1	Arduino	Theory	Project
	Credit 2	Credit 1	Credit 1
		Classes 15	Classes 15
SEC B 2	Electrical Circuits &	Theory	
	Network Skill	Credit 2	
	Credit 2	Classes 30	
DSE B 1	Digital Electronics	Theory	Practical
	Credit 6	Credit 4	Credit 2
		Classes 60	Classes 60
DSE B 2	Nuclear Physics	Theory	Tutorial
	Credit 6	Credit 5	Credit 1
		Classes 75	Classes 15

DSE B (1)

6.1 Digital Electronics

6.1.1 Digital Electronics (Theory)

Paper: PHS-G-DSE-B-TH	**Credits: 4**

1. Integrated Circuits **4 Lectures**

Principle of Design of monolithic Chip. Advantages and drawbacks of ICs. Scale of integration: SSI, MSI, LSI and VLSI (basic idea and definitions only w.r.t. micron/submicron feature length).

2. Number System **7 Lectures**

Binary Numbers. Decimal to Binary and Binary to Decimal Conversion. BCD, Octal and Hexadecimal numbers. Signed and unsigned number representation of binary system. Binary addition, Representation of negative number. 1's Complement and 2's Complement method of subtraction.

3. Digital Circuits **20 Lectures**

(a) Difference between Analog and Digital Circuits.

(b) AND, OR and NOT Gates (Realization using Diodes and Transistor). NAND and NOR Gates as Universal Gates. XOR and XNOR Gates. De Morgan's Theorems.

(c) Switching algebra, Simplication of logical expression using switching Algebra. Fundamental Products and sum term (p term and s term). Minterms and Maxterms. Conversion of a Truth Table into an algebraic expression in (1) Sum of Products form and (2) Product of sum term form. Implementation of a truth table by NAND or NOR gate. Simplification of algebraic expression from truth table using Karnaugh Map.

4. Data processing circuits **5 Lectures**

Basic idea of Multiplexers, De-multiplexers, Decoders, Encoders.

5. Sequential Circuits: **12 Lectures**

Introduction to Next state present state table, excitation table and truth table for Sequential circuits. SR, D, and JK Flip-Flops. Clocked (Level and Edge Triggered) Flip-Flops. Preset and Clear operations. Race condition in SR and Race-around conditions in JK Flip-Flop. M/S JK Flip-Flop, T type FF.

6. Registers and Counters **12 Lectures**

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

(b) Counters (4 bits): Asynchronous counters: ripple counter, Decade Counter. Synchronous Counter, Ring counter.

Reference Books

1. Digital Principles and Applications, A.P. Malvino, D.P. Leach and Saha, 7th Ed., 2011, Tata McGraw Hill
2. Electronic devices & circuits, S. Salivahanan & N.S. Kumar, 2012, Tata Mc-Graw Hill
3. Electronics: Fundamentals and Applications, D. Chattopadhyay, P.C. Rakshit, New Age Publication

6.1.2 Digital electronics (Practical)

Paper: PHS-G-DSE-B-P	**Credits: 2**

1. To verify and design AND, OR, NOT and XOR gates using NAND gates.

2. Construction of half adder, and full adder using NAND/NOR gate.

3. Construction of SR, D FF circuits using NAND gates.

4. Construction of 4 bit shift registers (serial & parallel) using D type FF IC 7476.

5. Construction of 4 × 1 Multiplexer using IC 74151.

Reference Books

1. Advance Practical Physics (Vol 2), B. Ghosh, Sreedhar Publication
2. Electronic devices & circuits, S. Salivahanan & N.S. Kumar, 2012, Tata Mc-Graw Hill

DSE B (2)

6.2 Nuclear & Particle Physics

6.2.1 Nuclear & Particle Physics (Theory)

Paper: PHS-G-DSE-B-TH Credits:	**5 (+1 for Tutorial)**

1 General Properties of Nuclei **10 Lectures**

(a) 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.

2. Nuclear Models **10 Lectures**

(a) Liquid drop model approach, semi empirical mass formula and significance of its various terms, condition of nuclear stability, two nucleon separation energies.

(b) Evidence for nuclear shell structure - nuclear magic numbers. Basic assumptions of shell model, concept of nuclear force.

3. Radioactivity **12 Lectures**

(a) α decay: basics of α decay processes. Theory of α emission, Geiger Nuttall law, α decay spectroscopy.

(b) β decay: energy and kinematics of β decay, positron emission, electron capture, neutrino hypothesis.

(c) γ decay: Gamma ray emission & kinematics, internal conversion.

4. Nuclear Reactions **7 Lectures**

Types of Reactions, Conservation Laws, kinematics of reactions, Q value, reaction rate, reaction cross section, Concept of compound and direct Reaction, resonance reaction.

5. Detector for Nuclear Radiations **15 Lectures**

Gas detectors: estimation of electric eld, 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.

6. Particle Accelerators **15 Lectures**

Accelerator facility available in India, Different type of accelerators

- Van-de Graaf generator (Tandem accelerator)
- Linear accelerator
- Cyclotron
- Betatron
- Synchrotrons

8. Particle Physics **6 Lecuters**

Fundamental particles and their families. Fundamental particle interactions and their basic features. Symmetries and Conservation Laws, Baryon number, Lepton number, Isospin, Strangeness and Charm. Quark model, Quark structure of hadrons.

Tutorial: In tutorial section, problems in the theory classes should be discussed. Problems and solutions regarding the theory course may be discussed.

Reference Books

1. Nuclear Physics, D. C. Tayal, Himalayan Publisher
2. Atomic and Nuclear Physics, Subramanyam, Brij Lal, Seshan, S. Chand Publications

3. Physics of the Nucleus, Books and Allied Private Limited
4. Introduction to Nuclear and Particle Physics, Mittal, Verma, Gupta, Prentice Hall India Learning Private Limited

Question patterns in different examinations for General Course in Physics

The number allotted for each course is 100. The marks distributions are given previously. The duration of examinations and details of marks distribution are given in the following table.

Examination		Conducted by	Center	Total Marks	Marks Division: Question	Marks Division: Marks	Total Question to be allotted	Time allotted
Internal Assessment		College	Home	10 Marks	10×2=20 (scaled down to 10)		15 Question	1 Hours
CC/GE-Theory		University	Away	50 marks	$5 \times 2 = 10$		7 Questions	2 Hours
					$4 \times 10 = 40$		6 Questions	
CC/GE-Practical		College	Home	30 marks	LWB	5		3 Hours
					Viva	5		
					Experiment	20		
DSE -Theory		University	Away	50 marks	$5 \times 2 = 10$		7 Questions	2 Hours
					$4 \times 10 = 40$		6 Questions	
DSE-Practical		College	Home	30 marks	LWB	5		3 Hours
					Viva	5		
					Experiment	20		
DSE-Theory		University	Away	65 marks	$5 \times 2 = 10$		7 Questions	3 Hours
					$3 \times 5 = 15$		5 Questions	
					$4 \times 10 = 40$		6 Questions	
DSE-Tutorial		College	Home	15 marks	****			
SEC (Theory)		University	Away	80 marks	$10 \times 2 = 20$		12 Questions	3 Hours
					$4 \times 5 = 20$		6 Questions	
					$4 \times 10 = 40$		6 Questions	
SEC (Project type)	Th	University	Away	20 marks	$10 \times 2 = 20$		12 MCQ type	30 minute
	Proj	College	Home	60 marks				

**** Students must be given at least one assignment or set of small problems. On the basis of regularity of submission and evaluation of assignment by the respective Teacher credits should be awarded to the students.