# CHRIST COLLEGE (AUTONOMOUS), IRINJALAKUDA

# DEGREE OF M. Sc. Physics

## MASTER OF SCENCE IN PHYSICS

(CHOICE BASED CREDIT AND SEMESTER SYSTEM FOR UNDERGRADUATE CURRICULUM)

UNDER THE FACULTY OF SCIENCE

## SYLLABUS

**(FOR THE STUDENTS ADMITTED FROM THE ACADEMIC YEAR 2019 – '20 ONWARDS)**

BOARD OF STUDIES IN PHYSICS (PG)

***CHRIST COLLEGE (AUTONOMOUS), IRINJALAKUDA - 680125, KERALA, INDIA***

**JUNE, 2019**

## M.SC. (PHYSICS) PROGRAMME COURSE STRUCTURE

The duration of the M.Sc. (Physics) programme shall be 2 years, split into 4 semesters. Each course in a semester has 4 credits (4C) with Practicals having 3 credits (3C). The total credits for the entire programme (Core &Elective) is 80. The credits for audit courses is 8. The scheme and syllabus of the programme, consisting of sections *(a) Programme structure (b) Courses and credit distribution summary (c) Courses in various semesters (d) Constitution of clusters (e) The credits and hours (f) Evaluation and Grading (g) Internal evaluation/continuous assessment (h) Pattern of question papers*

### a) PROGRAMME STRUCTURE

1. The programme shall include three types of courses: **Core courses**, **Elective courses and Audit Courses**.
2. Comprehensive Viva-voce and Project Work / Dissertation shall be treated as Core Courses and these shall be done in the final semester.
3. Total credit for the programme shall be 80 (eighty), this describes the weightage of the course concerned and the pattern of distribution is as detailed below:
   i. Total Credit for Core Courses (both theory &practical's) shall be 60 (sixty).
   ii. Total Credit for Elective Course shall be 12 (twelve).
   iii. Total Credits for Comprehensive Viva-voce and Project Work combined together shall be 8 (eight) subject to a minimum of 4 (four) credit for Project Work
4. **Audit Courses:** In addition to the above courses there will be two Audit Courses ***(Ability Enhancement Course & Professional Competency Course)*** with **4** credits each. These have to be done one each in the first two semesters. The credits will not be counted for evaluating the overall SGPA & CGPA. Students have to obtain only minimum pass requirements in the Audit Courses. The details of Audit courses are given below.

| Semester | Course Title | Suggested Area | Details |
|---|---|---|---|
| I | Ability Enhancement Course (AEC) | Internship / Seminar presentation / Publications / Industrial or Practical Training /Community linkage programme / Book reviews etc. | Seminar: Each student has to present a seminar on a selected topic in physics. A report has to be prepared and submitted before presenting the seminar. The abstract of the seminar has to be sent to the head of the department through the teacher in charge.<br>Or<br>It can be a course related to any topic from the suggested areas. |

| | | | |
|---|---|---|---|
| II | Professional Competency Course (PCC) | To test the skill level of students like testing the application level of different softwares such as Latex/Data visualization/ Python/Any software relevant to the programme of study /Translations etc. | The students in their second semester will be trained on the use of Latex scientific document preparation system. (The syllabus will be part of the second semester). The latex codes for preparing the following items will be developed.<br>1. A question paper<br>2. A review paper on a topic related to the seminar given in the first semester<br>3. A power point presentation<br><br>Evaluation of this will be based on a multiple choice written examination and an internal practical exam.<br><br>or<br>It can be a course related to any topic from the suggested areas. |

**b) COURSES AND CREDIT DISTRIBUTION SUMMARY**

<table>
<tr><th>Semester</th><th>Courses</th><th>Teaching Hours</th><th>Credit</th><th>Total Credit</th></tr>
<tr><td>I</td><td>Core Courses (Theory/Practical)</td><td rowspan="4">Teaching hours can be fixed by the concerned BoS for various courses and shall not exceed 25 hours per week<br>@ 5 hours per day.</td><td rowspan="4">For Core course total credit can vary from 60 to 68. For Elective Course total credit can vary from 12 to 20 Minimum Credit for one course shall not be less than 2 (two) and shall not exceed 5 (five).<br><br>The maximum credit for comprehensive Viva-voce and Project Work combined together shall be 8 (eight) subject to a minimum credit of 4 (four) for Project Work.</td><td rowspan="4">Vary from 18 to 22 in each Semester (For M.sc Physics programme, since conducting practical examination in each semester is not viable, practical exams will be conducted in even semesters. Hence the total credits for the various semesters are as given under:<br>Sem I:16<br>Sem II:22<br>Sem III:16<br>Sem IV:26</td></tr>
<tr><td>II</td><td>Core Courses (Theory/Practical)</td></tr>
<tr><td>III</td><td>(I) Core Courses Theory/Practical)<br>(ii) Elective</td></tr>
<tr><td>IV</td><td>(i) Core Courses (Theory /Practical) Including:<br>(a) Comprehensive Viva-voce (Optional) Project Work/ Dissertation<br>(ii) Elective Courses (Theory/Practical)</td></tr>
<tr><td colspan="4" align="right">Total credit shall be</td><td>80</td></tr>
</table>

<table>
<tr><td>I</td><td>Audit Course I:<br>Ability Enhancement Course (AEC)</td><td rowspan="2">Not coming in the normal work load</td><td>4 (Not added for SGPA / CGPA)</td><td>4</td></tr>
<tr><td>II</td><td>Audit Course II:<br>Professional Competency Course (PCC)</td><td>4 (Not added for SGPA / CGPA)</td><td>4</td></tr>
</table>

**c) COURSES IN VARIOUS SEMESTERS**

**Semester – I (16C)**

(PHY1C01) Classical Mechanics (4C)
(PHY1C02) Mathematical Physics – I (4C)
(PHY1C03) Electrodynamics and Plasma Physics (4C)
(PHY1C04) Electronics (4C)
(PHY1L01) General Physics Practical -I *
(PHY1L02) Electronics Practical – I**
(PHY1A01 Ability Enhancement Course (4C)

**Semester – II (22C)**

(PHY2C05) Quantum Mechanics –I (4C)
(PHY2C06) Mathematical Physics – II (4C)
(PHY2C07) Statistical Mechanics (4C)
(PHY2C08) Computational Physics (4C)
(PHY2L03) General Physics Practical - II (3C)*

(PHY2L04) Electronics Practical – II (3C)**
(PHY2A02 Professional Competency Course (4C)

**External Practical Exam for PHY1L01&PHY2L03 together will be conducted at the end of 2nd semester*

*** External Practical Exam for PHY1L02&PHY2L04 together will be conducted at the end of 2nd semester.*

**Semester -III (16C)**

(PHY3C09) Quantum Mechanics -II (4C)
(PHY3C10) Nuclear and Particle Physics (4C)
(PHY3C11) Solid State Physics (4C)
Elective -I (4C)
Project#
(PHY3L05) Modern Physics Practical –I##

**Semester -IV (26C)**

(PHY4C12) Atomic and Molecular Spectroscopy (4C)
Elective -II (4C)
Elective -III (4C)
(PHY4P01) Project (4C)#
(PHY4L06) Modern Physics Practical –II (3C)##
(PHY4L07) Computational Physics Practical (3C)
Viva Voce (Comprehensive) (4C)

*#Project will be started at 3rd semester and external evaluation for PHY4P01 will be conducted at the end of 4th semester.*

*##External Practical Exam for PHY3L05 & PHY4L06 together will be conducted at the end of 4th semester*

**d) CONSTITUTION OF CLUSTERS**

**Elective -I Cluster**

(PHY3E01) Plasma Physics
(PHY3E02) Advanced Quantum Mechanics
(PHY3E03) Radiation Physics
(PHY3E04) Digital Signal Processing
(PHY3E05) Experimental Techniques
(PHY3E06) Elementary Astrophysics

**Elective -II Cluster**

(PHY4E07) Advanced Nuclear Physics
(PHY4E08) Advanced Astrophysics
(PHY4E09) Astrophysics and Astronomical Data Analysis (PHY4E10)
Advanced Statistical Mechanics
(PHY4E11) Materials Science
(PHY4E12) Electronic Instrumentation
(PHY4E13) Laser Systems, Optical Fibres and Applications
(PHY4E14) Communication Electronics

**Elective -III Cluster**

(PHY4E15) Quantum Field Theory
(PHY4E16) Chaos and Nonlinear Physics
(PHY4E17) Advanced Condensed Matter Physics
(PHY4E18) Modern Optics
(PHY4E19) Physics of Semiconductors
(PHY4E20) Microprocessors, Microcontrollers and Applications

**e) THE CREDITS AND HOURS PER WEEK**

**The credits and hours proposed for various courses in different semesters are as given under.**

| Semester | No. of Theory Papers | Practicals | Theory | | Practical | | Project | | Seminar/ Tutorial | Viva Credit | Total Hours | Total Credit |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Hrs | Cred | Hrs | Cred | Hrs | Cred | Hrs | | | |
| I | 4 | 1. Gen. Phys I<br>2. Electronics I | 16 | 16 | 8 | 0 | 0 | 0 | 1 | 0 | 25 | 16 |
| II | 4 | 1. Gen. Phys II<br>2. Electronics II | 16 | 16 | 8 | 6 | 0 | 0 | 1 | 0 | 25 | 22 |
| III | 4 | 1. Mod. Phys I | 16 | 16 | 4 | 0 | 4 | 0 | 1 | 0 | 25 | 16 |
| IV | 3 | 1. Mod Phys II<br>2. Comp. Phys | 12 | 12 | 8 | 6 | 4 | 4 | 1 | 4 | 25 | 26 |
| **Total Credits for the Programme** | | | | | | | | | | | | **80** |

**f) EVALUATION AND GRADING**

1. **Evaluation**: The evaluation scheme for each course shall contain two parts; (a) Internal / Continuous Assessment (CA) and (b) External / End Semester Evaluation (ESE). Of the total, 20% weightage shall be given to internal evaluation / Continuous assessment and the remaining 80% to External/ESE and the ratio and weightage between Internal and External is **1:4.**

i. Accumulated minimum credit required for successful completion of the course shall be 80.

ii. A project work of 4 credits is compulsory and it should be done in III & IV semesters. Also, a comprehensive Viva Voce may be conducted by external examiners at the end of IV Semester and carries 4 credits.

iii. Evaluation and Grading: The evaluation scheme for each course shall contain two parts;

**(a)** Internal / Continuous Assessment (CA) and (b) External / End Semester Evaluation (ESE). Of the total, 20% weightage shall be given to Internal evaluation / Continuous assessment and the remaining 80% to External/ESE and the ratio and weightage between internal & external in **1:4**

iv. Primary evaluation for Internal and External shall be based on 6 letter grades **(A+, A, B, C, D and E) with** numerical values (Grade Points) of **5, 4, 3, 2, 1 & 0** respectively.

| Grade | Grade Points |
|---|---|
| A+ | 5 |
| A | 4 |

| | |
|---|---|
| B | 3 |
| C | 2 |
| D | 1 |
| E | 0 |

2. **Grade Point Average:** Internal and External components are separately graded and the combined grade point with weightage **1** for Internal and **4** for external shall be applied to calculate the **Grade Point Average (GPA)** of each course. Letter grade shall be assigned to each course based on the categorization based on **Ten point Scale** shown below

**The Grade Range for both Internal & External shall be:**

| Letter Grade | Grade Range | Range of Percentage (%) | Merit /Indicator |
|---|---|---|---|
| O | 4.25 – 5.00 | 85.00 – 100.00 | Outstanding |
| A+ | 3.75 – 4.24 | 75.00 – 84.99 | Excellent |
| A | 3.25 – 3.74 | 65.00 – 74.99 | Very Good |
| B+ | 2.75 – 3.24 | 55.00 – 64.99 | Good |
| B | 2.50 – 2.74 | 50.00 – 54.99 | Above Average |
| C | 2.25 – 2.49 | 45.00 – 49.99 | Average |
| P | 2.00 -2.24 | 40.00 – 44.99 | Pass |
| F | < 2.00 | Below 40 | Fail |
| I | 0 | - | Incomplete |
| Ab | 0 | - | Absent |

No separate minimum is required for internal evaluation for a pass, but a minimum **P** Grade is required for a pass in the external evaluation. However, a minimum **P grade** is required for pass in a course. A student who fails to secure a minimum grade for a pass in a course will be permitted to write the examination along with the next batch.

3. **Semester Grade Point Average (SGPA)**

The **SGPA** is the ratio of sum of the product of the number of credits with the grade points scored by a student in all the courses taken by a student and the sum of the number of credits of all the courses taken by a student. After the successful completion of a semester, **S**emester **G**rade **P**oint **A**verage **(SGPA)** of a student in that semester is calculated using the formula given below.

**Semester Grade Point Average - SGPA ($S_j$) = $\Sigma$ ($C_i$ x $G_i$) / Cr** (SGPA= Total Credit Points awarded in a semester / Total credits of the semester)

where **'$S_j$'** is the **$j^{th}$** semester , '**$G_i$**' is the grade point scored by the student in the **$i^{th}$** course '**$c_i$**' is the credit of the **$i^{th}$**course,'**Cr**' is the total credits of the semester .

4. **Cumulative Grade Point Average (CGPA)**

**Cumulative Grade Point Average (CGPA) = $\Sigma$($C_i$ x $S_i$) / Cr**(CGPA= Total Credit points awarded in all semesters/Total credits of the programme) where C1 is the credit of the Ist semester **S1** is the **SGPA** of the **Ist** semester and **Cr** is the total number of credits in the programme. The **CGPA** is also calculated in the same manner taking into account all the courses undergone by a student over all the semesters of a programme. The **SGPA** and **CGPA** shall be rounded off to 2 decimal points.

For the successful completion of a semester, a student should pass all courses and score a minimum **SGPA** of 2.0. However, the students are permitted to move to the next semester irrespective of their **SGPA.**

**5. Evaluation of Audit Courses**

The examination and evaluation shall be conducted by the college itself either in the normal structure or MCQ model from the Question Bank and other guidelines. The Question paper shall be for minimum 20 weightage and a minimum of 2 hour duration for the examination. The result has to be intimated / uploaded to the Controller of Examinations during the Third Semester as per the notification.

**g) INTERNAL EVALUATION / CONTINUOUS ASSESSMENT (CA)**

This assessment shall be based on a predetermined transparent system involving periodic written tests, assignments, seminars and viva-voce in respect of theory courses and based on tests, lab skill and records/viva in respect of practical courses. The criteria and percentage of weightage assigned to various components for internal evaluation are as follows

| **Theory** | | | |
|---|---|---|---|
| **Sl. No** | **Component** | **Percentage** | **Weightage** |
| 1 | Examination /Test | 40% | 2 |
| 2 | Seminars / Presentation | 20% | 1 |
| 3 | Assignment | 20% | 1 |
| 4 | Attendance | 20% | 1 |
| **Practical** | | | |
| 1 | Lab Skill | 40% | 4 |
| 2 | Records/viva | 30% | 3 |
| 3 | Practical Test | 30% | 3 |

Grades given for the internal evaluation are based on the grades A+, A, B, C, D & E with grade points 5,4,3,2, 1 & 0 respectively. The overall grades shall be as per the Ten Point scale. There shall be no separate minimum Grade Point for internal evaluation.

**Project**

**Internal evaluation:**

a) Monthly progress - wt =2

b) Regularity and attendance -wt =1

c) Seminar and Viva Voce- wt =1

**h) PATTERN OF QUESTION PAPERS**

**a) Theory**: Every semester

Directions for question paper setters:

Part A: Set each question to be answered in 7.5 minutes duration and should extract the critical knowledge acquired by the candidate in the subject.

Part B: 30 minutes answerable questions each may be asked as a single question or parts. Derivation type questions can be also asked.

Part C: 20 minutes answerable questions each and as far as possible avoid numerical type questions.

| *Division* | *Type* | *No.of Questions* | *Weightage* | *Total Weightage* |
|---|---|---|---|---|
| Part A | Short Answer | 8(No Choice) | 1 | 8 |
| Part B | Essay | 2 out of 4 | 5 | 10 |
| Part C | Problems | 4 out of 7 | 3 | 12 |
| Total weightage for a question paper | | | | 30 |

Theory papers must contain at least 4 lectures plus 1 Tutorial. Project is equivalent to one theory paper (4 hours) and one practical (4 hours)

Answer to each question may be evaluated based on

(a) Idea/knowledge – wt =1

(b) Logic/steps – wt =1

(c) Analytic skill – wt =1

(d) Correctness – wt =1

b) **Practical exam**: At the end of II and IV semesters and each will be of 6 hours duration.

c) **Project evaluation**: At the end of IV semester. Its evaluation is based on:

**External evaluation:**

a) Presentation-wt= 4

b) Project Report (Novelty, Creativity & work)-wt = 8

c) Project viva-wt = 4

d) **Comprehensive Viva-Voce** at the end of IV semester.

# SEMESTER I

# PHY1C01 – CLASSICAL MECHANICS

*Number of Contact Hours: 72 hrs*

*Number of Credits: 4*

## Course Outline

**1. Lagrangian and Hamiltonian Formulation**

Constraints and Generalized coordinates, Dd'Alembert's principle and Lagrange's equation, Velocity dependent potentials, Simple applications, Hamilton's Principle, Lagrange's equation from Hamilton's principle, Kepler problem, Scattering in a central force field, Transformation to lab coordinates, Legendre Transformation, Hamilton's canonical equations, Principle of least action, Canonical transformations, examples (17 hours)

Text: Goldstein, Sections 1.3 – 1.6, 2.1 – 2.3, 3.10, 3.11, 8.1, 8.5, 8.6, 9.1, 9.2

**2. The classical background of quantum mechanics**

Equations of canonical transformations, Examples, Poisson brackets and other canonical invariants, Equation of motion in Poisson bracket form, Angular momentum Poisson brackets, Hamilton-Jacobi equation, Hamilton's principal and characteristic function, H-J equation for the linear harmonic oscillator, Separation of variables, Action-angle variables, H-J formulation of the Kepler problem, H-J equation and the Schrödinger equation. (19 hours)

Text: Goldstein, Sections 9.1, 9.2, 9.4 - 9.6, 10.1 – 10.5, 10.7, 10.8

**3. The Kinematics and Dynamics of Rigid Bodies**

Space-fixed and body-fixed systems of coordinates, Description of rigid body motion in terms of direction cosines and Euler angles, Infinitesimal rotation, Rate of change of a vector, Centrifugal and Coriolis forces, Moment of inertia tensor, Euler's equation of motion, Force free motion of a rigid bodies. (14 hours)

Text: Goldstein, Sections 4.1, 4.4, 4.8 – 4.10

**4. Small Oscillations**

Formulation of the problem, Eigen value equation, Eigenvectors and Eigenvalues, Orthogonality, Principal axis transformation, Frequencies of free vibrations, Normal coordinates, Free vibrations of a linear tri atomic molecule. (9 hours)

Text: Goldstein, Sections 6.1 – 6.4

**5. Nonlinear Equations and Chaos**

Introduction, Singular points of trajectories, Nonlinear oscillations, Limit cycles, Chaos: Logistic map, Definitions, Fixed points, Period doubling, Universality. (13 hours)

Text: Bhatia, Sections10.1, 10.2, 10.3, 10.4, 10.5, 10.51

## *References*

1. Goldstein "Classical Mechanics" (Addison Wesley)
2. V.B.Bhatia : "Classical Mechanics" (Narosa Publications, 1997)

## *Reference books*

1. Michael Tabor: "Chaos and Integrability in Nonlinear Dynamics" (Wiley, 1989)
2. N.C. Rana and P.S. Joag: "Classical Mechanics" (Tata McGraw Hill)

3. R.G. Takwale and P.S. Puranik: “Introduction to Classical Mechanics” (Tata McGraw Hill)
4. Atam P. Arya: "Introduction to Classical Mechanics, (2nd Edition)" (Addison Wesley1998)
5. Laxmana: “Nonlinear Dynamics” (Springer Verlag, 2001)

***For further reference***:

Classical Physics Video Prof. V. Balakrishnan IIT Madras
http://nptel.iitm.ac.in/video.php?subjectId=122106027
Special Topics in Classical Mechanics Video Prof. P.C. Deshmukh IIT Madras
http://nptel.iitm.ac.in/courses/115106068/
Physics I - Oscillations & Waves Video Prof. S. Bharadwaj IIT Kharagpur
http://nptel.iitm.ac.in/video.php?subjectId=122105023
Chaos, Fractals & Dynamic Systems Video Prof. S. Banerjee IIT Kharagpur
http://nptel.iitm.ac.in/video.php?subjectId=108105054

## PHY1C02 – MATHEMATICAL PHYSICS - I

*Number of Contact Hours: 72 hrs*

*Number of Credits: 4*

### Course Outline

**1. Vectors**

Rotation of coordinates, Orthogonal curvilinear coordinates, Gradient, Divergence and Curl in orthogonal curvilinear coordinates, Rectangular, cylindrical and spherical polar coordinates, Laplacian operator, Laplace’s equation – application to electrostatic field and wave equations, Vector integration, Enough exercises. (11 hours)
Text: Arfken & Weber, Sections 1.2, 1.6 - 1.9, 1.10, 2.1 – 2.5

**2. Matrices and Tensors**

Basic properties of matrices (Review only), Orthogonal matrices, Hermitian and Unitary matrices, Similarity and unitary transformations, Diagonalization of matrices, Definition of Tensors, Contraction, Direct products, quotient rule, Pseudo tensors, Dual tensors, Levi Cevita symbol, irreducible tensors, Enough exercises. (11 hours)
Text: Arfken & Weber, Sections 3.2 - 3.5, 2.6 – 2.9

**3. Second Order Differential Equations**

Partial differential equations of Physics, Separation of variables, Singular points, Ordinary series solution, Frobenius method, A second solution, Self adjoint differential equation, eigen functions and values, Boundary conditions, Hermitian operators and their properties, Schmidt orthogonalization, Completeness of functions, Enough exercises. (14 hours) Text: Arfken & Weber, Sections 8.1, 8.3 – 8.6, 9.1 – 9.4

4. **Special functions**

Gamma function, Beta function, Delta function, Dirac delta function, Bessel functions of the first and second kinds, Generating function, Recurrence relation, Orthogonality, Neumann function, Spherical Bessel function, Legendre polynomials, Generating function, Recurrence relation, Rodrigues‟ formula, Orthogonality, Associated Legendre polynomials, Spherical harmonics, Hermite polynomials, Laguerre polynomials, Enough exercises. (24 hours) Text: Arfken & Weber, Sections 10.1, 10.4, 1.15, 11.1 – 11.3, 11.7, 12.1 – 12.4, 12.6, 13.1, 13.2

5. **Fourier Series**

General properties, Advantages, Uses of Fourier series, Properties of Fourier series, Fourier integral, Fourier transform, Properties, Inverse transform, Transform of the derivative, Convolution theorem, Laplace transform, Enough exercises. (12 hours) Text: Arfken & Weber, Sections 14.1 – 14.4, 15.2 – 15.5, 15.8

## *References*


1. G.B. Arfken and H. J. Weber: "Mathematical Methods for Physicists (5th Edition, 2001)" (Academic Press)


## *Reference books*


1. J. Mathews and R. Walker: "Mathematical Methods for Physics" (Benjamin)
2. L.I. Pipes and L.R. Harvill: "Applied Mathematics for Engineers and Physicists (3rd Edition)" (McGraw Hill)
3. Erwin Kreyzig: "Advanced Engineering Mathematics - 8th edition" (Wiley)
4. M. Greenberg: "Advanced Engineering Mathematics – 2nd edition " (Pearson India 2002)
5. A.W. Joshi: Matrices and tensors
6. Mathematical methods in the physical sciences, 2nd Edn, Mary L Boas, John Wiley & Sons
7. Elementary Differential Equations and boundary value problems, William E. Boyce, Richard C. DiPrima, John Wiley & Sons, Inc.
8. Mathematics of Classical and Quantum Physics, F. W. Byron and R. W. Fuller, Dover Publications, Inc., New York


***For further reference***

Mathematics I Video Prof. Swagato K. Ray,Prof. Shobha Madan,Dr. P. Shunmugaraj
http://nptel.iitm.ac.in/video.php?subjectId=122104017

Mathematics II Video Prof. Sunita Gakkhar, Prof. H.G. Sharma, Dr. Tanuja Srivastava IIT Roorkee
http://nptel.iitm.ac.in/video.php?subjectId=122107036

Mathematics III Video Prof. P.N. Agrawal, Dr. Tanuja Srivastava IIT Roorkee

http://nptel.iitm.ac.in/video.php?subjectId=122107037

## PHY1C03 – ELECTRODYNAMICS AND PLASMA PHYSICS

*Number of Contact Hours: 72 hrs*

*Number of Credits: 4*

### Course Outline

**1. Time varying fields and Maxwell's equations**

Maxwell's equations, Potential functions, Electromagnetic boundary conditions, Wave equations and their solutions, Time harmonic fields, Multipole expansion of electric scalar potential and magnetic vector potential, Enough exercises. (14 hours) Text: Cheng, Sections 7.3 – 7.7, Griffiths, Sections 3.4, 5.4.2

**2. Plane electromagnetic waves**

Plane waves in lossless media, Plane waves in lossy media, Group velocity, Flow of electromagnetic power and the Poynting vector, Normal incidence at a plane conducting boundary, Oblique incidence at a plane conducting boundary, Normal incidence at a plane dielectric boundary, Oblique incidence at a plane dielectric boundary, Enough exercises. (13 hours) Text: Cheng, Sections 8.2 – 8.10

**3. Transmission lines, Wave guides and cavity resonators**

Transverse electromagnetic waves along a parallel plane transmission line, General transmission line equations, Wave characteristics on finite transmission lines, General wave behaviour along uniform guiding structures, Rectangular wave guides, Cavity resonators (Qualitative ideas only), Enough exercises. (14 hours) Text: Cheng, Sections 9.2 - 9.4, 10.2, 10.4, 10-7.1

**4. Relativistic electrodynamics**

Magnetism as a relativistic phenomenon, Transformation of the field, Electric field of a point charge moving uniformly, Electromagnetic field tensor, Electrodynamics in tensor notation, Potential formulation of relativistic electrodynamics, Enough exercises. (15 hours) Text: Griffiths, Sections 10.3.1 – 10.3.5

**5. Plasma Physics**

Plasma - Definition, concepts of plasma parameter, Debye shielding, Motion of charged particles in an electromagnetic field - Uniform electric and magnetic fields, Boltzmann and Vlasov equations, their moments - Fluid equations, Plasma oscillations, Enough exercises. (16 hours) Text: Chen, Sections 1.1 - 1.6, 2.2 - 2.2.2, 3.1 - 3.3.2, 4.3, 4.18, 4.19, 7.2-7.3

### *References*


1. David K. Cheng: "Field and Wave Electromagnetics (Addisson Wesley)
2. David Griffiths: "Introductory Electrodynamics" (Prentice Hall of India, 1989)

3. F. F. Chen, Introduction to Plasma Physics and Controlled Fusion, Volume I and II, Plenum Press, recent edition

### *Reference books*

1. K.L. Goswami, Introduction to Plasma Physics – Central Book House, Calcutta
2. J.D. Jackson: “Classical Electrodynamics” (3rd Ed.) (Wiley,1999)

## PHY1C04 – ELECTRONICS

*Number of Contact Hours: 72 hrs*

*Number of Credits: 4*

### Course Outline

1. **Field effect transistors**

V-I characteristics of JFETs and device operation, construction of depletion and enhancement MOSFETs, V-I characteristics and device operation. Biasing of FETs, FETs as VVR and its applications, small signal model of FETs, analysis of Common Source and Common Drain amplifiers at low and high frequencies, MOSFET as a switch, CMOS and digital MOSFET gates (NOT, NAND, NOR). (10 hours)

**Text**: Integrated Electronics Millman and Halkias: Tata McGraw Hill

### *Reference*

Electronic devices and Circuit theory, Robert L Boylstead & L. Nashelsky – Pearson Education

Micro Electronic Circuits: Sedra/Smith: Oxford University Press

2. **Microwave and Photonic devices**

Tunnel diode, construction and characteristics, negative differential resistance and device operation, radiative transitions and optical absorption, Light emitting diodes (LED) – visible and IR, semiconductor lasers, construction and operation, population inversion, carrier and optical confinement, optical cavity and feedback, threshold current density. Photodetectors – Photoconductor (Light dependent resistor- LDR) and photodiode, p-n junction solar cells - short circuit current, fill factor and efficiency (14 hours)

**Text**: Semiconductor Devices- Physics and Technology - S. M. Sze, John Wiley and Sons Semiconductor Optoelectronic devices: Pallab Bhattacharya: Prentice Hall

### *Reference*

Principles of semiconductor devices: B. Van Zeghbroeck

Principles of semiconductor devices: S.M. Sze: John Wiley & Sons

3. **Operational Amplifier**

Differential amplifiers, analysis of Emitter coupled differential amplifiers, OPAMP parameters: Open loop gain, CMRR, error currents and error voltages, input and output impedances, slew rate and UGB. Frequency response, poles and zeros; transfer functions (derivation not required), expression for phase angle. Need for compensation, dominant pole, pole zero and lead compensation (12 hours)

**Text**: Integrated Electronics: Millman and Halkias: Tata McGraw Hill

### *Reference*

OPAMPS and Linear Integrated Circuits: Ramakant A. Gaekwad

4. **OPAMP Applications**

Closed loop inverting, non-inverting and difference OPAMP configurations and their characteristics; OPAMP as inverter, scale changer, summer, V to I converter, practical integrator & differentiator, active low pass , high pass and band pass Butterworth filters, band pass filter with multiple feedback, OPAMP notch filter, OPAMP Wien bridge oscillator, OPAMP astable and monostable multivibrators, Schmidt triggers.

(14 hours) **Text**: Integrated Electronics: Millman and Halkias: Tata McGraw Hill OPAMPS and Linear Integrated Circuits: Ramakant A. Gaekwad

### *Reference*

Linear Integrated circuits: D. Roychoudhuri: New Age International Publishers

5. **Digital Electronics**

Minimization of Boolean functions using Karnaugh map and representation using logic gates, JK and MSJK and D flip-flops, shift registers using D and JK flip flops and their operations, shift registers as counters, ring counter, design of synchronous and asynchronous counters, state diagram,cascade counters, basic idea of static and dynamic RAM, basics of charge coupled devices. R-2R ladder D/A converter, Introduction to 8-bit microprocessor; internal architecture of Intel 8085, register organisation. (22 hours)

**Text:** Digital Principles and Applications: Malvino and Leach: Tata McGraw Hill Digital Fundamentals: Thomas. L. Floyd: Pearson Education.

Fundamentals of Microprocessors and Microcomputers: B. Ram: Dhanpathi Rai& Sons.

### *Reference*

Modern Digital Electronics: R.P. Jain: Tata McGraw Hill

For further reference: Electronics Video Prof. D. C. Dube IIT Delhi, http://nptel.iitm.ac.in/courses/115102014/

Digital Integrated Circuits Video Prof. Amitava Dasgupta IIT Madras

http://nptel.iitm.ac.in/video.php?subjectId=108106069

## PHY1A01 – ABILITY ENHANCEMENT COURSE

*Number of Credits: 4*

### Course Outline

Each student has to prepare and present a seminar on recent trends in a selected topic in physics. A report has to be prepared and submitted before presenting the seminar. The abstract of the seminar has to be sent to the head of the department through the teacher in charge.

# SEMESTER II

## PHY2C05 – QUANTUM MECHANICS

*Number of Contact Hours: 72 hrs*

*Number of Credits: 4*

### Course Outline

**1. Formulation of Quantum Mechanics (20 hours)**

Sequential Stern-Gerlach experiments – Analogy with the polarization of light – Need for representing a quantum mechanical state as a vector in complex vector space. Dirac notation – Ket space, Bra space and Inner products – Operators - Hermitian adjoint – Hermitian operator – Multiplication – Associative axiom – Outer product. Eigenkets and eigenvalues of Hermitian operator – Eigenkets as base kets – Completeness relation – Projection operator – Matrix representation of operators, kets and bras. Measurement in a quantum mechanical system – Expectation value –Illustration with spin-1/2 systems – Compatible observables and simultaneous eigenkets – Maximal set of commuting observables – Incompatible observables and general uncertainty relation. Unitary operator – Change of basis and transformation matrix – Similarity transformation – Diagonalization – Unitary equivalent observables. Position eigenkets and position measurements – Infinitesimal translation operator and its properties – Linear momentum as a generator of translation – Canonical commutation relations. Position-space wavefunction – wavefunction as an expansion coefficient – Momentum operator in the position basis – Momentum-space wavefunction – Transformation function or the momentum eigenfunction in position basis –Relations between wavefunctions in position-space and momentum-space. Gaussian wave packet – Computation of dispersions of position operator and momentum operator – Minimum uncertainty product. Generalization to three dimensions.

**Text**: Chapter 1, Modern Quantum Mechanics (Edn.2) by J. J. Sakurai

**2. Quantum Dynamics (20 hours)**

Time-evolution operator – Schrodinger equation for the time-evolution operator and its solutions according to the time- dependence of the Hamiltonian operator –Energy eigenkets – Time dependence of expectation values – Time evolution of a spin-1/2 system and Spin precession – Correlation amplitude and energy-time uncertainty relation. Schrodinger picture and Heisenberg picture – Behaviour of state kets and observables in Schrodinger picture and Heisenberg picture – Heisenberg equation of motion – Ehrenfest's theorem. Time-evolution of base kets and transition amplitudes. Simple harmonic oscillator – energy eigenkets and energy eigenvalues – Dirac's method – Time development of the oscillator. Schrodinger's wave equation – Time-dependent wave equation – Time-independent wave equation – Continuity Equation – Interpretations of the wavefunction – Classical limit of wave mechanics. Boundary conditions – Elementary solutions to Schrodinger's wave equation – Free particle in one dimension and three dimensions – Simple harmonic oscillator – Particle in a one- dimensional box – Particle in a finite potential well – One-dimensional potential step – Square potential barrier.

**Text**: (1) Chapter 2 – upto section 2.5, Modern Quantum Mechanics (Edn.2) by J. J. Sakurai

(2) Chapter 4 – section 4.3, Quantum Mechanics (Edn.4) by V. K. Thankappan

**3. Theory of Angular Momentum (15 hours)**

Non-commutative nature of rotations around different axes – Rotation operator – Infinitesimal rotations in quantum mechanics – Fundamental commutation relations for angular momentum operators. Rotation operators for spin-1/2 systems - Spin precession in a magnetic field – Pauli's two component formalism – Representation of the rotation operator as 2 x 2 matrix. Ladder operators and their commutation relations – Eigenvalue problem for angular momentum operators $J^2$ and $J_Z$ – Matrix elements of angular momentum operators and rotation operator. Orbital angular momentum – Orbital angular momentum as generator of rotation – Spherical harmonics – Spherical harmonics as rotation matrices. Addition of orbital angular momentum and spin angular momentum – Addition of angular momenta of two spin-1/2 particles – Formal theory of Angular Momentum addition – Computation of Clebsch-Gordan coefficients – Clebsch-Gordan coefficients and the rotation matrices.

**Text**: Chapter 3 – sections 3.1, 3.2, 3.5, 3.6 and 3.8, Modern Quantum Mechanics (Edn.2) by J. J. Sakurai

**4. Central Potentials (8 hours)**

Schrodinger's equation for central potentials – The radial equation – Particle in an infinite spherical well – Isotropic harmonic oscillator – The Coulomb potential and the hydrogen atom problem.

**Text**: Chapter 3 – section 3.7, Modern Quantum Mechanics (Edn.2) by J. J. Sakurai.

**5. Invariance Principles and Conservation Laws (9 hours)**

Symmetry and conservation laws –Space-time symmetries – Displacement in space and conservation of linear momentum – Displacement in time and conservation of energy – Rotation in space and conservation of angular momentum – Space inversion and conservation of parity – Time reversal symmetry. The indistinguishability principle – Symmetric and antisymmetric wavefunctions – Eigenvalues and eigenvectors of particle-exchange operator – Spin and statistics – Pauli's exclusion principle and antisymmetric wavefunction – The ground state of Helium atom.

**Text:** Chapter 6 and 9 – relevant sections, Quantum Mechanics (Edn.4) by V. K. Thankappan

### *References*


1. Modern Quantum Mechanics (Edn.2): J. J. Sakurai, Pearson Education.
2. Quantum Mechanics (Edn.4): V. K. Thankappan, New Age International


### *References*


1. Principles of Quantum Mechanics (Edn.2): R. Shankar, Springer.
2. Introductory Quantum Mechanics: Richard L. Liboff, Pearson Education.
3. Introduction to Quantum Mechanics (Edn.2): D.J. Griffiths, Pearson Education.
4. A Modern Approach to Quantum Mechanics: J S Townsend, Viva Books.
5. Quantum Mechanics: Non-Relativistic Theory (Course of Theoretical Physics Vol3): L. D. Landau and E. M. Lifshitz, Pergamon Press.
6. The Feynman Lectures on Physics Vol. 3, Narosa.
7. Quantum Mechanics: Concepts and Applications (Edn.2): Nouredine Zettili, Wiley.
8. Quantum Mechanics Demystified: David McMohan, McGrawHill 2006.
9. Quantum Mechanics (Schaum's Outline): Yoav Peleg*etal*. Tata McGraw Hill Private Limited, 2/e.
10. Quantum Mechanics: 500 Problems with Solutions: G Aruldhas, Prentice Hall of India.
11. www.nptel/videos.in/2012/11/quantum-physics.html
12. https://nptel.ac.in/courses/115106066/


## PHY2C06 – MATHEMATICAL PHYSICS

*Number of Contact Hours: 72 hrs*

*Number of Credits: 4*

### Course Outline

**1. Functions of Complex Variables**

Introduction, Analyticity, Cauchy-Reimann conditions, Cauchy's integral theorem and integral formula, Laurent expansion, Singularities, Calculus of residues and applications (15 hours) - Text: Sections 6.1 to 6.5, 7.1, 7.2

**2. Group Theory**

Groups, multiplication table, conjugate elements and classes, subgroups, direct product groups, isomorphism and homomorphism, permutation groups, distinct groups of given order, reducible and irreducible representations Text: Sections 1-1.8, Joshi.

Generators of continuous groups, rotation groups SO(2) and SO(3), rotation of functions and angular momentum, SU(2)-SO(3) homomorphism, SU(2) isospin and SU(3) eight fold way (20 hours) - Text: Sections 4.2, Arfken 5th edition.

**3. Calculus of Variations**

One dependent and one independent variable, Applications of the Euler equation, Generalization to several independent variables, Several dependent and independent variables, Lagrange Multipliers, Variation subject to constraints, Rayleigh-Ritz variational technique. (14 hours) Sections 17.1 to 17.8

**4. Integral equations**

Integral equations- introduction, Integral transforms and generating functions, Neumann series, separable kernel (12 hours) - Sections 16.1 to 16.3

**5. Green's function**

Green's function, eigenfunction expansion, 1-dimensional Green's function, Green's function integral-differential equation, eigenfunction, eigenvalue equation Green's function and Dirac delta function, Enough exercises. (11 hours) Section 9.51

## *References*


1. G.B.Arfken and H.J.Weber : "Mathematical Methods for Physicists (5th Edition, 2001)" (Academic Press)
2. A.W.Joshi, Elements of Group theory for Physicists()(New Age International (P). Ltd.


## *Reference books*


1. J.Mathews and R.Walker : "Mathematical Methods for Physics" (Benjamin)
2. L.I.Pipes and L.R.Harvill : "Applied Mathematics for Engineers and Physicists (3rd Edition)" (McGraw Hill)
3. Erwin Kreyzig: "Advanced Engineering Mathematics - 8th edition" (Wiley)
4. M. Greenberg: "Advanced Engineering Mathematics – 2nd edition " (Pearson India 2002)
5. Mathematical methods in the physical sciences, 2nd edn, Mary L Boas, John Wiley & Sons
6. Elementary Differential Equations and boundary value problems, William E. Boyce, Richard C. DiPrima, John Wiley & Sons, Inc.
7. Mathematics of Classical and Quantum Physics, F. W. Byron and R. W. Fuller, Dover Publications, Inc., New York


***For further reference***


Mathematics I Video Prof. Swagato K. Ray,Prof. Shobha Madan,Dr. P. Shunmugaraj

http://nptel.iitm.ac.in/video.php?subjectId=122104017

Mathematics II Video Prof. Sunita Gakkhar, Prof. H.G. Sharma, Dr. Tanuja Srivastava IIT Roorkee

http://nptel.iitm.ac.in/video.php?subjectId=122107036

Mathematics III Video Prof. P.N. Agrawal, Dr. Tanuja Srivastava IIT Roorkee

http://nptel.iitm.ac.in/video.php?subjectId=122107037

# PHY2C07 – STATISTICAL MEHCANICS

*Number of Contact Hours: 72 hrs*

*Number of Credits: 4*

## Course Outline

**1. The Statistical Basis of Thermodynamics**

The macroscopic and the microscopic states – Contact between statistics and Thermodynamics: Expressing T, P and μ in terms of Ω – The classical Ideal gas - The entropy of mixing and the Gibbs paradox - Phase space of a classical system - Liouville"s theorem and its consequences. (13 Hours) Text: Pathria, Sections 1.1 – 1.6, 2.1 – 2.2

**2. Microcanonical, Canonical and Grand Canonical Ensembles**

The microcanonical ensemble – Examples : (1) Classical Ideal gas, (2) Linear harmonic oscillator - Quantum states and the phase space – Equilibrium between a system and a heat reservoir- Physical significance of the various statistical quantities in the canonical ensemble- Alternative expressions for the partition function- Examples: (1) The classical systems: Ideal gas, (2) A system of harmonic oscillators, (3) The statistics of paramagnetism - Energy fluctuations in the canonical ensemble -Equipartition theorem - Virial theorem - Equilibrium between a system and a particle-energy reservoir- Physical significance of the various statistical quantities in the grand canonical ensemble- Example : Classical Ideal gas - Density and energy fluctuations in the grand canonical ensemble. (21 Hours) Text: Pathria, Sections 2.3 -2.5, 3.1, 3.3 - 3.9, 4.1, 4.3 – 4.5

**3. Formulation of Quantum Statistics**

Quantum-mechanical ensemble theory: The density matrix- Statistics of the various ensembles-Example: An electron in a magnetic field - Systems composed of indistinguishable particles- An ideal gas in a quantum-mechanical microcanonical ensemble- An ideal gas in other quantum-mechanical ensembles-Statistics of the occupation numbers (15 Hours) Text: Pathria, Sections 5.1 - 5.4, 6.1 – 6.3

**4. Ideal Bose Systems**

Thermodynamic behaviour of an ideal Bose gas- Thermodynamics of the blackbody radiation- The field of sound waves. (10 Hours) Text: Pathria, Sections: 7.1 - 7.3

**5. Ideal Fermi Systems**

Thermodynamic behaviour of an ideal Fermi gas- Magnetic behaviour of an ideal Fermi Gas: (1) Pauli paramagnetism, (2) Landau diamagnetism – The electron gas in metals (Discussion of heat capacity only), Enough exercises. (13 Hours) Text: Pathria, Sections: 8.1 – 8.3

***References***

1. Statistical Mechanics (2nd Edition), R. K. Pathria, Butterworth-Heinemann /Elsevier (1996)

### *Reference books*


1. Statistical Mechanics: An Elementary Outline, Avijit Lahiri, Universities Press (2008)
2. An Introductory Course of Statistical Mechanics, Palash. B. Pal, Narosa (2008)
3. Statistical Mechanics: An Introduction, Evelyn Guha, Narosa (2008)
4. Statistical and Thermal Physics: An Introduction, S. Lokanathan and R. S. Gambhir, Prentice Hall of India (2000).
5. Introductory Statistical Mechanics (2nd Edition), Roger Bowley and Mariana Sanchez, Oxford University Press (2007)
6. Concepts in Thermal Physics, Stephen. J. Blundell and Katherine. M. Blundell, Oxford University Press (2008)
7. An Introduction to Thermal Physics, Daniel. V. Schroeder, Pearson (2006)
8. Statistical Mechanics, Donald. A. McQuarrie, Viva Books (2005)
9. Problems and Solutions on Thermodynamics and Statistical Mechanics, Ed. by Yung – Kuo Lim, Sarat Book House (2001)


***For further reference***

Basic Thermodynamics Video Prof. S. K. Som IIT Kharagpur

http ://nptel.iitm.ac.in/video.php?subjectId=112105123

## PHY2C08 – COMPUTATIONAL PHYSICS

*Number of Contact Hours: 72 hrs*

*Number of Credits: 4*

### Course Outline

**1. Introduction to Python Programming**

Concept of high-level language, steps involved in the development of a Program - Compilers and Interpreters - Introduction to Python language: Inputs and Outputs, Variables, operators, expressions and statements - Strings, Lists, Tuples, and Dictionaries, Conditionals, Iteration and looping, Functions and Modules -. Mathematical functions (math module), File input and Output, Pickling. Formatted Printing. (13 hours)

**2. Tools for maths and visualisation in Python (The numpy and pylab modules) ***

Numpy module:- Arrays and Matrices – creation of arrays and matrices ( arange, linspace, zeros, ones, random, reshape, copying), Arithmetic Operations, cross product, dot product , Saving and Restoring, Matrix inversion, solution of simultaneous equations, Data visualization- The Matplotlib, Module- Plotting graphs, Multiple plots, Polar plots, Pie Charts, Plotting mathematical functions, Sine and other functions, Special functions – Bessel & Gamma, Fourier Series. (13 hours)

**3. Numerical Methods 1***

Interpolation: linear and polynomial interpolation, equidistant points - Newton's forward/backward difference, spline interpolation. Curve fitting- Least square fit- linear and exponential. Derivatives: Lagrange polynomials, Newton difference polynomials, finite difference approximations. Numerical integration: simple quadratures (trapezoid, Simpson). Solution of non-linear equations: closed domain methods (bisection and regula falsi. Monte Carlo Method – Simple Integration. (15 hours)

**4. Numerical Methods-2***

Ordinary differential equations: Initial value problems: the first-order Euler method, the second-order single point methods (predictor), Runge-Kutta methods. Boundary value problems: the shooting method, the equilibrium method, the Numerov's method, the eigenvalue problems - the equilibrium method. Fourier transforms: discrete Fourier transforms, fast Fourier transforms. (15 hours)

**5. Computational methods in Physics and Computer simulations 12 hrs (24 marks) ***

Classical Mechanics: One Dimensional Motion: Falling Objects: Introduction – Formulation: from Analytical methods to Numerical Methods - Euler Method, Freely falling body, Fall of a body in viscous medium, Two dimensional motion: Projectile motion (by Euler method) and Planetary motion (R-K Method), Accuracy considerations, -, Oscillatory motion – Ideal Simple Harmonic Oscillator (Euler method), Motion of a damped oscillator (Feynmann-Newton method)., Logistic maps. Monte-Carlo simulations: value of π, simulation of radioactivity. Quantum Mechanics: 1D Schrodinger equation – wave function and eigen values. (16 hours)

(Visualisation can be done with matplotlib/pylab) *(Programs are to be discussed in Python)

***Textbooks for Numerical Methods***

1. Introductory methods of numerical analysis, S.S. Shastry , (Prentice Hall of India,1983)
2. Numerical Methods in Engineering and Science, Dr. B S Grewal, Khanna Publishers, New Delhi (or any other book)
3. Numerical Mathematical Analysis, J.B. Scarborough

## *References*

(For Python any book can be used as reference. Moreover, a number of open articles are available freely in internet. Python is included in default in all GNU/Linux platforms and It is freely downloadable for Windows platform as well. However, use of GNU/Linux may be encouraged).

1. www.python.org
2. Python Essential Reference, David M. Beazley, Pearson Education

3. Core Python Programming, Wesley J Chun, Pearson Education
4. Python Tutorial Release 2.6.1 by Guido van Rossum, Fred L. Drake, Jr., editor. This Tutorial can be obtained from website http://www.altaway.com/resources/python/tutorial.pdf
5. How to Think Like a Computer Scientist: Learning with Python, Allen Downey , Jeffrey Elkner, Chris Meyers, http://www.greenteapress.com/thinkpython/thinkpython.pdf
6. Numerical Recipes in C, second Edition (1992), Cambridge University Press
7. Numerical Recipes in Fortran 77, second Edition (1992), Cambridge University Press
8. Numpy reference guide, http://docs.scipy.org/doc/numpy/numpy-ref.pdf (and other free resources available on net)
9. Matplotlib, http://matplotlib.sf.net/Matplotlib.pdf (and other free resources available on net)
10. Numerical Methods, E Balagurusamy, Tata McGraw-Hill
11. Numerical Methods, T Veerarajan, T Ramachandran, Tat MC Graw Hill
12. Numerical Methods with Programs I BASIC, Fortran & Pascal, S Balachandra Rao, C K Shantha. Universities Press
13. Numerical methods for scientists and engineers, K. Sankara Rao, PHI
14. Computational Physics, V. K. Mittal, R. C. Verma & S. C. Gupta-Published by Ane Books,4821, Pawana Bhawan, first floor,24 Ansari Road, Darya Ganj, New Delhi-110 002 (For theory part and algorithms. Programs must be discussed in Python)
15. Numerical Methods in Engineering with Python by Jaan Kiusalaas

## PHY2A02 – PROFESSIONAL COMPETANCY COURSE

*Number of Credits: 4*

### Course Outline

Latex – scientific document preparation system: Downloading and installing a LATEX distribution, Basic types of LATEX documents, Packages and use of package physics, Format words, lines, paragraphs and pages, create lists, tables, figures and captions, Citing books and journals.

Typeset complicated equations and formulas, inserting centered and numbered equations and aligning multi-line equations, typesetting mathematical symbols such as roots, arrows, Greek letters, and different mathematical operators, math structures such as fractions and matrices. Enhance the documents by bringing color.

**Activities:**

1. Typeset a model question paper for M. Sc programme
2. Develop a review paper in a format suitable for the journal “Pramana – Journal of Physics”
3. Create a professional presentation using beamer

### *References*

1. A document preparation system – Latex: User's guide and Reference manual, 2nd ed. Leslie Lamport, Pearson Education
2. A student's guide to the study, practice and tools of modern mathematics, Donald Bindner and Martin Erickson, CRC Press

***Evaluation of this will be based on a multiple choice written examination and an internal practical.***

**Practical for Semester I & II**

**a) PHY1L01 & PHY2L03 (GENERAL PHYSICS)**

*External Practical Exam for PHY1L01&PHY2L03 together will be conducted at the end of 2nd semester*

***Note:***

1. *All the experiments should involve error analysis. Internal evaluation to be done in the respective semesters and grades to be intimated to the controller at the end of each semester itself. Practical observation book to be submitted to the examiners at the time of examination.*
2. *Eight experiments are to be done by a student in a semester. One mark is to be deducted from internal marks for each experiment not done by the student if the required total of experiments are not done in the semesters.*
3. *The PHOENIX/EXPEYES Experimental Kit developed at the Inter University Accelerator Centre, New Delhi, may be used for the experiments wherever possible.*

**(At least 16 experiments should be done, 8 each for I & II semesters)**

1. Y and σ - Interference method (a) elliptical (b) hyperbolic fringes. To determine Y and σ of the material of the given specimen by observing the elliptical and hyperbolic fringes formed in an interference set up
2. Y & σ by Koenig's method
3. Variation of surface tension with temperature-Jaegar's method. To determine the surface tension of water at different temperatures by Jaegar's method of observing the air bubble diameter at the instant of bursting inside water
4. Stefan's constant-To determine Stefan's constant
5. Thermal conductivity of liquid and air by Lee's disc method.
6. Dielectric constant by Lecher wire- To determine the wave length of the waves from the given RF oscillator and the dielectric constant of the given oil by measurement of a suitable capacitance by Lecher wire setup.
7. Viscosity of a liquid - Oscillating disc method. To determine the viscosity of the given liquid by measurements on the time period of oscillation of the disc in air and in the liquid
8. Mode constants of a vibrating strip. To determine the first and second mode constants of a steel vibrating

strip; Y to be measured by the Cantilever method and frequency of vibration by the Melde's string method

9. Constants of a thermocouple and temperature of inversion.
10. Study of magnetic hysteresis - B-H Curve using standard toroid / specimen in any form.
11. Maxwell's L/C bridge -To determine the resistance and inductance of the given unknown inductor by Maxwell's L/C bridge OR Anderson's Bridge – L/C and self-inductance. (The kit developed by Indian Academy of Science can also be used)
12. Susceptibility measurement by Quincke's and Guoy's methods - Paramagnetic susceptibility of salt and specimen
13. Michelson's interferometer - (a) λ and (b) d λ and thickness of mica sheet.
14. Photoelectric effect. Determination of Plank's constant
15. Frank Hertz experiment. To measure the ionization potential of Mercury by drawing current versus applied voltage.
16. Fabry Perot etalon -Determination of thickness of air film.
17. Elementary experiments using Laser: (a) Study of Gaussian nature of laser beam (b) Evaluation of beam spot size (c) Measurement of divergence (d) Diameter of a thin wire
18. Diffraction Experiments using lasers (a)Diffraction by single slit/double slit/circular aperture (b)Diffraction by reflection grating
19. Measurement of the thermal and electrical conductivity of Cu to determine the Lorents number. (The kit developed by Indian Academy of Science can also be used)
20. Passive filters. (The kit developed by Indian Academy of Science can also be used)
21. Microwave experiments - Determination of wavelength, VSWR, attenuation, dielectric constant.
22. Experiments with Lock-in Amplifier(a) Calibration of Lock in Amplifier (b) Phase sensitive detection (c) Mutual inductance determination (d) Low resistance determination. (The kit developed by Indian Academy of Science can also be used)
23. Cauchy's constants using liquid prism
24. Forbe's method of determining thermal conductivity
25. Zeeman effect using Fabry-Perot etalon.

### *References*


1. B.L. Worsnop and H.T. Flint - Advanced Practical Physics for students - Methusen & Co (1950)
2. E.V. Smith - Manual of experiments in applied Physics - Butterworth (1970)
3. R.A. Dunlap - Experimental Physics - Modern methods - Oxford University Press (1988)
4. D. Malacara (ed) - Methods of experimental Physics - series of volumes - Academic Press Inc (1988)
5. S.P. Singh –Advanced Practical Physics – Vol I & II – Pragati Prakasan, Meerut (2003) – 13th Edition
6. A.C. Melissinos and J. Napolitano, Experiments in Modern Physics, Academic Press, 2003
7. K. Muraleedhara Varier, A Practical Approach to Nuclear Physics, Narosa Publishing House (2018)

**b) PHY1L02 & PHY2L04 (ELECTRONICS)**

**(At least 16 experiments should be done, 8 each for I & II semesters.)**

*External Practical Exam for PHY1L02&PHY2L04 together will be conducted at the end of 2nd semester.*

1. Study the V-I characteristics of a Silicon Controlled Rectifier – Construct half-wave and full-wave circuits using SCR.
2. a). Study the V-I characteristics of UJT. Determine intrinsic stand-off ratio. Design and construct a relaxation oscillator and sharp pulse generator for different frequencies.

   b). Design and construct a time delay circuit to switch ON a suitable load driven by a SCR. Trigger the SCR using UJT.
3. a) Study the V-I characteristics of a JFET. Determine pinch-off voltage, saturation drain current and cut-off voltage of the device.

   b). Design and construct a low frequency common source amplifier using JFET. Study the frequency response, measure the i/p and o/p impedances.
4. Design and construct a d.c voltage regulator using transistors and Zener diode. Study the line and load regulation characteristics for suitable o/p voltage and maximum load current.
5. Design a single stage bipolar transistor amplifier. Compare the characteristics and performance of the circuit without feedback and with a suitable negative feedback. Compare theoretical and observed magnitudes of voltage gain, i/p and o/p impedances in both cases.
6. Design and construct a differential amplifier using transistors. Study frequency response and measure i/p, o/p impedances. Also measure CMRR of the circuit.
7. a) Design and construct an amplitude modulator circuit. Study the response for suitable modulation depths.

   b) Design and construct a diode A.M detector circuit to recover the modulating signal from the A.M wave.
8. Design and construct two stage I.F amplifier circuit. Study the response of single and coupled stages.
9. Design and construct a Darlington pair amplifier using medium power transistors for a suitable output current. Study the frequency response of the circuit and measure the i/p and o/p impedances.
10. Design and construct a piezo-electric crystal oscillator to generate square waves of suitable frequencies. Compare designed and observed frequencies.
11. Design and construct an R.F oscillator using tunnel diode. Measure frequency of the output signal.
12. Design and construct OPAMP based summing and averaging amplifier for three suitable inputs. Compare the designed and observed outputs.
13. Design and construct a Wien bridge oscillator using OPAMP for different frequencies. Compare designed and observed frequencies.
14. Design and construct an astable multivibrator using OPAMP for suitable frequencies. 15.Design and

construct a monostable multivibrator using OPAMP for suitable pulse widths. 16.Design and construct a triangular wave generator using OPAMPs for different frequencies.

17. Design and construct OPAMP based precision half and full wave rectifies. Observe the o/p on CRO and study the circuit operation.
18. Design and construct an astable multivibrator using timer IC 555. Measure frequency and duty cycle of the o/p signal. Modify the circuit to obtain almost perfect square waves.
19. Design and construct a monostable multivibrator using timer IC 555, for different pulse widths. Compare designed and observed pulse widths.
20. Design and construct a voltage controlled oscillator using timer IC 555. Study the performance.
21. Design and construct Schmidt triggers using OPAMPS – for symmetrical and non-symmetrical LTP/UTP. Trace hysteresis curve.
22. Design and construct OPAMP based analogue integrator and differentiator. Study the response in each case.
23. a). Design and construct OPAMP based circuit for solving a second order differential equation. Study the performance.

    b). Design and construct OPAMP based circuit for solving a simultaneous equation. Study the performance.
24. Design and construct Second order Butterworth Low pass, High Pass and Band Pass filters using OPAMPs. Study the performance in each case.
25. Design and construct a narrow band-pass filter for a given centre frequency using a single OPAMP with multiple feedback. Study the frequency response.
26. 4bit D/A converter using R-2R ladder network. Realization of 4bit A/D converter using D/A converter.
27. Study of 4bit binary counter (IC 7493) and 4bit decade counter (IC 7490) at various modes. Use the counters as frequency dividers.
28. Design and construct a 3bit binary to decimal decoder using suitable logic gates. Verify the operation.
29. Set up 4bit shift register IC 7495 and verify right shift and left shift operations for different data inputs.

## *References*

1. Design and construction ideas may be obtained from standard electronics text books.

***For further reference***

Basic Electronics and Lab Video Prof. T.S. Natarajan IIT Madras

http://nptel.iitm.ac.in/video.php?subjectId=122106025

# SEMESTER III

## PHY3C09 – QUANTUM MECHANICS - II

*Number of Contact Hours: 72 hrs*

*Number of Credits: 4*

### Course Outline

**1.Time-Independent Perturbation Theory (20 Hrs.)**

Non-degenerate perturbation theory – First-order theory and Second-order theory – Examples : (1) Linear harmonic oscillator (2) Anharmonic oscillator – Degenerate perturbation theory – Two-fold degeneracy – Higher-order degeneracy – The fine-structure of hydrogen – Relativistic correction – Spin-orbit coupling - Zeeman effect – Weak-field Zeeman effect - Strong-field Zeeman effect – Intermediate-field Zeeman effect – Hyperfine splitting – Linear Stark effect in the hydrogen atom.

**Text**: (1) Chapter 6, Introduction to Quantum Mechanics (Edn.2) by David. J. Griffiths,

(2) Chapter 8, section 8.3, Quantum Mechanics (Edn.4) by V. K. Thankappan

**2.Variational Method and WKB Method (12 Hrs.)**

Bound states (Ritz method) – Linear harmonic oscillator – Helium atom – WKB wavefunction in classical region – Example: Potential well with two vertical walls – WKB wavefunction in nonclassical region – Example: Tunneling – Connection formulae – Examples: (1) Potential well with one vertical wall (2) Potential well with no vertical walls.

Text: (1) Chapter 8, section 8.2A, Quantum Mechanics (Edn.4) by V. K. Thankappan

(2) Chapter 6, Introduction to Quantum Mechanics (Edn.2) by David. J. Griffiths

**3.Time-dependent perturbation theory (12 Hrs.)**

First order time-dependent perturbation theory – Constant perturbation – Transition to a continuum – Fermi's Golden rule – Scattering cross section in the Born approximation – Harmonic perturbation – Radiative transitions in atoms.

Text: Chapter 8, sections 8.4, 8.4A, 8.4B, Quantum Mechanics (Edn.4) by V. K. Thankappan

**4.Scattering (12 Hrs.)**

Scattering amplitude – Method of partial waves – Scattering by a central potential – Optical theorem – Scattering by a square-well potential

Text: Chapter 7, relevant sections, Quantum Mechanics (Edn.4) by V. K. Thankappan

**5.Relativistic Quantum Mechanics (16 Hrs.)**

Klein-Gordon equation – First order wave equations – Weyl equation – Dirac equation – Properties of Dirac matrices – Dirac particle is spin-1/2 particle – Spinor – Equation of continuity – Dirac particle in an external magnetic field: Non- relativisitc limit – Hole theory

Text: Chapter 10, relevant sections; Quantum Mechanics (Edn.4) by V. K. Thankappan

### *Textbooks*

1.Quantum Mechanics (Edn.4): V. K. Thankappan, New Age International.

2.Introduction to Quantum Mechanics (Edn.2) D.J. Griffiths, Pearson Education.

### *References*


1. Principles of Quantum Mechanics (Edn.2): R. Shankar, Springer.
2. Introductory Quantum Mechanics: Richard L. Liboff, Pearson Education.
3. A Modern Approach to Quantum Mechanics: J S Townsend, Viva Books.
4. Quantum Mechanics: Non-Relativistic Theory (Course of Theoretical Physics Vol3): L. D. Landau and E. M. Lifshitz, Pergamon Press.
5. The Feynman Lectures on Physics Vol 3, Narosa.
6. Quantum Mechanics: Concepts and Applications (Edn.2): Nouredine Zettili, Wiley.
7. Quantum Mechanics Demystified: David Mc Mohan, Mc GrawHill 2006.
8. Quantum Mechanics (Schaum's Outline) Yoav Pelege*tal*. Tata McGraw Hill Private Limited, 2/e.
9. Quantum Mechanics: 500 Problems with Solutions: G Aruldhas, Prentice Hall of India.
10. www.nptel/videos.in/2012/11/quantum-physics.html
11. https://nptel.ac.in/courses/115106066/


## PHY3C10 – NUCLEAR AND PARTICLE PHYSCS

*Number of Contact Hours: 72 hrs*

*Number of Credits: 4*

### Course Outline

1. **Nuclear Forces**

Properties of the nucleus, size, binding energy, angular momentum, the deuteron and two- nucleon scattering experimental data, Simple theory of the deuteron structure, Low energy n-p scattering, characteristics of nuclear forces, Spin dependence, Tensor force, Scattering cross sections, Partial waves, Phase shift, Singlet and triplet potentials, Effective range theory, p-p scattering. (12 hours)

Text: K.S. Krane: "Introductory Nuclear Physics" (Wiley), (Ch. 3 and 4)

2. **Nuclear Decay**

Basics of alpha decay and theory of alpha emission, Beta decay, Energetics of beta decay, Fermi theory of beta decay, Comparative half-life, Allowed and forbidden transitions, Selection rules, Parity violation in beta decay. Neutrino. Energetics of Gamma Decay, Multipole moments, Decay rate, Angular momentum and parity selection rules, Internal conversion, Lifetimes. (12 hours)

Text: K.S. Krane: "Introductory Nuclear Physics" (Wiley), (Ch. 8, 9 and 10)

3. **Nuclear Models, Fission and Fusion**

Shell model potential, Spin-orbit potential, Magnetic dipole moments, Electric quadruple moments, Valence Nucleons, Collective structure, Nuclear vibrations, Nuclear rotations, Liquid drop Model, Semiempirical Mass formula, Energetics of Fission process, Controlled Fission reactions. Fusion process, Characteristics of fusion, solar fusion, Controlled fusion reactors. (19 hours)

Text: K.S. Krane: "Introductory Nuclear Physics" (Wiley), (Ch. 5,13.1-13.5,14)

4. **Nuclear Radiation Detectors and Nuclear Electronics**

Gas detectors – Ionization chamber, Proportional counter and G M counter, Scintillation detector, Photo Multiplier Tube (PMT), Semiconductor detectors – Ge (Li), Si (Li) and surface barrier detectors, Preamplifiers, Amplifiers, Single channel analyzers, Multi- channel analyzers, counting statistics, energy measurements. (12 hours)

Text: S S Kapoor and V S Ramamurthy: "Nuclear Radiation Detectors" (Wiley)

5. **Particle Physics**

Four basic forces - Gravitational, Electromagnetic, Weak and Strong - Relative strengths, classification of particles, Yukawa's theory, Conservation of energy and masses, Electric charges, Conservation of angular momentum, Baryon and lepton numbers, Conservation of strangeness, Conservation of isospin and its components, Conservation of parity, Charge conjugation, CP violation, time reversal and CPT theorem. Extremely short lived particles, Resonances – detecting methods and experiments, Internal symmetry, The Sakata model, SU (3), The eight fold way, Gellmann and Okubo mass formula, Quarks and quark model, Confined quarks, Experimental evidence, Coloured quarks. (17 hours)

Text: Y. Neeman and Y. Kirsh: "The particle hunters' (Cambridge University Press), Ch 6.1- 3, 3.4, 7.1-10, 8.1, 9. 1-7)

## *Reference Books*


1. H. S. Hans: "Nuclear Physics – Experimental and theoretical" (New Age International, 2001).
2. G. F. Knoll: "Radiation Detection and Measurement, (Fourth Edition, Wiley, 2011)
3. G. D. Coughlan, J. E. Dodd and B. M. Gripalos "The ideas of particle physics – an introduction for scientists", (Cambridge Press)
4. David Griffiths – "Introduction to elementary particles" – Wiley (1989)
5. S.B.Patel : "An Introduction to Nuclear Physics" (New Age International Publishers)
6. Samuel S.M.Wong: "Introductory Nuclear Physics" (Prentice Hall,India)
7. B.L.Cohen : "Concepts of Nuclear Physics" (Tata McGraw Hill)
8. E.Segre : "Nuclei and Particles" (Benjamin, 1967)
9. K Muraleedhara Varier: "Nuclear Radiation Detection: Measurement and Analysis" (Narosa).

# PHY3C11 – SOLID STATE PHYSCS

*Number of Contact Hours: 72 hrs*

*Number of Credits: 4*

## Course Outline

**1. Crystal Structure and binding**

Symmetry elements of a crystal, Types of space lattices, Miller indices, Diamond Structure, NaCI Structure, BCC, FCC, HCP structures with examples, Description of X-ray diffraction using reciprocal lattice, Brillouin zones, Vander Waals interaction, Cohesive energy of inert gas crystals, Madelung interaction, Cohesive energy of ionic crystals, Covalent bonding, Metallic bonding, Hydrogen-bonded crystals (12 hours)

**2. Lattice Vibrations**

Vibrations of monatomic and diatomic lattices, Quantization of lattice vibrations, Inelastic scattering of neutrons, Einstein and Debye models of specific heat, Thermal conductivity, Effect of imperfection (9 hours)

**3. Electron States and Semiconductors**

Free electron gas in three dimensions, Specific heat of metals, Sommerfeld theory of electrical conductivity, Wiedemann-Franz law, Hall effect, Nearly free electron model and formation of energy bands, Bloch functions, Kronig Penny model, Formation of energy gap at Brillouin zone boundaries, Number of orbitals in a band, Equation of motion of electrons in energy bands, Properties of holes, Effective mass of carriers, Intrinsic carrier concentration, Hydrogenic model of donor and acceptor states. Direct band gap and indirect band gap semiconductors (17 hours)

**4. Dielectric, Ferroelectric and magnetic properties**

Theory of Dielectrics: polarization, Dielectric constant, Local Electric field, Dielectric polarisability, Polarisation from Dipole orientation, Ferroelectric crystals, Order-disorder type of ferroelectrics, Properties of Ba Ti O3, Polarisation catastrophe, Displasive type ferroelectrics, Landau theory of ferroelectric phase transitions, Ferroelectric domain, Antiferroelectricity, Piezoelectricity, Applications of Piezoelectric Crystals, Diamagnetism and Paramagnetism: Langevin's theory of diamagnetism, Langevin's theory of paramagnetism, theory of Atomic magnetic moment, Hund‟s rule, Quantum theory of magnetic Susceptibility Ferro, Anti and Ferri magnetism: Weiss theory of ferromagnetism, Ferromagnetic domains, Neel Model of Antiferromagnetism and Ferrimagnetism, Spin waves, Magnons in Ferromagnets (qualitative) (22 hours)

**5. Superconductivity**

Meissner effect, Type I and Type II superconductors, energy gap Isotope effect, London equation and penetration of magnetic field, Cooper pairs and the B C S ground state (qualitative, Flux quantization, Single particle tunneling, DC and AC Josepheson effects, High Tc Superconductors(qualitative) description of cuprates, Enough exercises. (12 hours)

### *Text books*

1. C. Kittel: Introduction to Solid State Physics 5th edition (Wiley Eastern)
2. A. J. Dekker: Solid State Physics (Macmillian 1958)

### *Reference Books*

1. M. Ali Omar, Elementary Solid State Physics, Addison-Wesley Publishing Company
2. N.W. Ashcroft and Mermin: Solid State Physics (Brooks Cole (1976)
3. Elements of Solid State Physics, Srivastava J.P. Prentice Hall of India (2nd edn)
4. Ziman J.H. Principles of Theory of Solids - (Cambridge 1964)
5. Harald Ibach and Hans Luth, Solid State Physics: An Introduction to Principles of Solid State Physics, Springer (2009)

## ELECTIVE – I

## PHY3E01 – PLASMA PHYSCS

*Number of Contact Hours: 72 hrs*

*Number of Credits: 4*

### Course Outline

**1. Introduction to Plasma Physics**

Existence of plasma, Definition of Plasma, Debye shielding 1D and 3D, Criteria for plasma, Applications of Plasma Physics (in brief), Single Particle motions -Uniform E & B fields, Nonuniform B field, Non uniform E field, Time varying E field, Adiabatic invariants and applications (15 hours) Text: Chen, Sections 1.1 to 1.7.7, 2.1 to 2.8.3

**2. Plasma as Fluids and waves in plasmas**

Introduction –The set of fluid equations, Maxwell's equations, Fluid drifts perpendicular to B, Fluid drifts parallel to B, The plasma approximations, Waves in Plasma - Waves, Group velocity, Phase velocity, Plasma oscillations, Electron Plasma Waves, Sound waves, Ion waves, Validity of Plasma approximations, Comparison of ion and electron waves, Electrostatic electron oscillations parallel to B, Electrostatic ion waves perpendicular to B, The lower hybrid frequency, Electromagnetic waves with B0, Cutoffs and Resonances, Electromagnetic waves parallel to B0, Experimental consequences, Hydromagnetic waves, Magnetosonic waves, The CMA diagrams (20 hours) Text: Chen, Sections 3.1 to 3.6, 4.1 to 4.21

3. **Equilibrium and stability**

Hydro magnetic equilibrium, The concept of b, Diffusion of magnetic field into plasma, Classification of instability, Two stream instability, the gravitational instability, Resistive drift waves, the Weibel instability (13 hours) Text: Chen, Sections 6.1 to 6.8

4. **Kinetic Theory**

The meaning of f(v), Equations of kinetic theory, Derivation of the fluid equations, Plasma oscillations and Landau damping, the meaning of Landau damping, Physical derivation of Landau damping, Ion Landau damping, Kinetic effects in a magnetic field (12 hours) Text: Chen, Sections 7.1 to 7.6.2

5. **Introduction to Controlled Fusion**

The problem of controlled fusion, Magnetic confinements such as Toruses, Mirrors, Pinches, Laser Fusion, Plasma heating, Fusion Technology (12 hours) Text: Chen, Sections 9.1 to 9.8

***Textbook***:

1. F. F. Chen, Introduction to Plasma Physics and Controlled Fusion, Volume I and II, Plenum Press, recent edition.

***References***

1. K. L. Goswami, Introduction to Plasma Physics – Central Book House, Calcutta

## ELECTIVE – II

## PHY3E02 – ADVANCED QUANTUM MECHANICS

*Number of Contact Hours: 72 hrs*

*Number of Credits: 4*

### Course Outline

1. **Basic Concepts (10 Hours)**

Reflections on the uncertainty principle, Complementarity principle, Information, Theory of quantum beats, The Aharonov – Bohm effect. Text: Sections 3.3, 3.4 and 4.1 to 4.5 of George Greenstein & Arthur G. Zajonc

2. **The EPR Experiment and Bell's Theorem (15 Hours)**

The EPR argument, The BKS theorem, The hidden variable theories, The Bell"s theorem and its proof, Tests of Bell"s inequalities, Alain Aspect"s experiments. Text: Sections 5.1 to5.3 and 6.1 of George Greenstein & Arthur G. Zajonc & 12.2 of David J Griffiths.

3. **Nonlocality (12 Hours)**

Bohm's nonlocal hidden variable theory, The Mystery of the EPR correlations, Nonlocality and principle of relativity, Quantum Nonlocality. Text: Sections 6.2 to 6.5 & 6.7 of George Greenstein & Arthur G. Zajonc

**4. Decoherence (17 Hours)**

Schrödinger's cat, Super positions and mixtures, Non-observation of quantum behaviour in macro systems, Decoherence, Watching decoherence Text: Sections 7.1 to 7.6 of George Greenstein & Arthur G. Zajonc

**5. The measurement problem in quantum mechanics (18 hours)**

The measurement problem, The collapse of wave function, The infinite regress, The active nature of measurement in quantum mechanics, Decoherence and measurement problem, Elementary ideas of quantum cryptography and quantum teleportation. Text: Sections: Chapter 8 complete & 9.1 to 9.3 of George Greenstein & Arthur G. Zajonc

### *Textbook*

1. The Quantum Challenge: Modern Researches on the foundations of Quantum Mechanics - George Greenstein & Arthur G. Zajonc, Narosa

### *Reference books*

1. Introduction to Quantum Mechanics: David J Griffiths, Pearson Education
2. Understanding Quantum Mechanics: Roland Omnes, Prentice-Hall, India
3. Quantum Theory and Measurement: J. A. Wheeler and W. H. Zurek, Princeton University Press, Princeton
4. Quantum Mechanics: V. K. Thankappan, Wiley Eastern, 2nd Ed.

### *For further reference*

1. Quantum Mechanics and Applications Video Prof. Ajoy Ghatak IIT Delhi
   http://nptel.iitm.ac.in/courses/115102023/
2. Quantum Physics Video Prof. V. Balakrishnan, IIT Madras
   http://nptel.iitm.ac.in/video.php?subjectId=122106034

## ELECTIVE – III

## PHY3E03 – RADIATION PHYSICS

*Number of Contact Hours: 72 hrs*

*Number of Credits: 4*

**Course Outline**

1. **Radiation source**

Types of radiations, ionizing, non-ionizing, electromagnetic, particles, neutral - gamma-neutrino-neutron, charged alpha, beta, gamma, and heavy ion sources, radioactive sources – naturally occurring production of artificial isotopes, accelerators–cyclotrons, nuclear reactors (12 hours) {Ref 1, 2}

2. **Interaction of radiations with matter**

Electrons – classical theory of inelastic collisions with atomic electrons, energy loss per ion pair by primary and secondary ionization, specific energy loss, bremsstrahlung, range energy relation, energy and range straggling Heavy charged particles – stopping power, energy loss, range and range – energy relations, Bragg curve, specific ionization, Gamma rays – Interaction mechanism – Photoelectric absorption, Compton scattering, Pair production, gamma ray attenuation, attenuation coefficients, Elastic and inelastic scattering, Cross sections, linear and mass absorption coefficients, stopping power, LET, Neutrons – General properties, fast neutron interactions, slowing down and moderation.(17 hours) {Ref 1,2}

3. **Radiation quantities, Units and Dosimeters**

Particle flux and fluence, calculation of energy flux and fluence, curie, Becquerel, exposure and its measurements, absorbed dose and its relation to exposure, KERMA, Biological effectiveness, wighting factors, (WR and WT), Equivalent dose, Effective dose, Dosimeters, Primary and secondary dosimeters, Pocket dosimeter, Films and solid dosimeter (TLD and RPL), Clinical and calorimetric devices, Radiation survey meter for area monitoring. (15 hours) {Ref 2,3}

4. **Biological effects**

Basic concepts of cell biology, Effects of ionizing radiations at molecular, sub molecular and cellular levels, secondary effects, free radicals, deterministic effects, stochastic effects, Effects on tissues and organs, genetic effects, Mutation and chromosomal aberrations, applications in cancer therapy, food preservation, radiation and sterilization (12 hours) {Ref 3,4}

5. **Radiation protection, shielding and transport**

Effective radiation protection, need to safeguard against continuing radiation exposure, justification and responsibility, ALARA, concept of radiologic practice. time distance and shielding, safety specifications. method of radiation control, shielding factor for radiations, Choice of material, Primary and secondary radiations, Source geometry, Beta shielding, Gamma shielding, neutron shielding, Shielding requirements for medical, industrial and research facilities, handling of the source, sealing, transport and storage of sealed and unsealed sources. records, spills. waste disposal, Enough exercises. (16 hours) {Ref 3,4,5}

## *Reference Books*

1. G. F. Knoll, Radiation detection and measurement, John Wiley & sons, New York, (2000)

2. K. Thayalan, Basic radiological physics, Jaypee brothers medical Publishers, New Delhi, (2003)

3. W.J. Meredith and J.B. Masse, Fundamental Physics of radiology, Varghese publishing house, Bombay (1992)

4. M.A.S. Sherer, P. J. Visconti, E.R Ritenour, Radiation Protection in medical radiography, Mosbey Elsevier, (2006)

5. Lowenthal G.C and Airey P.L., Practical applications of radioactivity and nuclear radiation sources, Cambridge University Press (2005)

# ELECTIVE – IV

# PHY3E04 – DIGITAL SIGNAL PROCESSING

*Number of Contact Hours: 72 hrs*

*Number of Credits: 4*

## Course Outline

**1. Introduction**

Signals and systems, Classification of signals, Concept of frequency in continuous time and discrete– time signals. Theory of A/D and D/A conversion, Sampling of analog signals, sampling theorem. Quantization of continuous amplitude signals. Quantization of sinusoidal signal, Coding of quantized samples- Digital to analog conversion (9 hours) Text: Digital Signal Processing by Proakis & Manolakis, Prentice Hall of India (Fourth edition -2013)– chapter 1 (complete)

**2. Discrete- time signals and systems**

Discrete- time linear time-invariant systems-Techniques of analysis of linear systems, Resolution of a discrete time signal into impulses- Response of LTI systems to arbitrary inputs: Convolution Sum- Properties of convolution and the interconnection of LTI systems- Casual LTI systems Stability of LTI systems- Systems with finite duration and infinite duration impulse, response. Discrete- time systems described by difference equations- Recursive and non-recursive discrete, time systems LTI systems characterized by constant coefficient difference equations, Solution to linear constant coefficient difference equations, correlation of discrete-time signals. (12 hours) Text: Digital Signal Processing by Proakis & Manolakis, Prentice Hall of India (Fourth edition -2013) Chapter 2 (complete)

**3. The Z-transform**

The Direct Z-Transform, The Inverse Z-Transform. Properties of Z-transform, Rational Ztransforms, Poles and zeros, Inversion of Z-transforms. The inverse Z-Transform by contour integration, Power series expansion, Partial fraction expansion – Decomposition of rational Z-transform–Analysis of linear time-invariant systems in the Z-domain (15 hours) Text: Digital Signal Processing by Proakis & Manolakis, Prentice Hall of India (Fourth edition -2013) (Section-3.6- 3.6.2)

4. **Frequency Analysis of Signals and Systems**

Frequency analysis of continuous-time signals.- The Fourier Series for continuous Time Periodic signals, Power Density Spectrum of Periodic Signals, The Fourier Transform of Continuous -Time Aperiodic Signals, Energy Density Spectrum of Aperiodic Signals, Frequency analysis of discrete time signals-The Fourier Series for discrete time Periodic Signals, Power Density Spectrum of Periodic Signals, Fourier transform for discrete time aperiodic signal, Convergence of the Fourier Transform, Energy Density Spectrum of aperiodic signals, Relationship of the Fourier Transform to the Z Transform, The Cepstrum. Properties of the Fourier Transform for Discrete Time Signals. LTI systems as Frequency selective filters: Ideal filter characteristics, Lowpass, Highpass and Band pass filters, Digital resonators, Notch filters, Comb filters, All-pass filters – Characteristics of practical frequency-selective filters, Design of linear- phase FIR filters using windows. (24 hours) Text: Digital Signal Processing by Proakis & Manolakis, Prentice Hall of India (Fourth edition -2013) Chapter 4-sections 4.1,4.2 and 4.4, chapter 5 section 5.4, chapter10 sections 10.1.2, 10.2.2)

5. **Discrete Fourier Transform**

Frequency domain sampling and reconstruction of discrete time signals – The Discrete Fourier transform – DFT as a linear transformation - Relationship of the DFT to the other transforms. Properties of DFT, Multiplication of two DFTs and Circular convolution, Linear filtering methods based on DFT - Frequency analysis of signals using the DFT – Discrete cosine transform - Computation of the Discrete Fourier Transform - Fast Fourier Transform algorithm (basic ideas only), Enough exercises. (12 hours) Text: Digital Signal Processing by Proakis & Manolakis, Prentice Hall of India (Fourth edition -2013) chapter 7 (complete), sections 8.1.1, 8.1.2

## *Textbook*

1. Digital Signal Processing by Proakis & Manolakis, Prentice Hall of India (Fourth edition -2013)

## *Reference Books*

1. Digital Signal Processing by Oppenheim & Schafer, Prentice Hall India –1995
2. Digital Signal Processing by Paulo S.R. Piniz, Eduardo A.B. De Silva and Sergio Netto – Cambridge University Press
3. Analog and digital signal processing by Ashok Ambradar
4. Theory and Applications of Digital Signal Processing, Rabiner& Gold, Prentice Hall India - 1996.

## *For further reference*

Digital Signal Processing Video Prof. T.K. Basu IIT Kharagpur[http://nptel.iitm.ac.in/video.php?subjectId=10810505](http://nptel.iitm.ac.in/video.php?subjectId=10810505)

## ELECTIVE – V

## PHY3E05 – EXPERIMENTAL TECHNIQUES

*Number of Contact Hours: 72 hrs*

*Number of Credits: 4*

### Course Outline

**1. Vacuum Techniques**

Units and basic definitions, Roughing pumps - Oil sealed rotary vacuum pump and Sorption pump, High vacuum pumps – Turbo molecular pump, Diffusion pump, Oil vapour booster pump, Ion pumps - Sputter ion pump and Getter ion pump, Cryo pump, Vacuum guages - Pirani gauge, Thermocouple gauge, penning guage (Cold cathode Ionization guage) and Hot filament ionization gauge, Vacuum accessories – Diaphragm, Gate valve, Butterfly valve, Baffle and isolation valves, magnetic valves, adjustable valves, air inlet valves, Traps - Liquid nitrogen trap, Sorption traps, and gaskets and O rings (19 hours) Text: Muraleedhara Varier et al. "Advanced Experimental Techniques in Modern Physics", Sections 1.4, 1.6 – 1.8, 1.9.2.3 – 1.9.2.5, 1.10.1, 1.10.6, 1.10.3

**2. Thin film techniques**

Introduction, Fabrication of thin films, Thermal evaporation in vacuum – Resistive heating, Electron beam evaporation and laser evaporation techniques, Sputter deposition, Glow discharge, Thickness measurement by quartz crystal monitor, optical interference method, electrical conductivity measurement, Thermo electric power, Interference filters - Multi layer optical filters, Technological Applications of thin films. (14 hours)
Text: Muraleedhara Varier, et al. "Advanced Experimental Techniques in Modern Physics" Sections 2.1, 2.2.1.1, 2.2.1.4, 2.2.1.5, 2.2.2, 2.3.2, 2.3.3, 2.3.1, 2.7, 2.6.1

**3. Accelerator techniques**

High voltage DC accelerators, Cascade generator, Van de Graaff accelerator, Tandem Van de Graaff accelerator, Linear accelerator, Cyclotron, Synchrotron (Electron and proton), Ion sources – Ionization processes, simple ion source, ion plasma source and RF ion source, Ion implantation – techniques and profiles, Ion beam sputtering– principles and applications. (14 hours) Text: Muraleedhara Varier, et al. "Advanced Experimental Techniques in Modern Physics", Sections 4.3, 4.4, 4.5.1, 4.5.4, 4.5.5, 4.6, 4.8.1 – 4.8.3, 4.9

**4. Materials Analysis by nuclear techniques**

Introduction, Basic principles and requirements, General experimental setup, mathematical basis and nuclear reaction kinematics, Rutherford backscattering – introduction, Theoretical background – classical and quantum mechanical, experimental set up, energy loss and straggling and applications. Neutron activation analysis – principles and experimental arrangement, applications, Proton induced X-ray Emission – principle and experimental set up, applications to water samples, human hair samples and forensic samples, limitations of PIXE. (15 hours) Text: Advanced Experimental Techniques in Modern Physics – K. Muraleedhara Varier, Antony Joseph and P. P. Pradyumnan, Pragati Prakashan, Meerut (2006)

**5. X- Ray Diffraction Technique**

Introduction, Lattice planes and Bragg's Law, Diffractometer - Instrumentation, Single crystal and Powder diffraction, Scherrer equation, Structure factor, Applications of XRD - Crystallinity, Unit Cell Parameters, Phase transition studies, thin film studies, Awareness on Powder Diffraction File (PDF) of the International Centre for Diffraction Data. (10 hours) Text: Elements of Modern X-ray Physics, Jens Als Nielsen and Des McMorrow, (John Wiley and Sons 2000)

### *Reference*


1. Scientific foundations of vacuum techniques – S. Dushman and J. M. Laffer, John Wiley New York (1962)
2. Thin film phenomena – K.L. Chopra, Mc Graw Hill (1983)
3. R. Sreenivasan – Approach to absolute zero - Resonance magazine Vol 1 no 12, (1996) vol 2 nos 2, 6 and 10 (1997)
4. R. Berry, P.M. Hall and M.T. Harris – Thin film technology – Van Nostrand (1968)
5. Dennis and Heppel – Vacuum system design
6. Nuclear Micro analysis – V. Valkovic
7. B.D. Cullity, Elements of X-ray diffraction, Addison Wesley Inc (1978)
8. Useful link for XRD-http://pd.chem.ucl.ac.uk/pdnn/powintro/whatdiff.htm


## ELECTIVE – VI

## PHY3E06 – ELEMENTARY ASTROPHYSICS

*Number of Contact Hours: 72 hrs*

*Number of Credits: 4*

### Course Outline

**1. The Celestial Co-ordinate systems**

Identification of stars- spherical coordinates - the Alt - azimuth system – Local equatorial system – the universal equatorial system – aspects of sky at a given place - Other systems - Stellar parallax and units of stellar distance. (14 hours)

**2. Stellar magnitude sequence**

Absolute magnitude and distance modulus, Colour index of a star, Luminosities of stars. Spectral classification of stars, Boltzmann's formula, Saha's equation of thermal ionization, Harward system of classification, Luminosity effect of stellar spectra, Importance of ionization theory, Spectroscopic parallax. (15 hours)

**3. Hertzsprung - Russel diagram**

Structure and evolution of stars, Observational basis, Equation of state for stellar interior, Mechanical and thermal equilibrium in stars, Energy transport in stellar interior, Energy generation in stars (thermonuclear reactions), Stellar evolution, White dwarfs, Neutron stars, pulsars and black holes. (15 hours)

**4. Astronomical Instruments**

Optical properties of telescopes - aberrations – Special purpose telescopes – photometry, photographic & photo-electric - instruments and techniques – radio telescopes. (14 hours)

**5. Space Astronomy**

Infrared Astronomy, detection and measurement – Ultra- violet astronomy, range and importance – X-ray astronomy – Gamma ray astronomy. (14 hours)

### *References*


1. K. D. Abhyankar: "Astrophysics – stars and galaxies", (Universities press) Relevant sections from Chapters 2, 19 and 20.
2. Baidyanath Basusu M: "An introduction to Astrophysics" (Prentice Hall of India) Relevant sections of Chapters 3,4, 14 and 15.


### *Reference books*


1. Gerald North: "Astronomy explained", (Springer, 2011)


## SEMESTER – IV

## PHY4C12 – ATOMIC AND MOLECULAR SPECTROSCOPY

*Number of Contact Hours: 72 hrs*

*Number of Credits: 4*

### Course Outline

**1. Atomic Spectroscopy (12 hours)**

Vector Atom model – L S coupling & J J coupling, effect of electric & magnetic field on atoms and molecules; Zeeman effect, Paschen Back effect and stark effect

Text: Sections10.1to10.11, 12.1to12.10, 13.1 to13.9, 20.1to 20.8 –Introduction to atomic spectra by H E White

**2. Microwave and Infrared spectroscopy (17 hours)**

The spectrum of non-rigid rotator, e.g. of HF, spectrum of symmetric top molecule e.g. of CH3Cl, Instrumentation for Microwave Spectroscopy Stark Modulator, Information derived from Rotational Spectrum: I R Spectroscopy: Born – Oppenheimer approximation, Effect of Breakdown of Born Oppenheimer approximation, Normal modes and vibration of H2O and CO2. Instrumentation for I R Spectroscopy – Fourier transformation I R Spectroscopy

Text: Sections 6.6 ,6.7,6.8,6.9 6.11,6.13,6.14 7.1 to 7.71,7.12,7.15,7.16,7.17,7.18 Molecular structure and Spectroscopy by G. Aruldhas

**3. Raman Spectroscopy (14 hours)**

Rotational Raman Spectrum of Symmetric top molecules, e.g. of CHCl3 Combined use of Raman & IR Spectroscopy in structure determination e.g. of CO2 and NO3. Instrumentation for Raman Spectroscopy, Non-linear Raman effects, Hyper Raman effect, stimulated Raman effect and Inverse Raman Effect

Text: Sections 8.32, 8.4, 8.5, 8.6, 8.7, 8.10, 15.1, 15.215.3, 15.4 Molecular structure and Spectroscopy by G.Aruldhas

**4. Electronic Spectroscopy of molecules (12 hours)**

Vibrational Analysis of band systems, Deslander's table, Progressions & sequences, Information Derived from vibrational analysis, Franck Condon Principle. Rotational fine structure and P R and R Branches, fortrat Diagram, Dissociation Energy, Example of Iodine molecule Text: Sections 9.1 to9.9 Molecular structure and Spectroscopy by G. Aruldhas

**5. Spin Resonance Spectroscopy (17 hours)**

Interaction of nuclear spin and magnetic field, level population Larmour precession, Resonance Conditions, Bloch equations, Relaxation times, Spin-spin and spin lattice relaxation. The chemical shift, Instrumentation for NMR spectroscopy, Electron Spin Spectroscopy of the unpaired e, Total Hamiltonian, Fine structure, Electron Nucleus coupling, and hyperfine spectrum ESR spectrometer. Mossbauer Spectroscopy, Resonance fluroscence of γ-rays, Recoilless emission of γ-rays and Mossbauer effect, Chemical shift, effect of magnetic field. Eg. of Fe57 Experimental techniques, Enough exercises. Text: Sections 10.1 to 10.9, 11.1 to11.5.4, 13.1 to13.5 Molecular structure and Spectroscopy by G. Aruldas

## *References*


1. Molecular Structure & Spectroscopy G Aruldas
2. C N Banwell & E.M. Mccash – Fundamentals of Molecular Spectroscopy
3. Atomic Spectroscopy – White


## *Reference books*

1. Straughan and Walker Spectroscopy Volume I, II and III
2. G. M. Barrow – Introduction to Molecular Spectroscopy
3. H.H. Willard, Instrumental Methods of Analysis,7th Edition, CBS-Publishers, New Delhi.
4. Atomic Spectroscopy –K P Rajappan Nair, MJP Publishers, Chennai
5. Elements of spectroscopy Gupta &Kumar –Pragati Prakasan, Meerut

# ELECTIVE – II

# PHY4E07 – ADVANCEED NUCLEAR PHYSICS

*Number of Contact Hours: 72 hrs*

*Number of Credits: 4*

## Course Outline

### 1. Nuclear Shell Model

Shell structure and magic numbers, The nuclear one particle potential, spin-orbit term, realistic one body potentials, Nuclear volume parameter, single particle spectra of closed shell + 1 nuclei, Harmonic oscillator and infinite square well potentials in 3- dimensions, coupling of spin and orbital angular momentum, magnetic dipole moment and electric quadrupole moment, Schmidt diagram; Single particle orbitals in deformed nuclei, perturbation treatment, asymptotic wave functions, single particle orbitals in an axially symmetric modified oscillator potential (18 Hours) Text: "Shapes and Shells in Nuclear Structure", S.G. Nilsson and I. Ragnarsson, Sections Chapter 5, 6, 7, 8.1-8.6

### 2. Nuclear collective models

Nuclear rotational motion- rotational energy spectrum and wave functions for eveneven and odd A nuclei - Nuclear moments- collective vibrational excitations, Rotational Bands - The particle rotor model, strong coupling- deformation alignment, Decoupled bands - rotational alignment; two particle excitations and back- bending; Fast nuclear rotation- the cranking model; Rotating harmonic oscillator (12 Hours)
Texts: 1. "Nuclear Physics- Theory and Experiment", R.R. Roy and B.P. Nigam (Wiley Eastern) Sections, 8.1 – 8.5 2. "Shapes and Shells in Nuclear Structure", S.G. Nilsson and I. Ragnarsson, Sections: 11, 11.1 – 11.3, 12, 12.1, 12.2

### 3. Nuclear Reactions

Reactions and Cross-sections, Resonances, Breit-Wigner formula for $l = 0$, Compound Nucleus formation, continuum theory, statistical theory, evaporation probability, Heavy ion reactions (12 Hours) Texts: 1. "Nuclear Physics- Theory and Experiment", R.R. Roy and B.P. Nigam (Wiley Eastern) Sections 6.1, 6.2, 6.4 – 6.8 2. Kenneth Krane – "Introductory Nuclear Physics", (Wiley), Section 11.13

### 4. Nuclear Fission

The semi-empirical mass formula, The stability peninsula, nuclear fission and the liquid drop model, some basic fission phenomena, fission barrier. Nuclear Fission- cross-section, spontaneous fission, Mass and energy distribution of fragments, Statistical model of Fission (15 Hours) Text: "Nuclear Physics- Theory and Experiment", R.R. Roy and B.P. Nigam (Wiley Eastern) Sections, Chapter 5 full

**5. Reactor Physics**

Fick"s law and its validity, Diffusion equation, diffusion length, Energy loss in elastic collision, Lethargy, Fermi age equation- solutions and measurement of age, Fermi age theory of bare thermal reactors, criticality, one region finite thermal reactor, criticality condition for different geometries (15 Hours) Text: "Introduction to Nuclear Reactor Theory", B.R. Lamarsh (Addisson- Wesley) Sections 5.1, - 5.7, 5.11, 6.1, 6.4, 6.9 – 6.14, 9.1 – 9.8

### *Reference*


1. "Introductory Nuclear Physics", Samuel M. Wong (Prentice Hall India 1996) Chapter 7)
2. "Nuclear Physics – Experimental and theoretical" – H.S. Hans, New Age International (2001)
3. "Theory of nuclear structure" – M.K Pal, (East West Press Pvt Ltd)


## PHY4E08 – ADVANCEED ASTROPHYSICS

*Number of Contact Hours: 72 hrs*

*Number of Credits: 4*

### Course Outline

1. **Radiative Process**

Theory of Black Body Radiation-Photoelectric Effect-Pressure of Radiation -Absorption and Emission spectra - Doppler Effect - Zeeman Effect- Bremsstrahlung - Synchrotron Radiation - Scattering of Radiation - Compton Effect - and Inverse Compton effect (10 Hours) Text: Baidyanath Basu, Ch 2

**2. Variable stars**

Classification of Variable stars – Cepheid variables – RV Tauri variables - Mira variables – Red Irregular and Semi-regular variables – Beta Canis Majoris Variables–U Geminorum and Flare stars–Theory of Variable stars. (10 hours) Text: Baidyanath Basu, Ch. 8

**3. Galaxies**

The Milkyway galaxy - Kinematics of the Milkyway – Morphology – Galactic Centre – Morphological classification of galaxies – Effects of environment – Galaxy luminosity function – The local group – Surface photometry of galaxies - ellipticals and disk galaxies – Globular cluster systems – Abnormal Galaxies-Active galactic nuclei. (24 Hours) Text: Binney & Merrifield, Ch.4

**4. General Relativity**

General Considerations - Connection Between Gravity and Geometry - Metric Tensor and Gravity - Particle Trajectories in Gravitational field - Physics in curved space-time – Curvature - Properties of Energy and momentum Tensor - Scwarzchild Metric - Gravitational Collapse and BlackHoles – Gravitational Waves (16 Hours) Text: Padmanabhan, Vol 2, Ch.11

**5. Cosmology**

Cosmological Principle - Cosmic Standard Coordinates - Equivalent Coordinates – Robertson-Walker Metric - The Red Shift - Measures of Distance - RedShift Versus Distance Relation - Steady State Cosmology (12 Hours) Text: Narlikar, Sections 3.1-3.8

## *Reference*


1. Gravitation & Cosmology-Steven Weinberg- John Wiley (1972) ISBN: 0-471-92567-5
2. Theoretical Astro Physics Vol 1 and 2- T. Padmanabhan- Cambridge University Press (2000) ISBN: 0-521-56240-6, 0-521-56241-4
3. Quasars and Active Galactic Nuclei- Ajit K Kembhavi and Jayat V Narlikar-Cambridge University Press (1999) ISBN:0-521-47477-9
4. The Physical Universe, An Introduction to Astronomy-F. Shu-Oxford University Press- (1982) ISBN: 0-19-855706-X
5. A Different Approach to Cosmology - Fred Hoyle, Geoffrey, Jayant V Narlikar Cambridge University Press (2000) ISBN:0-521-66223-0
6. An Introduction to AstroPhysics - Baidyanath Basu- Prentice Hall India (1997) ISBN:81-203-1121-3
7. Discovering the Cosmos-R.C. Bless - University Science Books (1996) - ISBN:0- 935702-67-9
8. Text Book of Astronomy and Astrophysics with Elements of Cosmology- V.B. Bhatia- Narosa publications (2001) ISBN:81-7319-339-8
9. Modern Astrophysics - B.W. Carroll & D.A. Ostille - Addison Wesley (1996) ISBN:0-201- 54730-9
10. Galactic Astronomy – J. Binney & M. Merrifield, Princeton University Press
11. Galactic Dynamics – J. Binney & S. Tremaine, Princeton University Press
12. An Introduction to Cosmology, Third Edition- J. V. Narlikar, Cambridge University Press (2002)


## *For further reference*

Astrophysics & Cosmology Video Prof. S. Bharadwaj IIT Kharagpur

http://nptel.iitm.ac.in/courses/115105046/

## PHY4E09 – ASTROPHYSICS AND ASTRONOMICAL DATA ANALYSIS

*Number of Contact Hours: 72 hrs*

*Number of Credits: 4*

### Course Outline

1. Introduction to Astronomy and astrophysics: Astronomy and astrophysics – importance, methods and scope, Apparent luminosities of stars. Mass, length andtime scales in astrophysics, the emergence of modern astrophysics, celestial coordinates, magnitude scale, applications of physics to, sources of astronomical information (12 Hours) Text: Astrophysics – stars and galaxies by K D Abhyankar : Chapter 1 and 3) Text : Astrophysics for physicist by Arnab Rai Choudhari Chapter 1: 1.1-1.6)

2. Stellar Physics: Stellar observational data and determination of stellar parameters, main sequence, red giants and white dwarfs, Stellar evolution, stellar rotation and magnetic fields, supernovae, Binary X-ray sources - Accretion disks (8 Hours) Text: Astrophysics for physicist by Arnab Rai Choudhari - Chapter 3: 3.5,3.6, Chapter 4 : 4.5,4.7,4.8 , Chapter 5 : 5.6

3. Galaxies: The Milkyway galaxy - of the Milkyway –Morphology –Galactic Centre –Morphological classification of galaxies –Effects of environment –Galaxy luminosity function –The local group –Surface photometry of galaxies -ellipticals and disk galaxies –Globular cluster systems –Abnormal Galaxies-Active galactic nuclei. (24 Hours) Text: Binney & Merrifield, Chapter 4.

4. X-ray astronomy: X-ray data reduction – event file, data, extracting analysis product and calibration and analysis, X-ray data analysis – introduction, low resolution spectral analysis, imaging analysis, timing analysis. (12 Hours) Text: Handbook of X-ray astronomy – Edited by Keith A Arnaud, Randal K Smith and Aneta Siemiginowska - Chapter 4: 4.1-4.4, Chapter 5: 5.1, 5.2.1 - 5.2.4, 5.4, 5.5

5. Infrared astronomy : Infrared sky- Introduction, Atmospheric transmission, Terrestrial background radiation, Extraterrestrial background sources, South Pole sites, The sky as revealed by infrared surveys, Balloon and airplane observatories, Satellite observatories, Infrared databases, Infrared photometry - Infrared photometric bands, Standard star observations, Colors of normal stars, Absolute calibration, IRAS photometry, Bolometric magnitudes, Stellar effective temperatures Photometry. (16 Hours) Text: Handbook of infrared astronomy by I S Glass – Chapter 2,3

### *Reference*


1. Astrophysics – stars and galaxies by K D Abhyankar, University Press. (First edition)
2. Astrophysics for physicist by Arnab Rai Choudhari, Cambridge University Press. (First South Asian edition)
3. Galactic Astronomy by James Binney & Merrifield, Princeton University Press. (First edition)

4. Handbook of X-ray astronomy – Edited by Keith A Arnaud, Randal K Smith and Aneta Siemiginowska, Cambridge University Press. (First edition)
5. Handbook of infrared astronomy by I S Glass, Cambridge University Press. (First edition)
6. Galactic Dynamics by James Binney and Scott Tremaine, Princeton University Press. (Second edition)
7. The Physical Universe, An Introduction to Astronomy by Frank H Shu, Oxford University Press. (First edition)
8. The handbook of image processing by Richard Berry and James Bernel (Second edition)
9. Galaxies in the Universe: an Introduction by Linda S Sparke, John S Gallagher III, Cambridge University Press. (Second edition)
10. An Introduction to Astrophysics Baidyanath Basu, Prentice Hall India Pvt. Ltd. (First edition)
11. An Introduction to Modern Stellar Astrophysics – Dale A. Ostlie, Bardley W Carroll, Addison-Wisely (Second edition)
12. Astronomy Today by Eric Chaisson and Steve McMillan, Addison-Wisely (8th Edition).

## PHY4E10 – ADVANCED STATISTICAL MECHANICS

*Number of Contact Hours: 72 hrs*

*Number of Credits: 4*

### Course Outline

1. **Thermodynamics of crystal lattice**, the field of sound waves, phonons and second sound, The Debye model, Debye temperature, specific heat of solid in the Debye model (12 hours)

2. **Non ideal systems**, intermolecular interactions, Lennard Jones potential, Corrections to the ideal gas law, Van der Waals equation, Short distance and long distance interaction, The plasma gas and ionic solutions, The Debye- Huckel radius (14 hours)

3. **Phase transition**, critical point, First order phase transition, Phase diagrams, The theory of Lang and Lee, A dynamical model for phase transitions, Weiss theory of ferromagnetism, Second order phase transition, Landau theory, Critical point exponents, Chemical equilibrium and chemical reactions (15 hours)

4. **Ising model** as a macroscopic model of phase transition, Why the Ising model is very important? Relationship betweeen lattice models, models of ferroelectrics and Ising model, the classical formulation of the problem, Exact solutions, Drawbacks of the mean field approximation, the static fluctuation approximation as new method for solving the Ising problem (17 hours)

5. **Fluctuations**, fluctuations of macroscopic variables, Theory of random processes, Response and fluctuation, Correlation functions, Spectral analysis of fluctuations: the Weiner-Khintchine theorem, The Nyquist theorem, Applications of the Nyquist theorem (14 hours) Text Book: Patria: "Statistical

Mechanics" (Butterworth-Heinemann,1996)

***Reference***


1. Kerson Huang: "Statistical Mechanics" (second edition) (Wiley,1987)
2. B.K. Agarwal and Melvin Eisner "Statistical Physics"
3. Guptha and Kumar: "Statistical Physics"
4. J.E. Meyer and M.G. Meyer, Statistical Mechanics, John Wiley


## PHY4E11 – MATERIAL SCIENCE

*Number of Contact Hours: 72 hrs*

*Number of Credits: 4*

### Course Outline

1. **Crystal Imperfections- 8 Hours**

   Point imperfections- The geometry of dislocations- Other properties of dislocations- Surface imperfections

   Text book: „ Materials Science and Engineering – A First Course‟ – IV th Edition- V. Raghavan (Prentice-Hall of India- 1988) (Sections: 6.1 to 6.4)

2. **Phase Diagrams & Diffusion In Solids - 14 Hours**

   The phase rule- Single component system- Binary phase diagrams- The Lever rule- Some typical phase diagrams and applications.

   Text book: "Materials Science and Engineering – A First Course" – IV th Edition- V. Raghavan (Prentice-Hall India- 1988) (Sections: 7.1 to 7.7)

   Fick's law and solutions- Applications based on the second law solution- The Kirkendall effect- The atomic model of diffusion- Other diffusion processes

   Text book: "Materials Science and Engineering – A First Course" – IV th Edition- V. Raghavan (Prentice-Hall of India- 1988) (Sections: 8.1 to 8.6)

3. **Plastic Deformation and Fracture of Materials - 12 Hours**

   The tensile stress- Strain curve- Plastic deformation by slip- Shear strength of perfect and real crystals-The stress to move a dislocation- Dislocation Multiplication-Work hardening- The effect of grain size and precipitate particles on dislocation motion- Mechanism of creep.

   Text book: "Materials Science and Engineering – A First Course" – IV th Edition- V. Raghavan (Prentice-Hall India- 1988) (Sections: 11.1, 11.2, 11.3, 11.4, 11.6,11.7, 11.8, 11.10 & 11.11)

   Ductile fracture- Brittle fracture- Fatigue fracture- Methods of protection against fracture.

   Text book: "Materials Science and Engineering – A First Course" – IV th Edition- V. Raghavan (Prentice-Hall of India- 1988) (Sections: 12.1, 12.2, 12.5 & 12.6

4. **Engineering Materials - 26 Hours**

Giant molecules-Linear polymers- Three dimensional polymers-Deformation of plastics-Electrical behavior of polymers-Stability of polymers

Text book: "Elements of Materials Science" –IIIrd Edition – Lawrence H. Van Vlack (Addison- Wesley Publishing Company Inc.1964.) (Sections: 7.1, 7.2, 7.4, 7.5, 7.6 & 7.7)

Ceramic phases- Silicate structures- Glasses- Electromagnetic behavior of ceramics- Mechanical behavior of ceramic materials.

Text book: "Elements of Materials Science" – IIIrd Edition – Lawrence H. Van Vlack (Addison- Wesley Publishing Company Inc. 1964) (Sections: 8.1, 8.5, 8.6, 8.7 & 8.8) -18 Hours

Growth techniques of nanomaterials- Top-down Vs.Bottom-up technique-Lithographic process and its limitations - Nonlithographic techniques-Plasma arc discharge-Sputtering- Evaporation-Thermal evaporation- e- beam evaporation – Chemical vapor deposition- Molecular beam epitaxy-Other processes.

Text book: "Introduction to Nanoscience & Technology" - K. K. Chathopadhyay, A. N. Banerjee (Prentice - Hall of India -2011.) (Sections 6.2, 6.3, 6.4, 6.4.1, 6.4.2,6.4.3, 6.4.3.1, 6.4.3.2, 6.4.4, 6.4.6 & 6.4.9.) - 8 Hours

5. **Characterization of Nanomaterials - 12 Hours**

Characterization tools of Nanomaterials-Scanning probe microscopy- Tunnelling current- Local barrier height-Applications of STM- AFM- Scanned –Proximity probe microscopes-Laser beam deflection-AFM cantilevers-piezoceramics-feedback loop-Alternative imaging modes-AFM and biology-Electron microscopy- Resolution vs. magnification-Scanning Electron microscope-SEM techniques-Electron gun-Specimen interactions- Environmental SEM- Transmission electron microscopy-Buckminsterfullerene-Carbon nanotube.

Text book: "Introduction to Nanoscience & Technology" - K. K. Chathopadhyay, A. N. Banerjee (Prentice-Hall of India -2011.) (Sections 7.1.2, 7.1.3.1, 7.1.3.2, 7.1.3.5, 7.2.1,7.2.2, 7.2.3, 7.2.4, 7.2.5, 7.2.6, 7.2.7, 7.3.1, 7.3.2, 7.3.3, 7.3.4, 7.3.5, 7.3.6, 7.3.7, 7.4, 8.2.1 & 8.2.2)

## *References*


1. Solid State Physics - A. J. Dekker (MacMillan India Ltd.- 1958)
2. Principles of the Solid State - H. V. Keer (Wiley Eastern – 1993)
3. Solid State Physics: Structure and Properties of Materials - M. A. Wahab (Narosa - 2007).
4. Materials Science and Processes – S. K. Hajra Choudhury (Indian Book Publishing Co. - 2009)
5. Nanotechnology - Richard Booker, Earl Boysen (Wiley Publishing Inc. 2005).

# PHY4E12 – ELECTRONIC INSTRUMENTATION

*Number of Contact Hours: 72 hrs*

*Number of Credits: 4*

## Course Outline

1. **Electronic Instrumentation for measuring basic parameters**

   Electronic DC voltmeters, DC voltmeter circuit with FET, amplified voltage and current meter, chopper stabilized amplifier, electronic AC voltmeters (average responding, peak responding and true rms responding types), electronic multimeters , differential voltmeters –digital voltmeters (ramp and staircase type), RF millivoltmeter, Q meter (basic circuit and measurement methods, sources of error), bolometer and RF power measurement (14 hours)

2. **Signal generators and Oscilloscopes**

   Standard signal generator, laboratory signal generator, AF sine wave and square wave generator, function generator and pulse generator, Block diagram of general purpose CRO, CRT circuits, vertical deflection system, delay line, multiple trace, horizontal deflection system, oscilloscope probes and transducers, oscilloscope technique, storage oscilloscopes, sampling oscilloscopes. (17 hours)

3. **Fibre optic measurements and Transducers**

   Sources and detectors, fibre optic power measurement, stabilized light sources, optical time domain reflectometer, Classification of transducers – strain gauges – displacement transducers – temperature measurements – photosensitive devices - Radiation detectors – solid state and scintillation detectors – neutron detectors, ECG and EEG (brain imaging – X ray, CT, MRI and nuclear imaging) (18 hours)

4. **Computer controlled test systems**

   Testing an audio amplifier – testing a radio receiver – instruments used in computer-controlled instrumentation – IEEE 488 electrical interface – digital control – signal timing in a microprocessor-based measurement. (11 hours)

5. **Power control: SCR**

   Control of current in rectifiers with an inductive load – triggering control by phase shifting – saturable reactor control – combined d.c. and phase control – on off pulse control of the SCR – SCR supply for d.c. motor – speed regulation by armature voltage and current control -–armature current limiting control of low torque a.c. motors (12 hours)

### *Reference*


1. Modern Electronic instrumentation and measurement technique – Albert D Helfrick and William D Cooper (Tata Mc Graw Hill) for modules 1, 3, 4 and second part of 2

2. Electronic Instrumentation – Second edition – H.S. Kalsi (Tata Mc Graw Hill) for modules 1 and first part of module 2
3. Principles of Medical electronics and bio medical instrumentation – C Rajarao and S.K. Gupta (Universities Press) for Transducers
4. Bio Instrumentation – John G Webster (Wiley student edition) – for Transducers
5. Introduction to Experimental Nuclear Physics", Singru, R. M., (Wiley Eastern, 1972). for transducers
6. Engineering Electronics", 2nd Edition, Ryder, J.D., (McGraw Hill, 1967). for module 5

## PHY4E13 – LASER SYSTEMS, OPTICAL FIBRES AND APPLICATIONS

*Number of Contact Hours: 72 hrs*

*Number of Credits: 4*

### Course Outline

1. **Basic Laser theory**: Einstein coefficients, Light amplification, The threshold condition, Line broadening mechanisms, Laser rate equations, Theory of Q-switched and Modelocked lasers, Cavity modes, stable and unstable resonators, Analysis of optical resonators. (18 hours)

2. **Various laser systems**: Ruby, Nd: YAG, Argon ion, He-Ne, CO2 laser, Fiber Laser, Semionductor Lasers, Optical parametric Oscillator – Working principle and energy level diagrams. (12 hours)

3. **Nonlinear optics**: Nonlinear polarization, Second and third Harmonic generation, Symmetry requirement for second Harmonic generation, Nonlinear refractive index, Multi photon absorption, Nonlinear materials, four waves mixing and Z-scan Technique (14 hours)

4. **Laser Applications**: Spatial frequency filtering, Holograpy, Industrial application of lasers, Lasers in medicine, Isotope separation, laser induced chemical reactions, Laser induced fusion (13 hours)

5. **Optical Fibers**: Introduction, What are optical fibers, Importance, propagation of light in optical fibers, Basic structure, Acceptance angle, Numerical aperture, Stepped index monomode fibers, disadvantages, Graded index monomode fibers, Optical fibers as cylindrical waveguides, Scalar wave equation and the modes of a fiber, Modal analysis for a step index fiber, Single mode fibers. (15 hours)

### *Reference*

1. K. Thyagarajan and Ajoy Ghatak: "LASERS: Fundamentals and Applications" (2nd Edition, Springer, 2010)
2. William T Silfvast:" Laser fundamentals" (2nd Edition, Cambridge University Press, 2004))
3. B. B Laud: "Lasers and Nonlinear Optics" (3rd Edition, New age international Publishers, 2011)
4. Ajoy Ghatak and K. Thyagarajan "Optical Electronics" (Cambridge University Press, 1989)
5. John. M.Senior: "Optical Fiber Communications: Principles and Practice" (3rd Edition, Pearson Education

India, 2009)

***Reference books***

1. Subirkumar Sarkar: “Optical Fiber and Fiber Optic Communication Systems” (S. Chand & Co.)
2. Ajoy Ghatak and K. Thayagarajan: Introduction to Fiber Optics” (Cambridge University Press, 1998)

# PHY4E14 – COMMUNICATION ELECTRONICS

*Number of Contact Hours: 72 hrs*

*Number of Credits: 4*

## Course Outline

1. **Amplitude and angle modulation**

   Amplitude modulation – Amplitude modulation and demodulation circuits – single side band generation and detection – SSB balanced modulator – Comparison of signal to noise ratios – Frequency modulation - Phase modulation – Angle modulation circuits – Detection of FM signals –Foster–Seeley discriminator – Ratio detector Noise in FM (12 hours)

2. **Pulse modulation and digital communication**

   Elements of information theory – Pulse transmission – Pulse amplitude modulation – Pulse time modulation – Pulse code modulation – Coding – Codes – Error detector and correction codes – Digital carrier systems – Teleprinter and telegraph circuits (12 hours)

3. **Communication systems**

   Receivers – Superheterodyne receiver – AM receivers – Automatic gain control –Communications receivers – FM receivers – Single and independent side band receivers. Transmitters –Telegraph transmitters AM transmitters – FM transmitters – Television transmitters HF radio systems –VHF/UHF systems – Microwave systems – Satellite communications (15 hours)

4. **Signals and Systems**

   Classifications of signals, concept of frequency in continuous - time and discrete –time signals. Theory of A/D and D/A conversion, Sampling of Analog signals, sampling Theorem. Quantization of continuous amplitude signal, Coding of quantized samples, Discrete time linear time invariant systems - Techniques of analysis of linear systems, Resolution of a discrete time signal into impulses- Response of LTI systems to arbitrary inputs: Convolution sum- properties of convolution and the interconnection of LTI systems-Casual LTI systems – Stability of LTI systems. (15 hours)

5. **Radiation and antennas**

   Potential functions and the EM field – Radiation from an oscillating dipole –Power radiated by a current element – Radiation resistance of a short dipole – Radiation from a quarter wave monopole - Directivity –

Gain and effective aperture - Antenna arrays – Two element, linear and binomial – Frequency independent antennae – Log periodic antennae – Yagi antennae. Propagation of radio waves - Ground waves, Sky wave propagation, Space waves, Tropospheric scatter propagation, Extra-terrestrial communication. Ionosphere – Reflection and refraction of waves by the ionosphere – Attenuation, Enough exercises. (18 hours)

***Reference***


1. "Electronic Communications", Roddy and Coolen, J., (PHI, 1986). Chapters 7, 8, 9, 10, 11, 12, 18, 19
2. "Electronic Communication Systems", 4th Edition, Kennedy, G. and Davis, B. (McGraw Hill, 1992). Chapter 6,8.
3. "Electromagnetic waves and Radiating Systems", Jordan E.C. and Balmain, K.G. (PHI, 1979). Chapters 10,11,15,17.
4. "Digital Signal Processing" by Proakis and Manolakis, Prentice Hall of India (1997)


## ELECTIVE – III

## PHY4E15 – QUANTUM FIELD THEORY

*Number of Contact Hours: 72 hrs*

*Number of Credits: 4*

### Course Outline

1. **Classical Field Theory**

   Harmonic oscillator, The linear chain- classical treatment, the linear chain – quantum treatment, classical field theory, Hamiltonian formalism, Functional derivatives, Canonical quantization of nonrelativistic fields, Lagrangian and Hamiltonian for the Schroedinger field, Quantization of fermions and bosons, Normalization of Fock states (14 hours) Textbook: "Field Quantization" Greiner and Reinhardt (Spinger-Verlag -1996), Sections 1.3 – 1.5, 2.2, 2.3, 3.1 – 3.3, Exercise 3.1

2. **Canonical quantization of Klein Gordon and photon fields**

   The neutral Klein – Gordon field Commutation relation for creation and annihilation operators, Charged Klein – Gordon field, Invariant commutation relations, Scalar Feyman propagator, Canonical quantization of photon field - Maxwells equations, Larangian density for the Maxwell field, Electromagnetic field in the Lorentz gauge, Canonical quantization of the Lorentz gauge – Gupta-Bleuler method, Canonical quantization in the Coulomb gauge (20 hours) Textbook: "Field Quantization" Greiner and Reinhardt (Spinger-Verlag -1996), Sections 4.1, 4.2, 4.4, 4. 5, 7.1 – 7.4, 7.7

3. **Canonical quantization of spin ½ fields**

   Lagrangian and Hamiltonian densities for the Dirac field, Canonical quantization of the Dirac field, Plane wave expansion of the field operator, Feyman propagator for the Dirac field (12 hours) Textbook: "Field

Quantization" Greiner and Reinhardt (Spinger-Verlag -1996), Sections 5.1 – 5.4 4.

4. **Interacting quantum fields and Quantum Electrodynamics**

   The interaction picture, Time evolution operator, Scattering matrix, Wick"s theorem, Feynman rules for QED, Moller scattering and Compton scattering (12 hours) Textbook: "Field Quantization" Greiner and Reinhardt (Spinger-Verlag -1996), Sections 8.2 – 8.6, Example 8.4

5. **The path integral method**

   Path integrals in non-relativistic Quantum Mechanics, Feynman path integral, Multidimensional path integral, Time ordered product and n-point functions, Path integrals for scalar quantum fields, The Euclidian field theory, The Feynman propagator, generating functional and Green"s function, generating functional for interacting fields, Enough exercises. (14 hours) Textbook: "Field Quantization" Greiner and Reinhardt (Spinger-Verlag -1996), Sections 11.2 – 11.5, 12.1 – 12.5

### *References*


1. "Quantum Field theory", Lewis H. Ryder (Cambridge University Press -1995)
2. "Field Theory – A modern primer" – Pierre Ramond (Bengamin – 1996)
3. "Quantum Field theory", Itzyskon and Zuber (McGraw Hill – 1989)
4. "Quantum Field theory", Karson Huang (Wiley)


## PHY4E16 – CHAOS AND NONLINEAR PHYSICS

*Number of Contact Hours: 72 hrs*

*Number of Credits: 4*

### Course Outline

1. **The Dynamics of Differential Equations**

   Integration of linear second order equations by quadrature, The damped oscillator, Integration of nonlinear second order equation, Jacobi elliptic functions, Weierstrass elliptic functions, Periodic structure of elliptic functions, The pendulum equation, Phase portrait of the pendulum, Phase portraits for conservative systems, Linear stability analysis, Linear stability matrix, Classification of fixed points, Examples of fixed point analysis, Limit cycle, Time dependent integrals, Non autonomous systems, The driven oscillator, Remarks on integration of differential equations, Elliptic functions .(Chap 1, Tabor) (16 hours)

2. **Hamiltonian Dynamics**

   Lagrangian formulation of mechanics, Lagrangian function and Hamilton's principle, Properties of the Lagrangian and generalized momentum, Hamiltonian formulation of mechanics, Hamilton's equations, Canonical transformations, The preservation of phase volume, The optimal transformation, Generating function, Hamilton Jacobi equation for one degree of freedom, Action angle variable for one degree of freedom, Integrable Hamiltonians, Separable systems, Properties of integrable systems, Examples of integrable systems, Motion on the tori, Fundamental issues, KAM theorem (Chap 2 and sec 3.4, Tabor) (15 hours)

3. **Chaos in Hamiltonian systems and area preserving mappings**

   Surface of section, Surface of section for two degrees of freedom Hamiltonians, The Henon Heiles Hamiltonian, The Toda lattice, Surface of section as a symplectic mapping, Twist maps, Mapping on the plane, Connection between area preserving maps and Hamiltonians, The standard maps, The tangent map, Classification of fixed points, Poincare Birkhoff fixed point theorem, Homoclinic and heteroclinic points, The intersection of H+ and H- whorls and tendrils, Criteria for local chaos, Lyapunov exponents, Power spectra, Criteria for onset of widespread chaos, Method of overlapping resonances, Greene's method, Statistical concepts in strongly chaotic systems, Ergodicity, Mixing, The Baker's transformation and Bernoulli systems, Heirarchies of randomness, Hamiltonian chaos in liquids, Fluid mechanical background, The model system, Experimental results (Sec 4.1 to 4.8, Tabor) (16 hours)

4. **Dynamics of dissipative systems**

   Dissipative systems and turbulence, The Navier Stokes equations, The concept of turbulence-a Hamiltonian degression, Experimental observations on the onset of turbulence, Couette flow, Rayleigh-Benard convection, Landau-Hopf theory, Hopf bifurcation theory, Ruelle-Takens theory, Other scenarios, Fractals, Mathematical model of strange attractors, Lorentz systems, Variations on Lorentz model, The Henon map, Period doubling bifurcations - Period doubling mechanism - Bifurcation diagram - Behaviour beyond 1μ - Other universality classes (Sec. 5.1 to 5.5, Tabor) (15 hours)

5. **Solitons**

   Historical background, Russel's observations, The F U P experiment, Discovery of the soliton, Basic properties of KdV equations, Effects of nonlinearity and dispersion, The traveling wave solution, Enough exercises. (Sec 7.1 and 7.2, Tabor) (10 hours) Text Book: "Chaos and Integrability in Nonlinear Dynamics", M.Tabor (Wiley, New York)

## *References*


1. "Chaos and Nonlinear Dynamics-An Introduction for Scientists and Engineers", R. Hilborn (Oxford University Press)
2. "Deterministic Chaos -An Introduction", H.G. Schuster (Wiley, New York)
3. "Chaos in Dynamical Systems", E. Ott (Cambridge University Press)
4. "Chaotic Dynamics-An Introduction", G. Baker and J. Gollub (Cambridge University Press)
5. "An Introduction to Chaotic Dynamical Systems", R. L. Devaney (Benjamin-Cummings, CA)
6. "Deterministic Chaos – Complex chance out of simple necessity", N. Kumar, Universities Press (1996)

7. "Nonlinear dynamics – Integrability, Chaos and Patterns", Muthusamy Laxmanan and Shanmuganathan Rajasekar (Springer Verlag, 2001)

## PHY4E17 – ADVANCED CONDENSED MATTER PHYSICS

*Number of Contact Hours: 72 hrs*

*Number of Credits: 4*

### Course Outline

1. **Elementary Excitations in Solids**

   Interacting electron gas - Hartree Fock approximation; Plasmons and electron plasmon interactions; Linhard equation for dielectric constant of electron gas; Electron Hole interactions-excitons; Block and Wannier representations, Frenkel excitons, Ion-ion interactions - classical equations of motion- Energy in lattice vibrations;Phonon dispersion relations-density of states Spin-spin interactions-magnons. (18 hours)

   Text: Introduction to solid state theory O Madlung Springer Ny1978

2. **Alloying phenomenon**

   Physics of alloy formation-Phase diagrams and alloy formation-Ternary groups and quaternary groups-band structure calculation of alloys superstructures-quantum well structures- super lattices (11 hours)

Text: Semiconductor physics and Devices: S S Islam, Oxford

3. **Defects in solids and strength of materials**

   Diffusion in solids, Vacancies, dislocations and mechanical strengths, ionic conductivity etching, photo graphic processes, radiation damage in solids, Fracture, Ductile and brittle fractures, Fracture mechanics, Fatigue, Crack initiation and propagation, Creep, Generalized creep behaviour, Stress and temperature effects. (14 hours) Text: Elementary solid state physics, Ali Omar; Pearson and Mechanical properties of matter: AH Cortell, Wiley NY.

4. **Nano scale science and technology**

   Nano materials and Quantum mechanics- quantum dots-Three dimensional Systems (bulk materials)-two dimensional systems(films)-one dimensional systems (quantum wires)-Zero dimensional systems (quantum dots)- Energy levels of quantum dots- nano wires and nano tubes synthesis and applications (16 hours). Text: Nano technology- Principles and fundamentals: Ed G nter ũ Schmid, Wiley

5. **Thin Film Technology and Applications**

   Thin film Growth process- Nucleation & film growth- Semiconducting thin films-Vapour deposition techniques- Solution deposition techniques- Optoelectronic applications of thin films- Microelectronic applications, Enough exercises. (13 hours). Texts: Thin film devises and applications: Chopra & I Kaur, Plenum Press Thin Film Fundamentals: A Goswami New Age Publishers

***Reference***


1. Solid State Physics: Structure and Properties of Materials by A. M. Wahab (Narosa Publishing House, India) 2nd Edition 2005
2. Elements of Solid State Physics (second Edition) by J. P. Srivatsava (Printice Hall of India) 2001
3. Introductory Solid State physics by H. P. Myers (Taylor & Francis Ltd, London) 2nd Edition 1998
4. Solid State Physics by Ashcroft & Mermin 1st edition 2003
5. Solid State Physics by C. M. Kachhava (Tata McGraw-Hill) 1st Edition 1996
6. Solid State Physics by C. Kittel (Wiley, 7th Edition) 2004


## PHY4E18 – MODERN OPTICS

*Number of Contact Hours: 72 hrs*

*Number of Credits: 4*

### Course Outline

1. **Light Propagation and Vectorial Nature**

   Electromagnetic wave propagation, Harmonic waves, phase velocity, group velocity, Energy flow Poynting vector. Different polarizations – Matrix representations – Jone's calculus. Ray vectors and ray matrices, Gaussian beams in homogeneous media, ABCD law. (13 hours)

2. **Coherence**

   Principle of superposition – Theory of partial coherence and visibility of fringes - coherence time and coherence length – Physical origin of line width. Spatial coherence, Hanburry-Brown-Twiss experiment. Basic idea of Fourier Transform Spectroscopy. (13 hours)

3. **Interference with multiple beams**

   Interference with multiple beams – Fabry-Perot interferometer –Resolving power, applications. Theory of multilayer films. (9 hours)

4. **Diffraction**

   Kirchoff‟s theorem, Fresnel-Kirchoff formula, Babinet‟s principle, Fresnel and Fraunhoffer diffraction, Fraunhoffer diffraction patterns of single slit, double slit and circular aperture, theory of diffraction grating. Fresnel diffraction pattern – zone plate, Rectangular aperture, Fresnel integrals, Corn spiral. Applications of Fourier transforms to diffraction. Aperture function, Apodization, Spatial filtering, phase contrast and phase gratings, wave form reconstruction by diffraction holography. (17 hours)

5. **Optics of Solids**

   Microscopic fields and Maxwell‟s equations. Propagation of light in isotropic dielectric media. Dispersion-

Sellmier‟s formula. Propagation of light in anisotropic media – double refraction, phase velocity surface, polarizing prisms. Optical activity, Faraday rotation in solids, Kerr effect and Pockel‟s effect (basic ideas only). Elements of nonlinear optics, Physical origin of nonlinearity. Second harmonic generation. Phase matching conditions. Applications of second harmonic generation, Enough exercises. (20 hours)

### *References books*


1. G.R. Fowles, Introduction to Modern Optics (Dover Publishers) ISBN: 0486659577
2. A. Yariv, Optical Electronics (1985)


### *References*


1. S.G. Lupson, H.L. Upaon and D.S. Tannhauser, Optical Physics (Cambridge University Press)
2. A.N. Matvev, Optics (MIR Publishers)
3. Hecht, Optics (Addison Wealey)
4. Ajov-Ghatak, Optics (Tata Mc Graw Hill)


## PHY4E19 – PHYSICS OF SEMICONDUCTORS

*Number of Contact Hours: 72 hrs*

*Number of Credits: 4*

### Course Outline

1. **Band structural aspects**

   Effects of temperature and electric field on band structure, Frank-Keldysh effect, Localized states of impurities: theoretical models and experimental probes (Capacitive and spectroscopic techniques), optical properties: allowed and forbidden, and phonon assisted transitions and their spectral shapes, Burstein Moss effect, excitons: free and bound excitons. (14 hours)

2. **Statistical thermodynamics of carriers**

   Fermi level in intrinsic and doped materials, Non stoichiometric semiconductors, role of structural defects, Heavy doping and degeneracy, electrical conductivity, Hall effect – two band model, mobility of carriers, Mechanisms of scattering, measurements of mobility, recombination process, Boltzmann equation for electron transport, equilibrium and non-equilibrium processes, effective mass and its measurement, Thermoelectric power, magneto resistivity. (17 hours)

3. **Metal-semiconductor contacts**

   Schottky barrier, P-N junctions, theory of carrier transport in p-n junctions, characteristics of practical junctions and deviations from ideality, capacitance effects, space charge and diffusion capacitance, impurity profiling through capacitance measurements, tunnel diode and applications (14 hours)

4. **Photoconductivity**

   Role of traps and recombination, photo voltaic devices for solar cells and radiation detection, luminescence, light emitting diodes and laser action in p-n junction diodes (10 hours)

5. **Surface states**

   Band bending and effect on bulk properties, Thin film structures, low dimensional semiconductors, Quantum wells, multiple quantum well structures, quantum dot structures, methods of preparation, special characteristics and devices based on quantum wells, Quantum Hall effect, high electron mobility transistor, Enough exercises. (17 hours)

### *References*


1. R.A Smith – Semiconductors, Academic Publishers, Calcutta (1989)
2. A.B. Lev – Semiconductors and electron devices, Prentice Hall (1987)
3. M. Shur – Physics of Semiconductor devices, Prentice Hall (1990)
4. S.M. Sze – Physics of Semiconductor devices, Wiley Eastern (1991)
5. W. Schockley – Electrons and Holes in semiconductors, D. Van Nostrand (1950)
6. W.C. Dunlop – An introduction to semiconductors, Wiley (1957)


## PHY4E20 – MICROPROCESSORS, MICROCONTROLLERS AND APPLICATIONS

*Number of Contact Hours: 72 hrs*

*Number of Credits: 4*

### Course Outline

1. **Microprocessor and Assembly language programming**

   Microprocessor as CPU, Internal architecture of Intel 8085, Instruction set, Addressing modes, Examples of Assembly language programming, Addition and subtraction of 2 byte numbers, multiplication and division of 1 byte numbers, Sorting of 1 byte numbers (12 hrs) Text: 1. Introduction to Microprocessors–A.P. Mathur (Tata-McGraw Hill). Fundamentals of Microprocessors and Micro Computers"– B. Ram-Dhanapati Rai

2. **Microprocessor timings; Interfacing memory and I/O devices**

   Instruction cycles, machine cycles and timing diagram, address space partitioning, generation of control signals for memory and I/O device interfacing, memory interfacing, I/O device interfacing, Address decoding using 74LS138 (10 hrs) Text: 1. "Introduction to Microprocessors" –A.P. Mathur (Tata-McGraw Hill). 2 Fundamentals of Microprocessors and Micro Computers"– B. Ram- Dhanapati Rai

3. **Peripheral devices and interfacing**

Programmable Peripheral Interface- Intel 8255, Programmable Interval Timer- Intel 8253, Programmable DMA controller- Intel 8257, Programmable Interrupt controller- Intel 8259. ADC interfacing - General idea with block diagram, 7 segment LED display interfacing – General idea of display and driver (16 hrs) Text 1. Fundamentals of Microprocessors and Micro Computers– B. Ram – Dhanapati Rai

Introduction to Microprocessors – A.P. Mathur (Tata-McGraw Hill). Microprocessors – Architecture, Programming and Applications with 8085 - R. S. Gaonkar (Wiley Eastern)

4. **Microcontrollers and Programming**

Microcontroller vs microprocessor, microcontrollers in embedded systems. Overview of AVR family of microcontrollers, simplified block diagram of AVR microcontroller, General idea of ROM, RAM, EEPROM, I/O pins and peripherals in microcontroller. AVR architecture and Assembly level programming – General purpose registers, Data memory and instructions, status register and instructions, branch instructions, call and time delay loops; Assembler directives, sample programs. Text: (Relevant sections from chapters 1,2 and 3: Textbook 4) Arithmetic and logical instructions – sample programs. (16 hrs) Text: (Relevant sections from chapters 5: The Book 4)

5. **AVR Programming**

I/O programming, I/O port pins and functions, features of ports A, B, C and D, dual role of Ports, sample programs. I/O ports and bit addressability. Text: (Relevant sections from chapter 4: Book 4) AVR programming in C: C language data types for AVR, C programs for arithmetic, logic time delay and I/O operations. (18 hrs) Text: (Relevant sections from chapter 7: Book 4)

## *Reference*

1. Introduction to Microprocessors–A.P. Mathur (Tata-McGraw Hill).
2. Fundamentals of Microprocessors and Micro Computers"– B. Ram- Dhanapati Rai
3. Microprocessors – Architecture, Programming and Applications with 8085 - R. S. Gaonkar (Wiley Eastern)
4. The AVR microcontroller and embedded systems – using Assembly and C. Muhammad Ali Mazidi, Sarmad Naimi, Sepehr Naimi, Prentice Hall – Pearson

## *Reference books*

1. Programming and customizing the AVR microcontroller: Dhananjay V Gadre.
2. Embedded C programming and the Atmel AVR: Barnett, Cox, O'Cull.

# SEMESTER – III & IV

## A) PHY3L05 & PHY4L06 – PRACTICAL (MODERN PHYSICS)

### Course Outline

*External Practical Exam for PHY3L05 & PHY4L06 together will be conducted at the end of 4th semester.*

*At least **10** experiments are to be done from **Part A** and **2** each from the elective paper as listed in **Part B**. If no practicals have been given for a particular elective paper, two more experiments from Part A should be done. It may be noted that some experiments are given both in Part A and B – of course such experiments can be done only once: either as included in part A or in part B. Internal evaluation to be done in each semester and final grades to be intimated to the controller at the end of $2^{nd}$ and 4th semesters. One mark is to be deducted from internal marks for each experiment not done by the student if the required total number of experiments are not done in the semesters. The PHOENIX/EXPEYES Experimental Kit developed at the Inter University Accelerator Centre, New Delhi, may be used for experiments wherever possible.*

## PART A

1. G.M. Counter plateau and statistics of counting - To obtain the plateau, operating voltage and to verify the distribution law satisfied by the radioactive decay
2. Absorption coefficient for beta & gamma rays -To determine the absorption coefficient of the given materials using a G. M. Counter
3. Feather analysis – End point energy - To determine the end point energy of the beta particles from a given source using Feather analysis
4. Scintillation counter - To calibrate the given gamma ray (scintillation) spectrometer using standard gamma sources and to determine the energy of an unknown gamma ray source
5. Compton scattering - To verify the theoretical expression for the energy of the Compton scattered gamma rays at a given angle using a Scintillation gamma spectrometer / determine the rest mass energy of the electron
6. Half life of Indium – thermal neutron absorption - To determine the half life of In-116 by irradiation of in foil and beta counting using a GM counter
7. Photoelectric effect in lead - To get the spectrum of X rays emitted form lead target by photo electric effect using Cs-137 gammas
8. Conductivity, Reflectivity, sheet resistance and refractive index of thin films
9. Hall effect in semiconductors-To determine the carrier concentration in the given specimen of semiconducting material
10. ESR spectrometer – Determination of g factor
11. Rydberg constant determination
12. Absorption spectrum of KMnO4 and Iodine. To determine the wavelength of the absorption bands of KMnO4 and to determine the dissociation energy of iodine molecule from its absorption spectrum.
13. Ionic conductivity of KCl/NaCl crystals
14. Curie Weiss law -To determine the Curie temperature
15. To study the Thermoluminescence of F-centres of Alkali halides
16. Variation of dielectric constant with temperature of a ferroelectric material (Barium Titanate)

17. Polarization of light and verification of Malu's law.
18. Refractive index measurement of a transparent material by measuring Brewster's angle
19. Measurement of the thermal relaxation time constant of a serial light bulb.
20. Dielectric constant of a non-polar liquid
21. Vacuum pump – pumping speed
22. Pirani gauge – characteristics
23. Ultrasonic interferometer. To determine the velocity and compressibility of sound in liquids.
24. Study of LED characteristics - Determination of wavelength of emission, I-V characteristics and variation with temperature, variation of output power vs. applied voltage
25. Optical fibre characteristics - To determine the numerical aperture, attenuation and band width of the given optical fibre specimen
26. Band gap energy of Ge by four probe method. -To study bulk resistance and to determine band gap energy.
27. Thomson's e/m measurement. -To determine charge to mass ratio of the electron by Thomson's method.
28. Determination of Band gap energy of Ge and Si using diodes.
29. Millikan's oil drop experiment. To measure the charge on the electron.
30. Zener voltage characteristic at low and ambient temperatures – To study the variation of the Zener voltage of the given Zener diode with temperature
31. Thermionic work function – To determine the thermionic work function of the material of the cathode of the given vacuum diode/triode from the characteristic at different filament currents

## PART B

### I. ADVANCED ELECTRONICS

1. Simple temperature control circuit
2. Binary rate multiplier
3. Optical feedback amplifier
4. Frequency modulation and pulse modulation
5. Binary multiplier
6. Write ALP and execute using 8085 kit for generating a square wave of desired frequency using PPI 8255 interfacing. observe the output on CRO and measure frequency.
7. Write ALP to alternately switch on/off a green and a red LED within a given small time interval. Execute using 8085 kit.
8. Write ALP to convert a given d.c voltage (between 0 and 5 V) using ADC 0800/0808 interfaced to 8085 microprocessors. Execute using the given kit and check the result.

## II MATERIAL SCIENCE / CONDENSED MATTER PHYSICS

1. Curie-Weiss law – (To determine the Curie temperature)
2. Solid-liquid phase transitions – measurement of resistivity of metals
3. Growth of a single crystal from solution and determination of structural, electrical and optical properties
4. Study of colour centres – Thermoluminiscence glow curves
5. Ionic conductivity in KCl/NaCl crystals
6. Thermoluminiscence spectra of alkali halides
7. Thermo emf of bulk samples (Al/Cu)
8. Electron spin resonance
9. Strain guage – Y of a metal beam
10. Variation of dielectric constant with temperature of a ferro electric material (Barium titanate)
11. Ferrite specimen – variation of magnetic properties with composition

## III COMMUNICATION ELECTRONICS

1. Amplitude modulation and demodulation
2. Frequency modulation and demodulation
3. Pulse amplitude modulation and demodulation
4. Pulse code modulation and demodulation
5. Pulse position modulation and demodulation
6. Study of crystal detector
7. L-C transmission line characteristic
8. Tuned RF amplifier
9. Seely discriminators
10. AM transmitter
11. Radiation from dipole antenna
12. Optical fibre characteristics (Numerical aperture, attenuation and bandwidth)
13. Optical feedback circuit (Feedback factor, gain and frequency response)

## IV. ADVANCED NUCLEAR PHYSICS and RADIATION PHYSICS

1. Half-life of Indium – thermal neutron absorption - To determine the half-life of In-116 by irradiation of In foil and beta counting using a GM counter
2. Alpha spectrometer - To calibrate the given alpha spectrometer and determine the resolution
3. Photoelectric effect in lead - To get the spectrum of X rays emitted form lead target by photo electric effect using Cs-137 gammas
4. Inner bremsstrahlung - To study the intensity spectrum of inner bremsstrahlung from given gamma source

5. Coincidence circuits - To construct and study the performance of series and parallel coincidence circuits using transistors and to determine the resolving time
6. Single channel analyzer - Study of characteristics of a SCA using precision pulser
7. Ionization chamber - Study of variation of pulse height with applied voltage and to obtaing the pulse height spectrum of X-rays
8. Proportional counter - Study of variation of pulse height with applied voltage and to obtaining the pulse height spectrum of X-rays
9. Track detector – track diameter distribution - To measure the diameters of the alpha tracks in CR-39 track detector
10. Beta ray spectrometer - To plot the momentum distribution of beta particles from given beta sources
11. Range of alpha particles in air and mylar - To determine the range of alpha particles from Am-241 source in air and in mylar using either a surface barrier detector or a GM counter

## V EXPERIMENTAL TECHNIQUES

1. Rydberg constant – hydrogen spectrum
2. ESR – Lande g factor
3. IR spectrum of few samples
4. Vacuum pump – pumping speed
5. Vacuum pump – Effect of connecting pipes
6. Absorption bands of Iodine
7. Vibrational bands of AlO
8. Pirani gauge – characteristics
9. Thin films – electrical properties (sheet resistance)
10. Thin films – optical properties (Reflectivity, transmission, attenuation, refractive index)

## VI ELECTRONIC INSTRUMENTATION

1. Strain gauge
2. Simple servomechanism
3. Temperature control
4. Coincidence circuits
5. Multiplexer
6. IEEE 488 Electrical interface
7. Single channel analyzer
8. Differential voltmeter
9. Frequency synthesizer – Signal generator
10. Silicon controlled rectifier – characteristics

11. Silicon controlled rectifier – power control

### VII DIGITAL SIGNAL PROCESSING

1 (a) Compute and plot the cross and auto correlation coefficients of one dimensional signal (b)Estimate the pitch period of a periodic signal using correlation method. (3 hours).

2 (a) Compute and plot the convolution coefficients of one-dimensional signal. (b)Estimate the pitch period of a periodic signal using convolution method. (3 hours).

3 Write a program for determining the Linear and circular Convolution of a finite sequence x(n) and h(n). Accept the sequences x(n) and h(n) from the user. Display the output sequence y(n). Plot all three sequences. (3 hours).

4 Compute the N-point DFT of the following. Vary the value of N and visualize the effect with N=8, 16, 24, 64,128,256. (3 hours).

5 Design an N point FIR low pass filter with cutoff frequency 0.2* pi using i) Rectangular ii) Hamming iii) Kaiser windows. Plot for N=16,32,64,128, 256.Compare with N=1024 and record your observations. (3 hours).

**(The programs are to be executed in Python/MATLAB)**

### VIII LASER SYSTEMS, OPTICAL FIBRES AND APPLICATIONS

1. Optical fibre characteristics (Numerical aperture, attenuation and bandwidth)
2. Optical feedback circuit (Feedback factor, gain and frequency response
3. Determination of size of lycopodium particles by Laser diffraction

## *Reference Books for PHY 305 & PHY 405*


1. B.L. Worsnop and H.T. Flint – Advanced Practical Physics for students – Methusen & Co (1950)
2. E.V. Smith – Manual of experiments in applied Physics – Butterworth (1970)
3. R.A. Dunlap – Experimental Physics – Modern methods – Oxford University Press (1988)
4. D. Malacara (ed) – Methods of experimental Physics – series of volumes – Academic Press Inc (1988)
5. A. C. Melissinos, J. Napolitano - Experiments in Modern Physics -Academic Press 2003.


# B) PHY4L07 – PRACTICAL (COMPUTATIONAL PHYSICS)

## Course Outline

*The programs are to be executed in Python. For visualization Pylab/matplotlib may be used. At least 10 experiments are to be done, opting any 5 from Part A and another 5 from Part B. The Practical examination is of 6 hours duration.*

## Part A

1. Interpolation: To interpolate the value of a function using Lagrange's interpolating polynomial
2. Least square fitting: To obtain the slope and intercept by linear and Non-linear fitting.
3. Evaluation of polynomials. Bessel and Legendre functions: Using the series expansion and recurrence relations.
4. Numerical integration: By using Trapezoidal method and Simpson's method
5. Solution of algebraic and transcendental equations. Newton Raphson method, minimum of a function
6. Solution of algebraic equation by Bisection method
7. Matrix addition, multiplication, trace, transpose and inverse
8. Solution of second order differential equation- Runge Kutta method
9. Monte Carlo method: Determination of the value of □ by using random numbers
10. Numerical double integration
11. Solution of parabolic/elliptical partial differential equations

(e.g.: differential equations for heat and mass transfer in fluids and solids, unsteady behaviour of fluid flow past bodies, Laplace equation etc.,)

## Part B

1. To plot the trajectory of a particle moving in a Coulomb field (Rutherford scattering) and to determine the deflection angle as a function of the impact parameter
2. Generate phase space plots - To plot the momentum v/s position plots for the following systems: (i) a conservative case (simple pendulum) (ii) a dissipative case (damped pendulum)
3. Simulation of the wave function for a particle in a box - To plot the wave function and probability density of a particle in a box; Schrödinger equation to be solved and eigen value must be calculated numerically.
4. Simulation of a two slit photon interference experiment: To plot the light intensity as a function of distance along the screen kept at a distance from the two-slit arrangement.
5. Trajectory of motion of (a) projectile without air resistance (b) projectile with air resistance
6. Logistic map function – Solution and bifurcation diagram
7. Experiment with Phoenix/expEYES kit - Time constant of RC circuits by curve fitting. *
8. Experiment with Phoenix/expEYES kit - Fourier analysis of different waveforms captured using the instrument. *

(*If Phoenix is not available, data may be given in tabulated form)

9. Simulation of Kepler's orbit and verification of Kepler's laws.
10. Simulations of small oscillations in simple molecules: Diatomic molecule/Triatomic molecule for various lengths (any one case)
11. Simulation of random walk in 1D/2D and determination of mean square distance.

12. Simulation of magnetic field - To plot the axial magnetic field v/s distance due to a current loop carrying current.
13. Simulation of the trajectory of a charged particle in a uniform magnetic field.
14. Simulation of polarisation of electromagnetic waves.
15. Simulation of coupled oscillators - Phase space portraits.

## *Reference*


1. Computational Physics - An introduction., R. C. Varma, P. K. Ahluwalia and K. C. Sharma, New Age International Publishers
2. Numpy Reference guide, http://docs.scipy.org/doc/numpy/numpy-ref.pdf (also, free resources available on net)
3. Matplotlib, http://matplotlib.sf.net/Matplotlib.pdf (and other free resources available on net)
4. Numerical Methods in Engineering and Science, Dr. B S Grewal, Khanna Publishers, New Delhi (or any other book)
5. Numerical Methods, E Balagurusamy, Tata Mc Graw-Hill
6. Numerical Methods, T Veerarajan, T Ramachandran, Tat Mc Graw-Hill
7. Numerical Methods with Programs I BASIC, Fortran & Pascal, S Balachandra Rao, C K Shantha. Universities Press
8. Numerical methods for scientists and engineers, K. Sankara Rao, PHI
9. Introductory methods of numerical analysis, S. S. Shastry, (Prentice Hall of India,1983)
10. Numerical Methods in Engineering with Python by Jaan Kiusalaas


Note: Experiments from Part A can be done with data from physical situations where ever possible. For example, consider the following cases.

a) The load W placed on a spring reduces its length L. A set of observations are given below. Calculate force constant and length of the spring before loading

| W (kg) | 0.28 | 0.51 | 0.67 | 0.93 | 1.15 | 1.38 | 1.60 | 1.98 |
|---|---|---|---|---|---|---|---|---|
| L (m) | 6.62 | 5.93 | 4.46 | 4.25 | 3.3 | 3.15 | 2.43 | 1.46 |

b) The displacements of a particle at different instants are given below. What is the time instant, at which the displacement is 70.2 m?

| t(s) | 1.0 | 2.2 | 301 | 4.5 | 5.8 | 6.7 | 7.6 | 8.3 | 9.4 |
|---|---|---|---|---|---|---|---|---|---|
| s(m) | 3.0 | 10.56 | 19.07 | 37.12 | 59.16 | 77.38 | 98.04 | 115.78 | 146.6 |

**PATTERN OF QUESTION PAPER**

(for Core and Elective courses in I/II/III/IV Sem M. Sc. Physics (**CBCSS-PG**) W. E. F. 2019)

**Code: (eg. PHY1C01) Subject (eg. Classical Mechanics)**

Time: 3 Hours. Total weightage: 30

**Section A**

(8 Short questions, each answerable within 7.5 minutes)

Answer all questions, each carry weightage 1)

*Question Numbers 1 to 8* Total weightage 8x1=8

**Section B**

(4 Essay questions, each answerable within 30 minutes)

Answer ANY TWO questions, each carry weightage 5)

*Question Numbers 9 to 12* Total weightage 2x5=10

**Section C**

(7 Problem questions, each answerable within 15 minutes)

Answer ANY FOUR questions, each carry weightage 3)

*Question Numbers 13 to 19* Total weightage 4x3=12