Master of Science in Physics

M.Sc. (Physics)

(Semester System)

Central Department of Physics

Tribhuvan University, Kirtipur

Feb 2014

Note: This curriculum is approved by the full subject committee meeting held at CDP, TU, Kirtipur on 20 Magh, 2070.

Introduction

The Central Department of Physics (CDP), Tribhuvan University has been helping to bring the world of Physics education and research to interested Nepalese students since 1965 by offering *Physics* course in the Master's level. The CDP has produced more than 2500 physics graduates in the nation. Time has come to join international standard by upgrading our higher education system. CDP is going to introduce semester system from the year 2014.

Objectives

The courses are designed with the following objectives:

1. To give students up to date knowledge of recent trends in physics.
2. To impart skills to the students in the areas of theoretical, experimental and applied physics.
3. To develop manpower in teaching physics at the tertiary level and to conduct research in physics.
4. To produce high level research manpower in physics.

Eligibility for Admission

The candidates who have passed B.Sc. degree with major in physics from Tribhuvan University or equivalent degree with the same major from a university recognized by Tribhuvan University shall be considered eligible to apply for admission to M.Sc. degree course.

Admission Criteria

An applicant seeking admission to M.Sc. physics must appear in an entrance examination conducted by the Central Department of Physics. The applicant who fails to appear in the entrance examination or to obtain a minimum qualifying score will not be given admission.

Course Structure

There will be four regular semesters in two years. The semester duration will be 15-18 weeks (15 weeks for course work and 1-3 weeks for evaluation). A student should complete 60 credit hour (hereafter CH) courses in order to earn Master’s degree in physics from Tribhuvan University. A credit hour (CH hereafter) means teaching a theory course work for 60 minutes each week throughout the semester. For the laboratory work, 3 CH is for a semester. There will be three hours laboratory class everyday throughout the semester for 3 CH. This includes laboratory assignments and evaluation. The course load will be 12-18 credit hours per semester. This course offers compulsory theoretical courses, laboratory work, computation work, elective and optional thesis/dissertation work in physics. There will be altogether twenty courses. In the first two semesters, all ten courses are compulsory and in the third and fourth semesters, there will be five compulsory courses and five elective courses.

Table 1: List of the Compulsory and Elective Courses offered for the semester system.

Sem-ester	Course Code No.	Course title	Full Mark	Pass Mark	CH	Lecture/Lab+ Tutorial (hrs)
1st	Phy501	Mathematical Physics I	50	25	3	45+15
1st	Phy502	Classical Mechanics	50	25	3	45+15
1st	Phy503	Quantum Mechanics I	50	25	3	45+15
1st	Phy504	Electronics	50	25	3	45+15
1st	Phy505	Physics Practical I (Compulsory)	50	25	3	180+45
2nd	Phy551	Mathematical Physics II	50	25	3	45+15
2nd	Phy552	Statistical Mechanics	50	25	3	45+15
2nd	Phy553	Solid State Physics	50	25	3	45+15
2nd	Phy554	Electrodynamics I	50	25	3	45+15
2nd	Phy555	Physics Practical II (Compulsory)	50	25	3	180+45
3rd	Phy601	Electrodynamics II	50	25	3	45+15
3rd	Phy602	Quantum Mechanics II	50	25	3	45+15
3rd	Phy603	Physics Practical (Advanced)	50	25	3	180+45
4th	Phy651	Quantum Mechanics III	50	25	3	45+15
4th	Phy652	Nuclear & Particle Physics	50	25	3	45+15
4rd	Phy653a	Electronics Practical	50	25	3	180+45
4th	Phy653b	Computational Physics	50	25	3	180+15
4th	Phy653c	Project	50	25	3	-
Elective courses (Any Two) Including dissertation						
3rd	Phy611	Advanced Solid State Physics I	50	25	3	45+15
3rd	Phy612	Micro and Optoelectronics I	50	25	3	45+15
3rd	Phy613	Seismology (Geophysics) I	50	25	3	45+15
3rd	Phy614	Atmospheric Physics I	50	25	3	45+15
3rd	Phy615	Plasma Physics I	50	25	3	45+15
3rd	Phy616	Biomedical Physics I	50	25	3	45+15
3rd	Phy617	Gravitation & Cosmology I	50	25	3	45+15
3rd	Phy618	Astrophysics I	50	25	3	45+15
4th	Phy661	Solid State Physics II	50	25	3	45+15
4th	Phy662	Micro and Optoelectronics II	50	25	3	45+15
4th	Phy663	Seismology (Geophysics) II	50	25	3	45+15
4th	Phy664	Atmospheric Physics II	50	25	3	45+15
4th	Phy665	Plasma Physics II	50	25	3	45+15
4th	Phy666	Biomedical Physics II	50	25	3	45+15
4th	Phy667	Gravitation & Cosmology II	50	25	3	45+15
4th	Phy668	Astrophysics II	50	25	3	45+15
4th	Phy699	Dissertation	100	50	6	-
Total			1000	400	60	720+720+600

Note: *The Course Number (Phy505 & Phy555) is for Physics Practical I & II (Compulsory). The term 'Compulsory' means the general, nuclear, optical and electronics experiments in separate laboratories. The number of teachers in the laboratory classes depends on the number of laboratories and number of students as per TU rule (1 teacher for 10 students & at least one teacher in a laboratory)*

A student can choose any two courses from the electives *including dissertation*. *There will be an option between one of the elective courses and the dissertation. Student should have at least B- grade in all credits of first semester in order to enroll for the dissertation.* The practical course in the third semester is compulsory however in the last semester, three optional courses namely electronics practical, project and computational physics will be offered. O*ne can choose project work or perform electronics experiments or take computational physics course. However, one student cannot choose dissertation and project work both*.

The first and the second semesters mainly focus on general theoretical courses as well as general experimental courses. The third semester mainly focuses on research oriented courses including computation courses. The fourth semester will be allocated for completion of the research work and the thesis writing or advanced courses. Elective courses will be offered by the Central Departments and other TU constituent and affiliated colleges on the basis of the availability of subject experts. In any case, at least 15% students of full quota are required to run an elective course. The physics subject committee may also develop new elective courses in the future.

Tutorial Class

There will be one 50 minutes long tutorial (or consultant) class per course per week. Concerned teacher will decide the mode of this class. This class will be used for the home assignment, class test, objective test, mid-term and final test for the internal assessment.

Hours of Instruction

a) Working days: 16 weeks (96 working days) in an academic semester.
b) Nature of the Classes:
   i) **Theory**: One theory paper of 50 marks will have 3 hours of lectures per week (45 minutes long four classes) throughout the semester. For a course, there should be 60 theory classes in a semester.
   ii) **Tutorial**: A tutorial class should be given per week per subject, mainly for the numerical, concepts, class tests, viva tests, discussions, etc. This class should be arranged for smaller number of students (up to 30). Altogether 15 hours tutorial classes should be held per semester per course (both theory and practical).
   iii) **Practical**: One CH of lab work is equivalent to 6 hours per week. One practical paper of 3 CH should have 18 (three hours lab works per day) hours of Practical per week throughout semester. One faculty will be allotted for 10 students. The first and second semester students need to perform lab work every day throughout the semester.
c) Attendance: 80 percent attendance in the class (theory, practical, tutorial) is required.

A brief block diagram showing course structure, full marks and Credit Hour is shown in the diagram below:

Course Structure of Semester System for Masters' Degree in Physics

Semester					
First Semester	Phy501 Mathematical Physics I	Phy502 Classical Mechanics	Phy503 Quantum Mechanics I	Phy504 Electronics	Phy505 Practical (compulsory)
Full Marks: 250	50	50	50	50	50
CH: 15	3	3	3	3	3
Second Semester	Phy551 Mathematical Physics II	Phy552 Statistical Mechanics	Phy553 Solid State Physics	Phy554 Electrodynamics I	Phy555 Practical (compulsory)
Full Marks: 250	50	50	50	50	50
CH: 15	3	3	3	3	3
Third Semester	Phy601 Electrodynamics II	Phy602 Quantum Mechanics II	Phy6XX Advanced paper 1	Phy6XX Advanced 2 or Thesis	Phy603 Practical (Advanced)
Full Marks: 250	50	50	50	50/0	50
CH: 15	3	3	3	3/0	3
Fourth Semester	Phy651 Quantum Mechanics II	Phy652 Nuclear Physics	Phy6XX Advanced paper 1	Phy6XX Advanced 2 or thesis	Phy653 Practical (a & b or c)
Full Marks: 250	50	50	50	50/100	50
CH: 15	3	3	3	3/6	3

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Kirtipur, Nepal

Total Credit Hour: 60 (Total Marks 1000)
Course Duration: 15-18 weeks
Final : Internal Evaluation: 60% : 40%

CH: Credit Hour
XX: Code Number for Advanced Papers

Evaluation

The evaluation mode is 40% internal and 60% final examinations.

1) **Internal Examination:** The in-semester (internal) examination shall have a total weight of 40% in each course. Students have to obtain 50% to pass the internal exam. The breakdown of in-semester exam will be as follows: Class Attendance: 5%, Home Work + VIVA Examination: 10%, Mid-Term Test: 10% (60 minute exam / scheduled in the calendar) and Final-Term Test: 15% (90 minutes exam / scheduled in the calendar)

   Evaluation will be based on GPA system. Concerned faculties will provide grades to the students. In case a student remains absent in the internal examination due to serious illness will given one-time opportunity to appear in the exam if he/she is able to produce authorize medical certificate.

1) **Final Examination:** Institute of Science and Technology, Tribhuvan University will conduct final examinations. The students will have to pass each course at each level separately. The final examination in each course will be a written examination carrying 60 full mark (this will be reduced to 30 later) and of 3 hours duration. In case percentage of marks obtained by the students in the internal exam exceeds the end-semester (final) examination marks by 20 or more, the marks obtained in the internal examination will be reduced to 80%. The six hours final practical

examination should be held according as semester calendar. Students are required to give one practical examination.

Semester Guidelines

1) The semester system is not only an examination system. The main objective of this system is to enhance student's knowledge, skill and capacity continuously, extensively and in depth.
2) The normal and maximum duration for obtaining the masters' degree is 24 months and 60 months, respectively. Students failing to complete the requirements in 60 months have to re-enroll.
3) Students need to maintain 80% attendance for both theory and laboratory classes. They should be regular in the class. They should enter before starting the classes.

Grade & Grade Point Average (GPA):

1) Total marks obtained in internal (40%) and end-semester (60%) exams shall be graded on absolute bases. The performance of a student shall be made on a four point scheme ranging from 0 to 4 grades. Students shall receive their semester grades and academic transcript grades only in letter grades and GPA scores. The percentage equivalent of the grade and GPA is as follows:

Grade	GPA	%equivalent	Performance
A	4.0	90 and above	Distinction
A-	3.7	80-89.9	Very good
B+	3.3	70-79.9	First Division
B	3.0	60-69.9	Second Division
B-	2.7	50-59.9	Pass
F	0.0	Below 50	fail

2) A student must secure a minimum grade point average (GPA) of 2.7 or Grade B minus (B-) in each course. Student securing only 2.7 in grade point are considered as "pass in individual subject".
3) Semester Grade Point Average (SGPA) is the grade point average of the semester, is calculated as

$$SGPA = \frac{total\ grade\ point\ earned\ in\ a\ semester}{total\ number\ of\ credit\ registered\ in\ a\ semester}$$

4) Cumulative Grade Point Average (CGPA) which is the grade point average of all semester, is calculated as

$$CGPA = \frac{total\ grade\ point\ earned}{total\ number\ of\ credits\ completed}$$

5) In order to pass the semester examination the student must secure a minimum of grade “B” or Cumulative grade point average (CGPA) of 3.0.
6) A student who scores CGPA less than 3 may request for the opportunity to improve the grade in two subjects. The office of the Dean will provide one time opportunity to appear in end-semester exam. The exam of the courses to improve grade shall be held as per the course cycle.
7) Students failing in not more than 2 subjects (courses or credits) in first, second and third semester exams shall appear in make-up exams in the following cycle of exams.
8) Students failing in two subjects in fourth semester shall be given opportunity to appear in make-up exam within the one month after the final result.

Student Seminar, Project & Dissertation

1) A student can give a seminar (minimum 1 hour length) on his interest. For this, students need to get permission from a faculty. Student seminar is optional for students. He will get a certificate for a seminar.
2) A student who opt project or dissertation, should give a pre-presentation before final VIVA examination. The final VIVA examination will be fixed by the dean office, which is a scheduled exam with internal and external examiners. The head of the evaluation committee will be HoD (in case of CDP), M.Sc. program coordinator and/or head of the department. The write up of project and thesis should be in a recommended format.

Academic Calendar

The CDP will publish a schedule of complete academic year for its semesters for the convenience of students and Faculty Members mentioning the following:

1. Semester starting date
2. Detailed class schedule per week
3. Mid-term/Final term test date
4. Holidays during the semester
5. Semester termination date

Students and faculties are responsible to meet the requirement and deadline published for each semester in the academic calendar of the department. Students will also be expected to know and adhere to the rules, regulations, course loads, prerequisites, and policies of the university, as well as those of the departments in which they are enrolled. The general orientation class will be held on that day and the detailed timetable for the all theory and laboratory classes as well as evaluation classes will be provided to all students. The website of the department (http://www.tucdp.edu.np/) will be updated and all information regarding the last minute change in the classes will be informed.

FIRST SEMESTER

Phy501: Mathematical Physics I (45L, 15T, 3CH)

Nature of the course: Theory
Full Marks: 50 Pass Marks: 25

Course Description:

This course contains different areas of mathematics that are used extensively in the study of physics.

Objectives:

The objective of this course is to train the students to use the methods of mathematics to formulate and solve problems in physics, and make them capable to apply this knowledge in higher studies and research.

Course Contents:

1. **Tensor analysis:** 1.1 Law of transformations of vectors, solenoidal vectors, rotational and irrotational vectors, vortex lines 1.2 Application of Vectors 1.3 Special Orthogonal curvilinear coordinates: cylindrical, spherical and ellipsoidal. 1.4 Review of Contravarient, covariant and mixed tensors, Kronecker delta 1.5 Tensors of rank greater than two, scalars or invariants, tensor fields, symmetric and skew symmetric tensors, fundamental operations with tensors, stress tensor, 1.6 Line element and matric tensor, reciprocal tensors, associated tensors, length of a vector, angle between vectors, physical components, 1.7 Christoffel's symbols, transformation laws of Christoffel's symbols, geodesics, covariant derivatives, 1.8 Tensor form of gradient, divergence, curl and Laplacian. [12 hours]

2. **Linear vector spaces:** 2.1 Vectors in n-dimensions, linear independence, Schwartz inequality, representation of vectors and linear operators with respect to a basis, change of basis, Schmidt orthogonalization process, 2.2 Linear operators and their matrix representation with examples [4 hours]

3. **Group Theory:** 3.1 Introduction, 3.2 Representation of groups, 3.3 Symmetry and physics 3.4 Discrete and continuous groups 3.5 Symmetric group 3.5 Symmetric group 3.6 Orthogonal groups 3.7 Lie groups 3.8 U(1) and SU(2) groups (introduction only) [8 hours]

4. **Review of Integral transforms:** 4.1 Fourier transform and convolution theorem, 4.2 Laplace transform: Laplace transform of derivatives and integrals, Derivative of Laplace Transform 4.3 Use of Fourier and Laplace transform in solving partial differential equations. [5 hours]

5. **Differential equations:** 5.1 Review of Series solutions of Bassels's, Legendre's, Hermite's, Laguerre's differential equations, 5.2 Associated Legendre and Laguerre polynomials, orthogonality and generating functions. 5.3 Sturm-Liouville's Theory – Self adjoint operators, Hermitian operators, completeness of eigen functions, Green's functions-eigenfunction expansion [10 hours]

6. **Partial differential equations:** 6.1 Review of Wave equations, Laplace, Poisson and diffusion equations, boundary value problems, 6.2 Green's method of solving partial differential equations. [6 hours]

Text Books:

1. Arfken G.B. , Weber H.J. and Harris F.E – **Mathematical Methods for Physicists**, 7th ed., Academic Press, Amsterdam (2013)

2. Mathew, J. & Walker, R. – **Mathematical Methods in Physics,** Benjamin, Menlo Park, Second Edition (1970)

3. Margenu & Murphy – **Mathematics for Physicist and Chemist**, East West Press Pvt. Ltd., New Delhi (1964)

4. Spiegel, Murray R. – **Vector Analysis (Schaum Series),** McGraw Hill, London (1992)

5. Morse, P.M. & Feshbach H. – **Methods of Theoretical Physics,** Part I & II, McGraw Hill, New York (1953)

Reference Books:

1. Rajput B.S.– **Mathematical Physics**, Pragati Prakashan, India (1997)

2. Gupta B.D.– **Mathematical Physics**, Vikash Publishing House, India (1994)

Phy502: Classical Mechanics (45L, 15T, 3CH)

Nature of the course: Theory
Full Marks: 50 Pass Marks: 25

Course Description:

This course contains a description and formulation of classical mechanics.

Objectives:

The objective of this course is to provide the students with knowledge of classical mechanics, and enable them to apply the knowledge for solving various problems in related topics, and also for higher studies and research.

Course Contents:

1. **Constraints:** 1.1 Constraints, 1.2. Generalized coordinates, generalized displacement, generalized velocity, generalized acceleration, generalized momentum, generalized force and generalized potential, 1.3. D'Alembert's principle and Lagrange's equations [4 hours]

2. **Variational principles and Lagrange's equations:** 2.1. Calculus of variations: Geodesics, Minimum surface of revolution, The brachistochrone problem, 2.2. Hamilton's principle and derivation of Lagrange's equation, 2.3. Extension of Hamilton's principle to nonholonomic systems (Method of Lagrange undetermined multipliers), 2.4. Conservation theorems and symmetry properties, 2.5. Energy function and the conservation of energy [7 hours]

3. **The Central Force Problem:** 3.1. Reduction to the equivalent one-body problem, 3.2 The equations of motion and first integrals, 3.3 The equivalent one-dimensional problem, and classification of orbits, 3.4 The Virial theorem, 3.5 The differential equation for the orbit, and integrable power-law potentials, 3.6 Conditions for closed orbits (Bertrand's theorem), 3.7 The Kepler's problem: Inverse-square law of forces, 3.8 The motion in time in the Kepler's problem, 3.9 The Laplace-Runge-Lenz vector, 3.10 Scattering in a central force field, 3.11 Transformation of the scattering problem to laboratory coordinates [10 hours]

4. **Oscillations:** 4.1. Formulation of the problem, 4.2. The eigenvalue equation and the principal axis transformation, 4.3. Free vibrations of a linear triatomic molecule [3 hours]

5. **The Hamilton equations of motion:** 5.1. Legendre transformations and the Hamilton equations of motion, 5.2. Cyclic coordinates and conservation theorems, 5.3. Derivation of Hamilton's equations from variational principle, 5.4. The principle of least action [4 hours]

6. **Canonical transformations:** 6.1. The equations of canonical transformation, 6.2. The symplectic approach to canonical transformation, 6.3 Poisson brackets and other canonical invariants, 6.4. Equations of motion, Infinitesimal canonical transformations, and Conservation theorems in the Poisson bracket formulation, 6.5 The angular momentum Poisson bracket relations, 6.6. Symmetry groups of mechanical systems [7 hours]

7. **Hamilton-Jacobi theory and action-angle variables:** 7.1. The Hamilton-Jacobi equation for Hamilton's principal function, 7.2. The Hamilton-Jacobi equation for Hamilton's characteristic function, 7.3. Separation of variables in the Hamilton-Jacobi equation, 7.4. Action-angle variables, 7.5. The Kepler problem in action-angle variables [6 hours]

8. **Introduction to the Lagrangian and Hamiltonian formulations for continuous systems and fields:** 8.1. The transition from a discrete to a continuous system, 8.2. The Lagrangian formulation for continuous systems, 8.4 Quantization of electromagnetic field 8.3. Hamiltonian formulation [4 hours]

Text books:

1. Herbert Goldstein, Charles Poole and John Safko, **Classical Mechanics**; Pearson Education (2002).

Reference books:

1. R. G. Takwale and P. S. Puranik, **Introduction to Classical Mechanics**, Tata McGraw-Hill (1997)

2. T. W. B. Kibble and F. H. Berkshire, **Classical Mechanics**, Prentice Hall (1996)

Phy503: Quantum Mechanics I (45L, 15T, 3CH)

Nature of the course: Theory
Full Marks: 50 Pass Marks: 25

Course Description:

This course develops the formulation of quantum mechanics and its applications in various areas.

Objectives:

The objective of this course is to provide the students with adequate knowledge of non-relativistic quantum mechanics and enable them to apply the knowledge to study the atomic, molecular and other mechanical systems.

Course Contents:

1. **Formulation of Quantum Theory:** 1.1 Development of Quantum Theory: Copenhagen Interpretation 1.2 Review of de Broglie's relations, wavefunctions and Schrodinger equation and Uncertainty principle [3 hours]

2. **Mathematical Tools of Quantum Mechanics:** 2.1 One particle wave function space: vector space, scalar product, linear operator, closure relation, discrete and continuous bases 2.2 State space, Dirac notation: ket and bra vectors, duel space, correspondence between ket and bra, projection operator, Hermitian conjugation 2.3 Representation in state space: orthonormalization relation, closure relation, matrix representations of kets, Bras, operators, change of representations 2.4 Eigenvalue equations, observables: definition of an observable, the projectors, sets of commuting observables, complete sets of commuting observables [10 hours]

3. **Postulates of Quantum Mechanics:** 3.1 Introduction 3.2 Statement of the postulates 3.3 Physical interpretation 3.4 Physical implications of the Schrodinger equation: superposition principle, conservation of probability, equation of motion for an observable, principle of first quantization, Ehrenfest theorem [7 hours]

4. **One Dimensional Barriers:** 4.1 Free particle, 4.2 Concept of potential, 4.3 Potential barrier, 4.4 Ramsauer Townsend effect, 4.5 Smooth barrier, 4.6 Cold emission of electrons in a metal, 4.7 Alpha decay, 4.8 Virtual binding. [6 hours]

5. **Bound States in one Dimension:** 5.1 Bound states, 5.2 Parity, 5.3 Potential with finite walls, 5.4 Box normalization, 5.5 Double well model of a molecule, 5.6 Kronig-Penny model for metals, 5.7 Linear harmonic oscillator, 5.8 Creation

operators, momentum representation for oscillators, 5.9 Two coupled harmonic oscillators. [8 hours]

6. **Motion in Three Dimensions:** 6.1 Integrals of motion, 6.2 Particle in a centrally symmetric field, 6.3 Angular solutions, 6.4 Orbital angular momentum, 6.5 Properties of spherical harmonics [6 hours]

7. **Central Potential Problems:** 7.1 Two interacting particles, 7.2 Rigid rotator, 7.3 Free particle radial function, 7.4 Particle in a spherical box, 7.5 Spherical potential well of finite depth, 7.7 Isotropic harmonic oscillator, 7.8 General results for two particles bound states. [7 hours]

Text Books:

1. Agrawal, B.K. & Prakash, H. – **Quantum Mechanics,** Prentice Hall of India, New Delhi (1997)

2. Cohen-Tannoudji, C, Duui. B. & Laloe, F. **– Quantum Mechanics,** Vol. I & II, John Wiley (1977)

Reference Books:

1. Schiff, L. I.- **Quantum Mechanics,** 3rd ed., Tata McGraw Hill, Delhi (1968)

2. Merzbacher, E. - **Quantum Mechanics,** 2nd ed., John Wiley, New York (1969)

3. Messiah, A. - **Quantum Mechanics,** John Wiley, New York (1963)

4. Thankappan, V. K. - **Quantum Mechanics,** Wiley Eastern Ltd., New Delhi (1993)

Phy504: Electronics (45L, 15T, 3CH)

Nature of the course: Theory
Full Marks: 50 Pass Marks: 25

Course Description:

This course further develops on the theory and applications of electronics.

Objectives:

The course will give an understanding of the formulation of the theory of electronics, so that the students will be able to apply the knowledge in different situations, and also in higher studies and research.

Course Contents:

Analog Electronics: Circuit Theory:

1. **(a) Network Transformation:** 1.1 Network definition, Mesh and node circuit analysis, Principle of duality, 1.2 Reduction of complicated network, Conversions between T and π sections, 1.3 The superposition theorem, The reciprocity theorem, 1.4 Brief revision of Thevnin's, Norton's Theorem and The maximum power-transfer theorem, 1.5 A.C. bridge (Lattice network), Sensitivity in bridge measurements [5 hours]

   (b) Resonance: 1.6 Definition of Q, Series resonance and Band width of the series resonant circuit, 1.7 Parallel resonance circuit or anti-resonance, Condition for maximum impedance and impedance variation with frequency, 1.8 Band width of anti- resonant circuits, The general case-resistance present in both branches and anti-resonance at all frequencies. [3 hours]

Semiconductor Circuit Response and Design:

2. **(a) Integrated, Differential and Operational Amplifier Circuits:** 2.1 Overview of CE, CC, CB and CS amplifiers, 2.2 Introduction of an ideal differential amplifier (BJT and FET), Common mode parameters, 2.3 Practical differential amplifiers, Introduction to operational amplifiers. [3 hours]

   (b) Operational Amplifier Theory: 2.4 The ideal operational amplifier, 2.5 Slew rate, Offset current and voltages. [2 hours]

   (c) Application of Operational Amplifiers: 2.6 Controlled voltage and current sources, 2.7 Integration, Differentiation and Wave-shaping, 2.8 Oscillators: The Barkhausen criterion, RC phase shift, Wein-bridge and Crystal, 2.9 Concept of active filters and its design, 2.10 Introduction of Clipping, Clamping and Rectifying circuits. [4 hours]

3. **(a) Frequency response:** 3.1 Definition and basic concepts, Decibel and logarithmic plots, Series capacitance and low frequency response, 3.2 Shunt capacitance and high frequency response, Transient response, Low and high frequency response of BJT and FET amplifiers. [2 hours]

(b) Power Supply and Voltage Regulators: 3.3 Introduction, Rectifiers and different types of filters, 3.4 Voltage multipliers, 3.5 Voltage regulation: Series and shunt voltage regulators, Switching regulators, 3.7 Concepts of Different types of Integrated circuit regulator (Three-terminal type and adjusted type). [4 hours]

Digital Electronics:

4. **(a) Digital Circuit Analysis and Design:** 4.1 Introduction, Boolean laws and theorem, 4.2 Sum of Products methods and Product of Sum methods, Truth table to Karnaugh map, Pairs, quads and octets, 4.3 Karnaugh's simplifications. [3 hours]

(b) Data Processing Circuits: 4.4 Multiplexers, De-multiplexers, 4.5 Decoder, BCD to decimal decoders and Seven segment decoders, 4.6 Encoders, Decimal to BCD encoder, 4.7 Exclusive-OR gates, Parity generators-checkers. [3 hours]

5. **(a) Arithmetic Circuits :** 5.1 Review of binary addition and subtraction, Unsigned binary numbers, Sign-magnitude numbers, 2's compliment representation and its arithmetic, 5.2 Arithmetic building blocks, 5.3 The adder and subtracter, Binary multiplication and division. [3 hours]

(b) TTL Circuits: 5.5 Digital integrated circuits, 7400 Devices: Two-input TTL NAND gate, 5.6 TTL Parameters, AND-OR-INVERT gates, 5.7 Three-state TTL devices, Positive and negative logic. [3 hours]

(c) Clock and Timers: 5.9 Clock Waveforms, Review of RS Flip-Flop, 5.10 Internal structure of 555 timer, 5.11 555 Timer-Astable and Mono-stable. [3 hours]

6. **(a) Flip-Flops:** 6.1 Review of D Flip-Flop, Edge Triggered D Flip-Flop, 6.2 Flip-Flop switching time, JK Flip-Flop, JK Master-Slave Flip-Flip, 6.3 Schmitt trigger. [3 hours]

(b) Shift Registers: 6.4 Types of registers (Serial in - Serial out, Serial in - Parallel out, Parallel in - Serial out, Parallel in - Parallel out), 6.5 Ring counters. [2 hours]

(c) Counters: 6.6 Asynchronous counters, Decoding gates, 6.7 Synchronous counters, Shift Counters. [2 hours]

Text Books:

1. Ryder, J.D. – **Network, Lines and Fields**, Prentice Hall of India (1955)

2. Bogart, T.F. – **Electronics Devices and Circuits**, Universal Book Stall, New Delhi (1995).

3. Malvino, A.P and Leach, D.P. – **Digital Principles and Application**, Tata McGraw Hill Publishing Company Ltd., New Delhi (1991).

Reference Books:

1. Malvino A.P. – **Electronic Principles**, Tata McGraw Hill Publishing Company, New Delhi (1984).

2. Boylestad, R.L. and Nashelsky , L. – **Electronic Devices and Circuit Theory**, 8th edition, Prentic Hall of India Private Ltd., New Delhi (2004)

3. Floyd, T.L. – **Digital Fundamentals**, 8th edition, Pearson Education, Inc.

4. Jain R.P. – **Modern Digital Electronics**, Tata McGraw Hill Publishing Company Ltd., New Delhi (1984).

Phy505: Physics Practical I (Compulsory) (L180, T45, 3CH)

Nature of the course: Practical Full Marks: 50 Pass Marks: 25

Course Description:

Practical course consists of four sections: (a) General Experiments, (b) Optical Experiments, (c) Nuclear Experiments and (d) Electronics Experiments. In the M.Sc. physics first semester, students have to perform 16-20 experiments in 180 working hours in order to fulfill 3 CH. Students are required to perform 3 hours laboratory work everyday. ***One credit hour lab work requires 6 hours lab work per week throughout the semester***. In addition, there will be 45 hours tutorial classes in order to learn the method of data and error analysis using suitable software. Students need to write a laboratory report on each experiment they perform and get them duly checked and signed by the concerned teacher. They should write their reports in a separate sheet, and to keep them neat and properly filed. Students are required to perform at least 15 experiments from the list (given below). The marking scheme is as follows:

1. Day to day evaluation - 40%
2. Final Examination - 60%

Course Objectives:

- To provide students with skill and knowledge in the experimental methods.
- To make them able to apply knowledge to practical applications.
- To make them capable of presenting their results/conclusions in a logical order.

Course Contents:

1. To study the Fresnel biprism for the determination of the wavelength of a given monochromatic light and thickness of mica sheet.

2. To study Lloyd's mirror for the determination of wavelength of Hg light.

3. To study the formation of fringe pattern by wedge shape.

4. To study the variation of refractive index with concentration of sugar solutions using a hollow prism.

5. To design and study the series and parallel LCR circuits for finding the quality factor of the elements.

6. To study the absorption of β-particle by material to estimate the end-point energy of the β-particle.

7. To study the absorption of γ-ray by the material of lead to determine its linear absorption coefficient, μ.

8. To study the level of natural background radiation at the laboratory in the given condition

9. To construct regulated power supply unit.

10. To construct CE amplifier for the determination of the voltage gain of the amplifier.

11. To construct CC amplifier for estimating input and output impedance.

12. Use Zener diode to construct a variable regulated power supply.

13. To construct astable multivibratorusing 555 timer and study its performance.

14. To construct monostable multivibratorusing 555 timer and study its function.

15. To construct and to study the characteristics of RS flip-flop and J-K flip-flop.

16. To construct a voltage multipliers (doubler and tripler) and study its characteristics.

17. To construct and study the working of NOT, AND, OR gates using diodes and transistors. Also calculate the power loss in transistors in each case wherever it is applicable.

18. Solve the given equation using K-map and construct the circuit with verification.

SECOND SEMESTER

Phy551: Mathematical Physics II (45L, 15T, 3CH)

Nature of the course: Theory
Full Marks: 50 Pass Marks: 25

Course Description:

This course contains different areas of mathematics that are used extensively in the study of physics.

Objectives:

The objective of this course is to train the students to use the methods of mathematics to formulate and solve problems in physics, and make them capable to apply this knowledge in higher studies and research.

Course Contents:

1. **Complex variable:** 1.1 Functions of a complex variable, single and multi valued functions, Riemann sheets 1.2 Analytic functions and Cauchy – Riemann conditions, 1.3 Analytic continuation 1.4 Cauchy integral theorem and formula, 1.5 Taylor and Laurent expansions of functions of a complex variable, 1.6 Residue theorem and applications, 1.7 Conformal transformations 1.8 Dispersion relation [15 hours]

2. **Numerical analysis** (*use of computer is optional*): 2.1 Interpolation and extrapolation: approximation of given data by a polynomial, interpolation and extrapolation of data, 2.2 Solution of equation: polynomial equation, determination of roots, 2.3 Numerical integration: trapezoidal, Simpson and Romberg method, 2.4 Matrices: eigen values and eogen vectors, inverse of square matrix by Gauss-Jordan elimination method, 2.5 Differential equation: solution of differential equation by Runge-Kutta method. [14 hours]

3. **Statistics:** 3.1 Review of Data handling: histogram, mean, mode, median and standard deviation, moments, skewness, Kurtosis, 3.2 Distribution functions: bionomial, normal and Poisson distributions, 3.3 Curve fitting: least square fit for straight lines and curves, 3.4 Chi-square tests: observed and theoretical frequencies, significance tests, goodness of fit, central limit theorem, 3.5 Error analysis. [10 hours]

4. **Differential Geometry:** 4.1 Introduction - Application of differential geometry in physics 4.2 differentiable manifolds 4.3 Tangent and co-tangent space 4.4 Vector fields [6 hours]

Text Books:

1. Arfken G.B. , Weber H.J. and Harris F.E – **Mathematical Methods for Physicists**, 7th ed., Academic Press, Amsterdam (2013)
2. Copson, E.T. – **An Introduction to the Theory of Functions of Complex Variable,** Oxford Clarendon Press (1935)
3. Mathew, J. & Walker, R. – **Mathematical Methods in Physics,** Benjamin Menlo Park, Second Edition (1970)
4. Margenu & Murphy – **Mathematics for Physicist and Chemist**, East, West Press Pvt. Ltd., New Delhi (1964)
5. Scarborough J.B. – **Numerical Analysis,** John Hopkins Press, USA (1962)
6. Press, M. et al. – **Numerical Recipe in C**, Cambridge University Press, or, Foundation Book, India (1998)
7. Morse, P.M. & Feshbach H. – **Methods of Theoretical Physics,** Part I & II, McGraw Hill, New York (1953)
8. Spiegel Murray R. – **Theory and Problems of Statistics (Schaum Series),** McGraw Hill, London (1992)
9. Isham C. J.- **Modern Differential Geometry for Physicists**, World Scientific Lecture Notes in Physics – Vol 61, 2nd ed. World Scientific, Singapore (2001)

Reference Books:

1. Rajput B.S.– **Mathematical Physics**, Pragati Prakashan, India (1997)
2. Gupta B.D.– **Mathematical Physics**, Vikash Publishing House, India (1994)

Phy552: Statistical Mechanics (45L, 15T, 3CH)

Nature of the course: Theory
Full Marks: 50 Pass Marks: 25

Course Description:

This course contains a description and formulation of statistical mechanics.

Objectives:

The objective of this course is to provide the students with knowledge of statistical mechanics, and enable them to apply the knowledge for solving various problems in related topics, and also for higher studies and research.

Course Contents:

1. **Classical statistical mechanics:** 1.1 Review of Thermodynamics 1.2 The statistical basis of thermodynamics 1.3 Review of classical mechanics – Hamiltonian equation of motion 1.4 Macroscopic and microscopic states, 1.5 Phase space, 1.6 Liouville's theorem 1.7 Postulate of statistical mechanics 1.8 Microcanonical ensemble 1.9 Derivation of thermodynamic properties 1.10 Classical ideal gas 1.12 Gibb's paradox 1.13 Classical harmonic oscillators in Microcanonical Ensemble 1.13 Canonical ensemble 1.14 Partition function 1.15 Energy fluctuation in canonical ensemble 1.16 Grand Canonical ensemble Energy and density fluctuations in grand canonical ensemble 1.17 Classical ideal gas in canonical and grand canonical ensemble 1.18 Classical harmonic oscillators in Canonical Ensemble 1.19 Equivalence of various ensembles, 1.20 Thermodyanmics of magnetic systems: negative temperature 1.21 Generalized equipartition theorem – theorem of equipartition of energy and virial theorem 1.22 Virial Theorem -equation of state for classical interacting particles [18 hours]

2. **Quantum statistical mechanics**: 2.1 Postulates of quantum statistical mechanics 2.2 Density matrix and its properties 2.3 Ensembles in quantum statistical mechanics – microcanonical, canonical, and grand canonical ensembles 2.4 Partition functions with examples including (I) an electron in magnetic field (II) a free particle in a box (III) a linear harmonic oscillator 2.5 Third law of thermodynamics 2.6 Symmetric and antisymmetric wave functions 2.7 The ideal gases: Microcanonical ensemble 2.8 The ideal gases: grandcanonical ensemble 2.9 Grand partition function 2.10 Occupation number 2.11 Partition functions for diatomic molecule [12 hours]

3. **Application of Ideal Bose and Fermi syatems**: 3.1 Thermodynamical behavior of ideal Bose gas, 3.2 Photons –Black body radiation and Planck's law of radiation, 3.3 Thermodynamics of weakly degenerate Bose gas, 3.4 Thermodynamics of strongly degenerate Bose gas – Bose-Einstein condensation and liquid helium^4 3.5

Phonons in solids, specific heat of solids 3.6 Thermodynamical behavior of ideal Fermi gas – weakly and strongly degenerate Fermi gas, 3.7 Free electron in metals, 3.8 Statistical equilibrium of white dwarf and neutron stars [10 hours]

4. **Phase Transitions:** 4.1 Condensation of van der Waals gas 4.2 A dynamical model of phase transitions, 4.3 Ising model [5 hours]

Text books:

1. Kerson Huang - **Statistical Mechanics**; John Wiley (1987)

Reference books:

1. R. K. Pathria - **Statistical Mechanics,** Butter Worth Heinemann, New Delhi, India (1996)
2. A. Mc Quarrie - **Statistical Mechanics**, Harper and Row, New York (1973)
3. R. Reif - **Fundamental of Statistical and Thermal Physics,** McGraw-Hill Book Company, New York (1965)
4. L.D. Landau *& E.*M. Lifshitz - ***Statistical Physics***, Vol. 5, Pergamon Press (1969)

Phy553: Solid State Physics (45L, 15T, 3CH)

Nature of the course: Theory
Full Marks: 50 Pass Marks: 25

Course Description:

This course develops the basic formulation of solid state physics and its applications in various areas.

Objectives:

The objective of this course is to provide the students with adequate knowledge of solid state physics and enable them to apply the knowledge to study the atomic, molecular and other mechanical systems.

Course Contents:

1. **Crystal Structure**: 1.1 Translation symmetry - periodic array of atoms 1.2 Simple lattice, 1.3 Index systems for crystal planes 1.4 Review of Simple crystal structures: NaCl, CsCl, hexagonal closed packed, diamond and cubic zinc sulfide structure 1.5 Reciprocal lattice, Brillouin zone, 1.6 Crystal diffraction, 1.7 Structure factor, 1.8 Crystal binding: a) Van der waal's crystals, b) ionic crystals, c) Metals, d) Covalent crystals, e) Hydrogen bonded crystals, 1.7 Elastic constants and their determination. [9 hours]

2. **Lattice Vibration**: 2.1 Vibration of crystals with monoatomic basis, 2.2 Vibration of crystals with two atoms per primitive basis, 2.3 Quantization of elastic waves, 2.4 Phonon momentum, 2.5 Inelastic scattering by phonon, 2.6 Thermal properties of solid: density of states in one, two and three dimensions, 2.7 Phonon heat capacity: Review of Debye and Einstein's model, 2.8 Thermal Conductivity 2.9 Anharmonic crystal interaction: Thermal expansion. [7 hours]

3. **Electrons in bands**: 3.1 Review of Nearly free electron model, Bloch theorem, Kronig-Penny model, 3.2 Wave equation of electron in periodic potential, 3.3 Number of orbitals in a band, 3.4 Calculation of energy Bands: Tight binding approximation, Wigner Seitz method, cohesive energy, pseudopotential methods 3.5 Fermi surface: Construction of Fermi surfaces – nearly free electrons, Electron orbits, hole orbits and open orbits 3.6 Experimental methods in Fermi surface studies: quantization of orbits in a magnetic field, de Haas-van Alphen effect, Fermi surface of copper and gold [13 hours]

4. **Semiconductor**: 4.1 Band diagram of semiconductor, 4.2 Intrinsic carrier concentration, 4.3 Impurity conductivity: thermal ionization of donors and acceptors. [3 hours]

5. **Dielectric properties**: 5.1 Dielectric constant and polarizability, 5.2 Electronic, ionic and orientational polarizabilities, 5.3 Complex dielectric constant 5.4 Dielectric losses and relaxation time. [4 hours]

6. **Magnetism**: 6.1 Diamagnetism and paramagnetism, 6.2 Quantum theory of diamagnetism of mononuclear systems, 6.3 Quantum theory of paramagnetism, Hund rules 6.4 Magnetic ordering, 6.5 Ferrommagnetic order: Curie point and exchange integral, Temperature dependence of the saturation magnetization, ferromagnetic domains, Bloch wall, Saturation Magnetization at Absolute zero, 6.6 Magnons, thermal excitation of magnons, 6.6 Ferrimagnetic order: Curie temperature and susceptibility 6.7 Antiferrimagnet, susceptibility below Neel temperature. [9 hours]

Text books:

1. Kittel C. – **Introduction to Solid State Physics,** (7th Ed.) John Wiley & Sons Ltd, India (2004)

References:

1. Ibach H. and Luth H. – **Solid State Physics**, Narosa Publishing House, New Delhi (1991)

2. Ashcroft NW and Mermin ND - **Solid State Physics**, Holt Rinehart and Winston. New York (1976).

3. Elliot R. J. & Gibson A. F. – **An Introduction to Solid state Physics and its Application**, Macmillan (1974).

4. Hall H. E. – **Solid State Physics**, Wiley (1974)

5. Walter A. Harrison – **Solid State Theory**, Curier Dover Publication (1970).

6. Dekker A. J. – **Solid State Physics**, Printice Hall (1965).

7. Ziman J.M. – **Principles of Theory of Solids**, Cambridge University Press (1979)

Phy504: Electrodynamics I (45L, 15T, 3CH)

Nature of the course: Theory
Full Marks: 50 Pass Marks: 25

Course Description:

This course further develops on the theory and applications of electrodynamics.

Objectives:

The course will give an understanding of the formulation of the theory of electrodynamics, so that the students will be able to apply the knowledge in different situations, and also in higher studies and research.

Course Contents:

1. **Introduction to Electrostatics:** 1.1 Review of the Electrostatic Field and Electrostatic Potential 1.2 Poisson and Laplace equations 1.3 Green's theorem 1.4 Uniqueness of the solution with Dirichlet or Neumann boundary conditions 1.5 Formal solution of electrostatic boundary-value problem with Green Function [4 hours]

2. **Boundary Value Problems in Electrostatics:** 2.1 Methods of image 2.2 Point charge in the presence of a (a) grounded conducting sphere (b) Charged insulated conducting sphere 2.3 Conducting sphere in a uniform electric field by method of image 2.4 Green function for the sphere and general solution for the potential 2.5 Conducting sphere with hemisphere at different potentials 2.6 Laplace equation in spherical coordinates and boundary value problems with azimuthal symmetry 2.7 Associated Legendre functions and the spherical harmonics Y^l_m, Use of addition theorem for spherical harmonics 2.8 Expansion of Green function in spherical coordinates [10 hours]

3. **Multipoles, Electrostatics of Macroscopic Media, Dielectrics**: 3.1 Multipole expansion 3.2 Multipole expansion of the energy of a charge distribution in an external field 3.3 Elementary treatment of electrostatics with ponderable media 3.4 Boundary value problem with dielectrics 3.5 Electrostatic energy in dielectric media [6 hours]

4. **Magnetostatics:** 4.1 Review of Magnetostatics (Biot and Savart law, Ampere's law, Vector potential) 4.2 Magnetic fields of a localized current distribution, magnetic moment 4.3 Force and torque on the energy of a localized current distribution in an external magnetic induction, 4.4 Macroscopic equations, Boundary conditions on B and H, 4.5 Method of solving boundary value problems in magnetostatics 4.6 Uniformly magnetized sphere 4.7 Magnetized sphere in an external field, permanent magnets 4.8 Faraday's law of induction 4.9 Energy in the magnetic field [8 hours]

5. **Maxwell's Equations:** 5.1 Maxwell's equations 5.2 Vector and scalar potentials 5.3 Gauge Transformations, Lorenz Gauge, Coulomb Gauge 5.4 Green functions for the wave equation 5.5 Poynting's theorem and conservation of energy and momentum for a system of charged particles and electromagnetic fields 5.6. Poynting's Theorem in Linear Dispersive Media with Losses [7 hours]

6. **Electromagnetic Waves and Wave Propagation:** 6.1 Plane waves in nonconducting medium 6.2 Linear and circular polarization; Stokes Parameters 6.3 Reflection and Refraction of electromagnetic waves at a plane interface between dielectrics 6.4 Polarization by Reflection and Total Internal Reflection 6.5 Frequency Dispersion Characteristics of Dielectrics, Conductors, and Plasmas 6.6 Simplified Model of Propagation in the Ionosphere and Magnetosphere [7 hours]

7. **Waveguides, Resonant Cavities**: 7.1 Fields at the surface of and within a conductor 7.2 Cylindrical cavities and waveguides 7.3 Waveguides 7.4 Modes in a rectangular waveguide [3 hours]

Text Books:

1. Jackson, J.D. – **Classical Electrodynamics** (3rd Ed.), John Wiley & Sons Asia Pvt Ltd. (1999).

Reference Books:

1. Panofsky, W.K.H. and Philips **- Classical Electricity and Magnetism**, Addison–Wesley Publishing Company, Inc. USA or Indian Book Company New Delhi (1970).

2. Born, Max and Wolf E. – **Principle of Optics**, Elsevier Holland (1980).

3. Reitz, J. R. and Milford F.J. – **Foundation of Electromagnetic Theory**, Addison Wesley Publishing Company (1975).

4. Miah M.A. and Wazed – **Fundamentals of Electromagnetic** (3rd Ed.) Tata McGraw Hill Publishing Company Ltd. New Delhi (1982).

5. Griffiths David J.- **Introduction to Electrodynamics** (4th Ed.), Addison-Wesley (2013).

Phy555: Physics Practical II (Compulsory) (L180, T45, 3CH)

Nature of the course: Practical Full Marks: 50 Pass Marks: 25

Course Description:

Practical course consists of four sections: (a) General Experiments, (b) Optical Experiments, (c) Nuclear Experiments and (d) Electronics Experiments. In addition, there is a computation laboratory in order to learn computational/numerical technique. In the M.Sc. physics second semester, students have to perform 15 experiments in 180 working hours in order to fulfill 3 CH. Students are required to perform 3 hours laboratory work everyday. ***One credit hour lab work requires 6 hours lab work per week throughout the semester***. In addition, there will be 45 hours computation classes in order to learn the method of data analysis using suitable software. Students need to write a laboratory report on each experiment they perform and get them duly checked and signed by the concerned teacher. They should write their reports in a separate sheet, and to keep them neat and properly filed. Students are required to perform at least 13 experiments from the list (given below). The marking scheme is as follows:

5. Day to day evaluation - 40%
6. Final Examination - 60%

Course Objectives:

- To provide students with skill and knowledge in the experimental methods.
- To make them able to apply knowledge to practical applications.
- To make them capable of presenting their results/conclusions in a logical order.

Course Contents:

1. To determine the half life of the given radioactive source. (nuclear lab)
2. To study the phenomenon of Back-Scattering using a thin radioactive source. (nuclear lab)
3. To study the phenomenon of hysteresis loss of the material and to determine the hysteresis loss of the material over a cycle. (general lab)
4. To study the Lissajous pattern for the determination of the frequency of a given unknown source. (general lab)
5. To study the current–voltage characteristics of a photocell and hence use photoelectric method to determine the value of Plank's constant. (optical lab)

6. To study the specific heat capacity of the materials using Calorimetric method. (general lab)

7. To study the temperature dependence of resistance of a given semiconductor. (general lab)

8. To study differential amplifier and estimate it’s CMRR.(electronics lab)
9. To construct and to study the Exclusive-OR and Exclusive-NOR gates by using universal gates. (electronics lab)

10. To study operational amplifier for its input-output waveform and use it as an integrator and differentiator. (electronics lab)

11. To study the working of half adder and full adder. (electronics lab)

12. To construct and study the Wien-bridge. (electronics lab)

13. To construct D/A converter and to study its working. (electronics lab)

14. To study the characteristic of a FET and construct it to work as an amplifier. (electronics lab)

15. Solve given numerical problem using computation. (computation lab)

THIRD SEMESTER

Phy601: Electrodynamics II (45L, 15T, 3CH)

Nature of the course: Theory Full Marks: 50 Pass Marks: 25

Course Description:

The aim of the course is to impart some fundamental knowledge of classical electrodynamics. This is in continuation of the first semester course.

Objectives:

The objective of this course is to train the students in the methods of classical electrodynamics and apply it to solve problems in classical electrodynamics.

Course Contents:

1. **Special Relativity:** 1.1 Postulates of relativity 1.2 Lorentz Transformations 1.3 Light cone, proper time, time dilation and Doppler shift 1.4 Four velocity and momentum 1.5 Thomas precession 1.6 Covariance of electromagnetic fields [10 hours]

2. **Relativistic electrodynamics:** 2.1 Lagrangian and Hamiltonian of relativistic charged particle in external Electromagnetic field 2.2 Motion in uniform static magnetic field and uniform static Electromagnetic field 2.3 Adiabatic invariance of flux through orbit of particle 2.4 Lagrangian for electromagnetic field, Stress tensors and Conservation laws 2.5 solution of wave equation in covariant form [10 hours]

3. **Scattering:** 3.1 Energy transfer in Coulomb collision 3.2 Energy transfer to harmonically bound charge 3.3 Density effects in collision, energy loss 3.4 Elastic scattering of fast particles by atoms [10 hours]

4. **Radiation by moving charge:** 4.1 Lienard - Wiechert potentials and fields for a point charge 4.2 Total power radiated by an accelerated charge 4.3 Angular distribution of radiation emitted by an accelerated charted 4.4 Radiation from extremely relativistic charge 4.5 Frequency and angular distribution of energy 4.6 Frequency spectrum of Radiation by relativistic charges in circular motion 4.7 Thomson scattering 4.8 Brehmsstrahlung in Coulomb collision [15 hours]

Text Books:

1. Jackson J. D. - **Classical Electrodynamics**, John Wiley and Sons, New York (1975)

2. Panofsky W.K.H. and Phillips M. - **Classical Electricity and Magnetism**, Addison - Wesley, Reading Mas (1962)

Reference Books:

1. Greiner, Walter – Classical Electrodynamics, Springer-Verleg, New York (1998)

Phy602: Quantum Mechanics II (45L, 15T, 3CH)

Nature of the course: Theory Full Marks: 50 Pass Marks: 25

Course Description:

This course further develops the formulation of quantum mechanics and spectroscopy for applications in various areas.

Objectives:

The objective of this course is to provide the students with adequate knowledge of non-relativistic quantum mechanics and enable them to apply the knowledge to study the atomic, molecular and other mechanical systems.

Course Contents:

1. **Spin and Magnetic Moment:** 1.1 Need for matrix representation of spin, 1.2 Pauli spin matrices, 1.3 Spinors and expectation values, 1.4 Pauli operators, 1.5 Magnetic moment of an electron, 1.6 Precession of an electron in a magnetic field, 1.7 Space inversion, 1.8 time reversal, 1.9 Isospin. [12 hours]

2. **Addition of Angular Momenta:** 2.1 Addition of two spins, 2.2 Addition of two angular momenta: general method, 2.3 Vector operators: Wigner-Eckart theorem, 2.4 Identical particles and symmetry, 2.5 Nuclear Forces [8 hours]

Spectroscopy:

3. **Atomic Spectra:** 3.1 Quantum mechanics of hydrogen atom, 3.2 Hydrogen like spectrum, 3.3 Fine and hyperfine structure, 3.4 Spin orbit interaction in one and two valence electrons, 3.5 Doublet splitting and intensity ratio, 3.6 Doublet, normal and inverted terms, 3.7 Zeeman effect of two valence electrons, 3.8 Paschen Back effect: intensity and polarization rules, 3.9 Different types of coupling, 3.10 Width of a spectral line: natural breadth and collisional broadening. [11 hours]

4. **Molecular Spectra of Diatomic Molecules:** 4.1 Structure and theory of pure rotation and pure vibration, 4.2 Anharmonic oscillator, 4.3 Vibration-rotation spectra and electronic spectra, 4.4 Intensity variation of spectra, 4.5 Frank Condon principle, 4.6 Fortrail diagram, 4.7 Vibrational spectroscopy – IR and Raman spectra. [8 hours]

5. **X-ray Spectroscopy:** 5.1 X-ray spectra, 5.2 Emission and absorption spectra, 5.3 Energy levels, 5.4 Selection and intensity rules, 5.5 Fine structure, 5.6

Regular and irregular doublet's law, 5.7 Multiple structure, 5.8 Satellites., 5.9 X-ray Term. [6 hours]

Text Books:

1. Agrawal, B. K. & Prakash, H. – **Quantum Mechanics,** Prentice Hall of India, New Delhi (1997)

2. Cohen-Tannoudji, C, Duui. B. & Laloe, F. **– Quantum Mechanics,** Vol. I & II, John Wiley (1977)

3. White, H. E. – **Introduction to Atomic Spectra,** International Edition, McGraw Hill, Singapore (1934)

4. Banwell, C. N. – **Fundamental of Molecular Spectroscopy,** 3rd ed., Tata McGraw Hill, Delhi (1994)

5. Compton, Arthur H. & Allison, Samuel K. – **X-Rays in Theory and Experiment,** D. Van Nostrand Company Inc. Princeton, New Jersey; East-West Edition, New Delhi (1968)

Reference Books:

1. Schiff, L. I.- **Quantum Mechanics,** 3rd ed., Tata McGraw Hill, Delhi (1968)

2. Merzbacher, E. - **Quantum Mechanics,** 2nd ed., John Wiley, New York (1969)

3. Messiah, A. - **Quantum Mechanics,** John Wiley, New York (1963)

4. Thankappan, V. K. - **Quantum Mechanics,** Wiley Eastern Ltd., New Delhi (1993)

5. Sindhu, P. S. – **Molecular Spectroscopy,** Tata McGraw Hill, Delhi (1993)

Phy603: Physics Practical (Advanced) (180L, 45T, 3CH)

Nature of the course: Practical Full Marks: 50 Pass Marks: 20

Course Description:

The main aim of this course is to provide skill in the experimental technique and strengthen the theoretical basis. It also provides skill to apply knowledge for the practical purposes. It consists of general practical carrying 50 marks. In the general practical laboratory a student will perform experiments covering practical work on nuclear physics, solid state physics, electronics and atomic and molecular physics. There will be a minimum of 12 experiments to be performed by each student. ***One credit hour lab work requires 6 hours lab work per week throughout the semester*** Once the student completes his laboratory work in the allotted period of time, it is expected that he/she clearly states the problem and objective of the experiment, write a brief outline of the procedure, makes a table of data he collects from the experimental work and interpret the results of his/her data. It also is expected that the data is well processed and appropriately error analyzed. The results must be presented in the logical order and concluded in a systematic way. The final write up must clearly be typed whenever possible or neatly written. The marking scheme is as follows:

7. Day to day evaluation - 40%
8. Final Examination - 60%

Course objective

- To give students the skill of experiment technique
- To develop students ability to verify theoretical aspect of physics experimentally
- To provide student skill and knowledge of independent thinking to pursue research work

List of Experiments

1. To study the Hall Effect for the determination of Hall Coefficients of N-type and P-type materials. (general lab)
2. To study the phenomenon of electron diffraction for the determination of inter-planer spacing ‘d’ of a given crystal. (general lab)
3. To study the phenomenon of quantization of energy levels using Frank Hertz experiment. (nuclear lab)
4. To study the paramagnetic and diamagnetic susceptibilities of materials. (general lab)

5. Compare the activity of given radioactive sources using End Window Counter. (nuclear lab)
6. Study the absorption coefficient of air using alpha source Am-241 and End Window Counter (nuclear lab)
7. To determine the Cauchy's constant of the given prism. (optical lab)
8. To determine the number of lines per millimeter of the grating using the green line of the mercury spectrum (optical lab)
9. Find the wavelength of given light using He-Ne Laser source (optical lab)
10. Study the properties of X-ray (nuclear lab)
11. Study the variation of solar radiation flux density using given Pyranometer.
12. Construct the Colpitt's oscillator and set up it for sinusoidal output waveform of desired frequency (electronics lab)
13. *To perform given program by using vmc-8503 microprocessor training cum-development kit based on 8085:* Microprocessor – I (electronics lab)
    (a) Hexadecimal addition of two 8-bit hexadecimal numbers (neglecting the carry)
    (b) Decimal addition of two 8-bit decimal numbers (the result should not be greater than 99)
    (c) Addition of two 16-bit hexadecimal numbers (neglecting the carry)
14. *To perform given program by using vmc-8503 microprocessor training cum-development kit based on 8085:* Microprocessor – II (electronics lab)
    (a) Addition of 8-bit number series (neglecting the carry)
    (b) Separation of hexadecimal number into two digits
    (c) Combination of two hex nibbles to form one byte number
15. *To perform given program by using vmc-8503 microprocessor training cum-development kit based on 8085:* Microprocessor –III (electronics lab)
    (a) Identification of odd or even parity of given hex number
    (b) Multiplication by two, employing bit rotation
    (c) Multiplication of two 8-bit hex numbers without neglecting carry

ELECTIVE PAPERS

Phy611: Advanced Solid State Physics I (45L, 15T, 3CH)

Nature of the course: Theory   Full Marks: 50   Pass Marks: 25

Course Description:

This course aims at providing students with basic knowledge and skill in theoretical as well as experimental aspects of Solid State Physics.

Objectives:

- To acquaint student with the theoretical and experimental methods in Solid State Physics.
- To prepare them in developing skill to pursue further study and research in the field of physics.

Course Contents:

1. **Transport Phenomena**: 1.1 The Boltzmann transport equation 1.2 Relaxation time approximation 1.3 Electrical conductivity 1.4 Thermal and thermoelectric effects 1.5 General transport coefficients 1.6 The Hall effect and magnetoresistance 1.7 Effects in strong magnetic fields [25 hours]

2. **Semiconductors**: 2.1 General properties of semiconductors 2.2 Carrier statistics in thermal equilibrium 2.3 Intrinsic and extrinsic semiconductors 2.4 Thermal equilibrium carrier density of impurity semiconductors 2.5 Mobility of charge carriers 2.6 Effects in magnetic fields 2.7 Thermoelectric effects 2.8 Excess carriers in semiconductors 2.9 Transport behavior of excess carriers [10 hours]

3. **Imperfection in solids**: 3.1 Classification of imperfection and irregularities in atomic arrays 3.2 Phonon, vacancies and interstitial atoms 3.3 Foreign atoms 3.4 Dislocations and crystal growth [10 hours]

Text Books:

1. Ziman J. M. – **Principles of the theory of Solids**, Cambridge University Press, London (1972)

2. Ziman J. M.– **Electrons and Phonons**, Clarendron Press, Oxford (1960)

3. Ashcroft N. W and Mermin N. D. – **Solid State Physics**, Holt Rinehart and Winston, New York (1976)

Reference Books:

1. McKelvey J. P. – **Solid State and Semiconductor Physics,** Joanna Cotler Books (1967)

2. Callaway J. – **Quantum Theory of Solid State**, Volume I and II Academic Press, New York and London (1974)

3. Animalu A. O. E. – **Intermediate quantum Theory of Crystalline solids**, Prentice Hall of India, New Delhi (1978)
4. Christman J. R. – **Fundamentals of Solid State Physics**, John Wiley & Sons, New York (1988)

5. Kittel C. – **Quantum theory of solids**, John Wiley & Sons, New York (1967)

6. Seitz F. and Turnbull D. - **Solid State Physics**, advances in Research and Applications (complete set), Academic Press, New York (1956)

7. **Springer series in solid state science**, (complete set), Springer Verlag, Berlin (2012)

8. Harrison W.A. – **Solid State Theory**, Tata McGraw Hill, India (1977)

Phy612: Micro and Optoelectronics I (45L, 15T, 3CH)

Nature of the course: Theory Full Marks: 50 Pass Marks: 25

Course description

This course contains two sections. The first section deals with Microelectronics and second section deals with Optoelectronics. The course is designed to fulfill the following objectives.

Course objective

- To give the adequate knowledge in designing digital electronics circuits
- To give the principle of architecture of the microprocessor and its application
- To introduce the Optoelectronics theory and devices together with their application in communication system

Course contents:

1. **Integrated Circuit Fabrication and Design:** 1.1 Monolithic Integrated Circuit Technology 1.2 Fabrication of Bipolar Transistor, FET, IC Diodes, Metal-Semiconductor Contacts, IC Resistors, Capacitors and Inductors 1.3 Logic Gate Characteristics 1.4 NMOS Logic Gates 1.5 CMOS Logic Gates 1.6 BJT Inverter 1.7 TTL Logic Gates 1.8 TTL Output Stages 1.9 Emitter Coupled Logic Circuits 1.10 Comparison of Logic Families. [20 hours]

2. **Combinatorial Digital Circuits:** 2.1 Standard Gate Assemblies 2.2 Binary Adders, 2.3 Arithmetic Functions 2.4 Decoder-Demultiplexers 2.5 Data Selector Multiplexers, 2.6 Encoder, 2.7 Read Only Memory (ROM) 2.8 Programmable Logic Arrays [15 hours]

3. **Optical Fiber Waveguides:** 3.1 Introduction 3.2 Optical Fiber Waveguides 3.3 Losses in Fibers 3.4 Fiber Joining 3.5 Measurement of Fiber Characteristics 3.6 Fiber Materials and Fiber Cables. [10 hours]

Text Books:

1. Millman J., Grabel A. – **Microelectronics**, McGraw Hill International edition, New York (1987)

2. Wilson J., Hawkes J. F. B. – **Optoelectronics an inttroduction**, Prentice Hall, India (1889).

Reference Books:

1. Smith Sedra - **Microelectronics circuits**, Fifth edition, New York Oxford, Oxford University Press (2004)

2. Mukhopadhyay A. K. - **Microprocessor Microcomputer and their Applications** (second edition), Narosa Publishing House (1999)

3. Gaonkar R. S. - **Microprocessor Architecture**, Programming and Applications with the 8085, Fourth Edition, Penram International Publishing, India (1995).

4. Khere R. P. – **Fiber Optics and Optoelectronics**, Oxford University Press (2004)

5. Sarkar C. K., Sarkar D. C. – **Optoelectronics and Fiber Optics Communication**, New Age International (P) Limited, Publishers, New Delhi (2001)

Phy614: Atmospheric Physics I (45L, 15T, 3CH)

Nature of the course: Theory Full Marks: 50 Pass Marks: 25

Course Description:

The course aims to provide the knowledge and to prepare students for the higher studies and research in the field of atmospheric physics. The course is designed with the following objectives.

Course objective:

- To provide a broad knowledge of atmospheric physics.
- To prepare students to explore contemporary issues of atmospheric phenomena.
- To develop skills to observed and to find the solutions to the atmospheric problems.

Course Contents:

1. **Brief survey of the earth atmosphere:** 1.1 Scope, definitions and terms of reference, 1.2Optical properties of the atmosphere, 1.3Mass and chemical composition of the atmosphere, 1.4 Structure of the atmosphere, 1.5 Winds, 1.6 Precipitation. [3 hours]

2. **The Earth System:** 2.1 Components of the earth system: oceans, cryosphere and terrestrial biosphere, 2.2The Earth's Crust and Mantle, 2.3 Roles of various earth system components, 2.4 The hydrological cycles, 2.5 Carbon cycles in the earth system: atmosphere, biosphere, oceans and earth crust, 2.6 Oxygen in the earth system and sources of free oxygen, 2.7 Formation and evolution of earth system into a habitable planet. [4hours]

3. **Atmospheric thermodynamics:** 3.1 Gas laws, 3.2 Virtual temperature, 3.3 Hydrostatic equation, 3.4 The first law of thermodynamics, 3.5 Adiabatic processes, 3.6 Water vapor in air, 3.7 Atmospheric stability, 3.8 Thermodynamic diagram: SkewT-lnPdiagram and its applications, 3.8 The second law of thermodynamics and entropy. [8 hours]

4. **Absorption and scattering of solar radiation:** 4.1 Sun as source of energy, 4.2 Radiation spectrum and quantitative description, 4.3 Solar constant and insolation outside the atmosphere, 4.4 Radiative properties of black and nonblack materials, 4.5 Physics of scattering, absorption and emission, 4.6 Broadening of absorption lines, 4.7 Computation of solar heating rates, 4.8 Representation of polarized light and Stokes parameter, 4.9 Rayleigh scattering: theoretical development, phase function, polarizability and sky polarization, 4.10 Introduction to Mie scattering. [8 hours]

5. **The ionosphere:**5.1 Formation and nature of ionosphere, 5.2 Properties of D, E and F layers, 5.3 Diffusive equilibrium, 5.4 Chapman's theory of a production layer, 5.5 Rate of production of ions, 5.6 Peak electron concentration, 5.7 Determination of number density of electrons, 5.7 Transmission of radio waves. [4 hours]

6. **Radiative transfer in the atmosphere:** 5.1 Thermal infrared spectrum and atmospheric effect, 5.2 The equation of radiative transfer, 5.3 Beer's law, 5.4 Schwarzschild's equation, 5.5 The plane-parallel approximation, 5.6 Infrared transfer in plane-parallel atmosphere, 5.6 Concept of transmission function, 5.7 Band models: single spectra line, regular band model, statistical band model, Curtis-Godson approximation, 5.8 Infrared cooling rates, 5.9 Concept of broadband flux emissivity. [8 hours]

7. **Atmospheric chemistry:** 7.1 Composition of tropospheric air, 7.2 Source, transport and sinks 7.3 Tropospheric trace gases: hydroxyl radical, nitrogen oxides, nitrate radical, ammonia, organic compounds, carbon monoxide, ozone, hydrogen compounds, sulfur gases, 7.4 Tropospheric aerosols: sources, composition, transport and sinks, concentration distribution, residence times, 7.5 Air pollution: potential sources, smogs, regional and global pollution, 7.6Tropospheric chemical cycles, 7.7 Stratospheric chemistry: unperturbed ozone distribution, Chapman's theory, anthropogenic perturbations, stratospheric aerosols. [10 hours]

Text Books:

1. Wallace J. M. and Hobbs P. V. **- Atmospheric Science,** International Geophysics Series, Elsevier Inc. (2006)

2. Liou K. N. **- An Introduction to Atmospheric Radiation** Academic Press Inc., New York (1980)

Reference Books:

1. Salby M. L. **- Fundamentals of Atmospheric Physics**, Academic Press, New York (1996)

2. Seinfeld J. H. and Pandits S. N. **- Atmospheric Chemistry and Physics**, John Wiley & Sons, Inc., New York (1998)

3. Ratcliffe J. A. **- An Introduction to the Ionosphere and Magnetosphere**, Cambridge University Press (1972)

Phy615: Plasma Physics I (45L, 15T, 3CH)

Nature of the course: Theory Full Marks: 50 Pass Marks: 25

Course Description:

The main aim of this course is to provide basic knowledge of plasma physics and develop skill in pursuing research work in plasma applications.

Course Objectives:

The objective of this course is to apply the knowledge and to lay the foundation on the fundamental study / research in plasma physics.

Course Contents:

1. **Introduction:** 1.1 Occurrence of plasma in nature, 1.2 concept of temperature in plasma, 1.3 Debye shielding, 1.4 Criteria for plasmas, 1.5 application of plasma [5 hours]

2. **Single-Particle Motions:** 2.1 Single-particle motions in uniform and nonuniform electric and magnetic fields, 2.2 Time-varying electric and magnetic fields, 2.3 Adiabatic invariants [10 hours]

3. **Plasmas as Fluids: 3.1** The dielectric constant of a plasma, 3.2 The fluid equation of motion, 3.3 Fluid drifts perpendicular and parallel to magnetic field, 3.4 The plasma approximation [6 hours]

4. **Kinetic Theory: 4.1** The Boltzmann equation, 4.2 The Vlasov equation, 4.3 The Krook collision term, 4.4 The Fokker-Planck equation, 4.5 Derivation of the fluid equations: continuity equation and momentum equation, 4.6 Plasma oscillation and Landau damping, 4.7 BGK and van Kampen modes [10 hours]

5. **Confinement of plasma for energy applications: 5.1** Importance of confinement, 5.2 Lawson criterion, 5.3 Magnetic confinement fusion, 5.4 Tokamak, 5.5 Inertial confinement fusion, 5.6 Self-generated magnetic field [7 hours]

6. **Plasma discharge and its applications: 6.1** Corona discharge, 6.2 arc discharge, 6.3 dielectric barrier discharge, 6.4 surface discharge, 6.5 Application of cold plasma for thin film deposition; physical vapor deposition, sputter deposition, ion plating, plasma enhanced chemical vapor deposition, surface modification, ozone generation [7 hours]

Text Books

1. Chen F. F. - **Introduction to Plasma Physics and Controlled Fusion** (second edition), Plenum Press (1984)

2. Duderstadt J. J. and Moses G. A. - **Inertial Confinement Fusion**, John Wiley and Sons (1982)

Reference Books

1. Krall N. A. and Trivelpiece A. W. - **Principles of Plasma Physics**, San Francisco Press (1986)

2. Chakraborty B. - **Principles of Plasma Mechanics**, John Wiley & Sons Inc (1991)

3. Chen F. F. and Chang J. P. - **Lecture Notes on Principles of Plasma Processing**, Plenum Kluwer Publisher (2002)

4. Bittencourt J. A. - **Fundamentals of Plasma Physics**, Springer (2004)

Phy616: Biomedical Physics I (45L, 15T, 3CH)

Nature of the course: Theory Full Marks: 50 Pass Marks: 25

Course Description:

This course develops the formulation of biophysics and its applications in different areas.

Objectives:

The objective of this course is to train the students to use the methods in formulating and solving the problems of biophysics, and upgrade skills of computational biophysics.

Course Contents (Biophysics):

1. **Physics of Macromolecules:** 1.1 Scope and methods of Biophysics, 1.2 Macromolecules and Rubber Elasticity, 1.3 Macromolecule as a Co-operative System, 1.4 Theories of Strong and Weak interactions, Dispersion or London Forces, Dipole-Dipole Interactions. [5 hours]

2. **Physics of Proteins:** 2.2 The Goals of Protein Physics, 2.2 Conformations of Polypeptide Chains, 2.3 Protein Globule-Structure and Stability, 2.4 Antigens and Antibodies: Structures, Iodination of Antibodies. [5 hours]

3. **Physics of Enzymes:** 3.1 Properties and Behaviour of Enzymes, Michaelis-Menten Equation, Line Weaver Burk Plot, 3.2 Chemical Kinetics and Catalysis, 3.3 Conformational Properties of Enzymes, Lock and Key Model of (E-S) Complex Formation, 3.4 Factors Affecting Enzyme Activity, 3.5 Myoglobin and Haemoglobin, 3.6 Enzyme-Substrate Interactions. [7 hours]

4. **Physics of Nucleic Acids:** 4.1 Structures of DNA and RNA, 4.2 Replication of DNA, 4.3 Genetic Code, 4.4 Protein Biosynthesis, 4.5 Types of RNA 4.6 Genetic disorder and cause of cancer [5 hours]

5. **Physics of Cell and Cell Membrane:** 5.1 Organization of Animal Cell, 5.2 Structure of Cell Membrane, Fluid Mosaic Model, Fick's Law of Diffusion, 5.3 Theory of Electro-diffusion, 5.4 Active Membrane Transport, 5.5 Passive Membrane Transport, Hodkin-Katz Formula. [6 hours]

6. **Neurophysics:** 6.1 Structure of Nerve Cell, 6.2 Axon and nerve Impulse, 6.3 Generation and Propagation of Nerve Impulse: Hodkin and Huxley Theory, 6.4 EEG and EMG. [4 hours]

7. **Blood Flow and Heart Action: 7.1** Blood Flow and Mechanics of the Heart, 7.2 Electrical Activities: ECG, Einthoven's Triangle. [3 hours]

8. **Computational Biophysics:** 8.1 Introduction, 8.2 Introducing the Symbolic Math Tool Box and Uses 8.3 Matrices and Arrays, 8.4 Graphics, 8.5 Programming, 8.6 Introduction to Simbiology, 8.7 Functions with Multiple Inputs and Outputs, 8.8 Graphs with Multiple X- and Y- Axes, 8.9 Three Dimensional Graphics Related to the Biophysics, Spherical Harmonics 8.10 Simbilogy Projects to Run the Plots for States vs. Time, 8.11 Computational Design of Bio-molecules and Study of their Functional Properties. [10 hours]

Text Books:

1. Volkenstein M. V.- **Biophysics**, Mir Publishers, Moscow (1983)
2. The Math Works, Inc.-**Learning Matlab& Simulink Student Version**, www. mathworks.com (2010)

Reference Books:

1. Roy R. N. **- A Textbook of Biophysics,** New Central Book Agency (P) Ltd., London (2013)
2. Hughes William – **Aspects of Biophysics**, John Wiley and Sons, New York (1979)
3. Gilat, Amos. **MATLAB®: An Introduction with Applications,** 2nd ed. Hoboken, NJ: John Wiley (2005)
4. Narayanan P. **- Essentials of Biophysics**, New Age International Publishers, New Delhi (2008)

Phy617: Gravitation & Cosmology I (45L, 15T, 3CH)

Nature of the course: Theory   Full Marks: 50   Pass Marks: 25

Course Description:

The aim of the course is to impart the fundamental knowledge of general relativity and cosmology.

Course Objectives:

The objective of the course is to introduce the student to the theory of general relativity and cosmology.

Course Contents:

1. **Introduction:** 1.1 Physics and geometry, 1.2 Riemannian Geometry , 1.3 Tensor algebra, 1.4 Vector transplantation, 1.5 Affine connection, 1.6 Christoffel symbols, 1.7 Geodesic equation, 1.8 Gaussian co- ordinates [12 hours]

2. **Tensor Analysis:** 2.1 Covariant differentiation, 2.2 Symmetric and antisymmetric tensors, 2.3 Closed and exact tensors, tensor densities, 2.4 Symmetry and Killing vactors, 2.5 Maxwell's equation in tensor form, 2.6 Relativisitc mechanics, 2.7 Fluid dynamics, 2.8 Gravity as a metric phenomenon, 2.9 Equivalence principle, 2.10 Mach's principle 2.11 Red shift [16 hours]

3. **Field equations in free space:** 3.1 Riemann curvature tensor, 3.2 Ricci tensor, 3.3 Bianchi identities, 3.4 Integrability and Riemann tensor, 3.5 Pseudo Euclidean and flat space, 3.6 Einstein field equation for free space, 3.7 Einstein tensor. [12 hours]

4. **Schwarzschild solution:** 4.1 Schwarzschild solution, perihelia shift, 4.2 Null geodesic and bending of light, 4.3 Schwarzschild coordinates and Kruskal co-ordinate [5 hours]

Text Books

1. Weinberg S. - **Gravitation and Cosmology: Principles and Applications of the General Theory of Relativity**, John Wiley & Sons. New York (1972)

2. Adler R., Bazin M., Schiffer M. - **Introduction to general Relativity**, McGraw Hill Inc, New York (1975)

Reference Books

1. Kolb E. W. and Turner M. S. - **Early Universe**, addison Wesley (1990)
2. Misher C. W., Thorne K. S. and Wheeler J. A. - **Gravitation** - W. H. Freeman and Company, New York (1991)

Phy618: Astrophysics I (45L, 15T, 3CH)

Nature of the course: Theory Full Marks: 50 Pass Marks: 25

Course Description:

The aim of the course is to impart the fundamental knowledge of Astronomy

Course Objectives:

The prime motive of this course is to give an overview of basic astronomy, stellar- and galaxy evolution. In addition, it is expected that student can learn the basics of research in Observational and Computational Astronomy

Course Contents:

1. **General Astronomy:** 1.1 Brief history & developments of Astronomy 1.2 Stellar magnitude: apparent and absolute 1.3 Opacity: distance-magnitude-extinction relation 1.4 colour index, colour excess 1.5. Mass-luminosity relation 1.6 Astronomical time scales: nuclear, thermal and dynamical 1.7 Analytical and numerical problems [10 hours]

2. **Stellar Interior:** 2.1 Pressure exerted by the gas in the star: non-degenerate, degenerate (both relativistic and non-relativistic) 2.2 Pressure exerted by the photons in the star: radiation pressure 2.3 Internal equilibrium conditions: hydrostatic equilibrium, mass-continuity relation 2.4 Linear stellar model: applications 2.5 Polytrophic model: modeling electron degenerate star 2.6 Polytrophic model: modeling neutron degenerate star 2.7 Convective energy transport 2.7 Theory of random walk: photon 2.10 Local thermodynamic equilibrium 2.8 problems [20 hours]

3. **Stellar Energy Sources:** 3.1 proton-proton chain 3.2 CNO cycle 3.3 Triple alpha process, oxygen, carbon and silicon burning, photo-dissociation, 3.4 Solar neutrino problem 3.5 Nuclear coulomb energy 3.6 Nuclear reaction cross-section [7 hours]

4. **Stellar Atmosphere**: 4.1 Stellar spectra: classification 4.2 Harvard & Yerkes classification 4.3 H-R diagram: evolutionary track of the star [4 hours]

5. **Open Database:** 6.1 NED, SIMBAD, SKYVIEW 6.2 IRAS maps: ALADIN [4 hours]

Text Books

1. Karttunan H., Kröger P., Oja H., Poutanen M., Donner K.J., **- Fundamental Astronomy**, fifth edition, Springer (2007)

2. Padmanabhan T. - **An invitation to Astrophysics**, Vol. 8, World Scientific (2006)

Reference Books

1. Harwit Martin - **Astrophysical Concepts**, fourth edition, Springer (2006)
2. Palene S. - **Schaum Outline Series: Astrophysics,** McGraw Hill (2004)
3. Choudhuri A. R. - **Astrophysics for Physicists**, Cambridge University Press (2010)

FOURTH SEMESTER

Phy651: Quantum Mechanics III (45L, 15T, 3CH)

Nature of the course: Theory Full Marks: 50 Pass Marks: 25

Course Description:

The aim of the course is to impart some fundamental knowledge of relativistic Quantum Mechanics. This is in continuation of the first year course on Quantum Mechanics.

Objectives:

The objective of this course is to train the students in the methods of Quantum Mechanics. At the completion of the course, the student should be able to solve problems in Quantum Mechanics

Course Contents:

1. **WKB approximation:** 1.1 Expansion in powers of h, 1.2 Turning point solutions 1.3 Validity 1.4 one dimensional barrier 1.5 Bound states, 1.6 Radial wave equation, 1.7 Double well levels [4 hours]

2. **Electron in the electromagnetic field:** 2.1 Maxwell's equations, 2.2 Uniform magnetic field 2.3 Charged particle in magnetic field 2.4 Flux Quantization 2.5 Aharnov Bohm effects [4 hours]

3. **Stationary Perturbation theory:** 3.1 Perturbation theory 3.2 Nondegenerate case 3.3 Simple applications 3.4 Degenerate case, Simple cases of removal of degeneracy 3.5 Exchange degeneracy 3.6 Rayleigh Ritz Variation Method [5 hours]

4. **Fine and Hyperfine Structures of Hydrogen atom:** 4.1 Mass correction 4.2 Spin orbit interaction 4.3 Fine structure of Hydrogen atom in and electric field: Stark effect 4.4 Hyperfine structure [5 hours]

5. **Helium atom:** 5.1 Normal Helium atom 5.2 Excited states 5.3 Auto ionization [2 hours]
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6. **Many electron atom:** 6.1 Central field approximation 6.2 Thomas-Fermi atom 6.3 Hartree method of self consistent fields 6.4 Hartree Fock method 6.5 Koopamans theorem [4 hours]

7. **Molecules:** 7.1 Born Oppenheimer method 7.2 H_2^+ ion 7.3 Hydrogen molecule 7.4 Main features of bonding 7.5 Quantum resonance [4 hours]

8. **Time dependent perturbation:** 8.1 Method of variation of constants 8.2 Constant perturbation coupling between two discrete States, Fermi golden rule discrete states 8.3 Periodic perturbation 8.4 Coupling with a continuum of final states 8.5 Adiabatic and sudden approximations [4 hours]

9. **Scattering method of partial waves:** 9.1 Scattering of a wave packet 9.2 Elastic scatting of plane waves 9.3 Scattering by a weak potential: Born approximation 9.4 General finite potentials 9.5 Square well potential 9.6 Coulomb Scattering 9.7 Screened Coulomb potential [6 hours]

10. **Relativistic single particle theory:** Zero spin 10.1 Uncertainty principle 10.2 Klien Gordon equation and its interpretation 10.3 Charged spin zero free particle, Eigenvalues of operators 10.4 Interaction with electromagnetic field [3 hours]

11. **Relativistic single particle theory:** Half spin 11.1 Dirac equation 11.2 Spin of a Dirac particle 11.3 Free particle solutions approximate Hamiltonian Solution of central potential problems, negative energy and significance of negative energy states, hydrogen atom [4 hours]

Text Books:

1. Agrawal B. K. and Hari Prakash - **Quantum Mechanics**, Prentice Hall of India (1977).

Reference Books:

1. Cohen Tannoudji C. Dui B. and Laloe F - **Quantum Mechanics**, John Wiley, New York (1977).

2. Ghatak A. K. and Lokanathan S- **Quantum Mechanics**, Macmillan India Limited (1984)

3. Sakurai J. J. and Napolitano J. J. – **Modern Quantum Mechanics**, Addison-Wesley; 2 edition (2010)

4. Wachter A. – **Relativistic Quantum Mechanics**, Springer (2011)

Phy652: Nuclear & Particle Physics (45L, 15T, 3CH)

Nature of the course: Theory   Full Marks: 50   Pass Marks: 25

Course Description:

This course consists of Nuclear and particle Physics.

Objectives:

To provide the students with the knowledge of fundamentals of particle interactions and particle phenomenology..

Course Contents:

1. **Background:** 1.1 Origin of nuclear physics 1.2 Emergence of particle physics: the standard model and hadrons, 1.3 Relativity and antiparticles, 1.4 Symmetries and conservation laws [5 hours]

2. **Nuclear reactions**: 2.1 Cross-sections, 2.2 Compound nucleus, 2.3 Scattering matrix, 2.4 Reciprocity theorem, 2.5 Breit-Wigner one level formula, 2.6 Resonance scattering, 2.7 Continuum theory, 2.8 Optical model, 2.9 Absorption cross-section at high energies. [8 hours]

3. **Particle Interactions**: 3.1 Introduction to Feynman diagrams, 3.2 Particle exchange: forces and potentials, 3.3 Range of forces, 3.4 Yukawa potential, 3.5 Observable quantities: cross sections and decay rates: Amplitudes, Cross-sections and Unstable states [8 hours]

4. **Particle phenomenology - Leptons:** 4.1 Lepton multiplets and lepton numbers 4.2 Neutrinos 4.3 Neutrino mixing and oscillations, 4.4 Neutrino masses 4.5 Universal lepton interactions – the number of neutrinos [10 hours]

5. **Particle phenomenology - Quarks:** 5.1 Evidence for quarks 5.2 Quark generations and quark numbers 5.3 Hadrons 5.4 Flavour independence and charge multiplets 5.5 Quark model spectroscopy 5.6 Hadron masses and magnetic moments 5.7 Problems [10 hours]

6. **Future Prospects:** 6.1 Higgs boson 6.2 Grand unification 6.3 Supersymmetry 6.4 Particle astrophysics [4 hours]

Text books:

1. Martin B. R. – **Nuclear and Particle Physics**, John Wiley & Sons (2006)

2. Roy R. R. and Nigam B. P. - **Nuclear Physics: Theory and Experiment,** New age International (P) Limited, India (1967)

Reference books:

1. Marmier P. and Sheldon E. - **Physics of Nuclei and Particles**, Academic Press New York London (1970)

2. Perkins D. H. - **Elementary Particle Physics**, Addison Wesley Publisbing Company Inc. (1986)

3. Hans H.S.- **Nuclear Physics: Experimental and Theoretical,** New age International (P) Limited, New Delhi (2001)

4. Patel S.B.- **Nuclear Physics: An Introduction**, New age International (P) Limited, Publishers New Delhi (2006)

5. Martin B. R. & G. Shaw - **Particle Physics**, JohnWiley & Sons Ltd, The Atrium, Southern Gate, Chichester,West Sussex, United Kingdom (2008)

6. Perkins D. H. - **Introduction to High Energy Physics**, Cambridge University Press, 4th Edition (2001)

Phy653: Electronic Lab / Computational Physics / Project

There are three courses in this code. Students are required to select only one course. The nature of the courses is not theoretical. They are experimental (Phy623a), Computational (Phy623b) and research (Phy623c).

Phy653a: Electronics Practical (Lab180, T45, 3CH)

Nature of the course: Practical Full Marks: 50 Pass Marks: 25

Course Description:

M.Sc. physics fourth semester students have to perform at least 12 experiments in 180 working hours to fulfill 3 CH course. Students are required to perform 15 hours laboratory work per week. Students need to write a laboratory report on each experiment they perform and get them duly checked and signed by the concerned teacher. They should write their reports in a separate sheet, and to keep them neat and properly filed.

Course Objectives:

- To provide students with skill and knowledge in the experimental methods.
- To make them able to apply knowledge to practical applications.
- To make them capable of presenting their results/conclusions in a logical order.

Course Contents:

1. To construct and study the pulse amplifier
2. To design the decimal-to-binary coded decimal (BCD) encoder and verify the conversion of binary from decimal
3. Study the tri-state logic (TSL) circuit and hence verify its truth table
4. To study the multiplexer and verify its truth table
5. Design and study the 1-bit digital comparator circuit
6. To study the de-multiplexer and verify its truth table
7. Design and study the memory circuit
8. Study the low frequency response (high pass filter) and high frequency response (low pass filter) circuits and calculate their cut-off frequencies.
9. Study the characteristics of the amplitude modulation and calculate the percentage modulation

10. Construct the Hartley oscillator and set up it for sinusoidal output waveform of desired frequency

Note: *Subject committee will add more experiments after consultation with the experts in the field in and abroad. All colleges should manage to purchase it in time.*

Phy653b: Computational Physics (Lab180, T45, 3CH)

Nature of the course: Practical Full Marks: 50 Pass Marks: 25

Course Description:

The aim of the course is to impart some fundamental knowledge of computational physics to solve real physical problems.

Course Objectives:

The objective of this course is to train the students in the methods of computations in physics and apply them to solve the real problems. At the completion of the course, the student should be able to solve different physical problems using recent computational techniques.

Course content

1. **Introduction: -** 1.1 Error, Precision, and Stability in Computational Science, 1.2 operating system – MS Windows and Linux, 1.3 Plotting programs – Gnuplot / Xmgrace 1.4 Mathematica, 1.5 Programing language(s) – Fortran / C
   [T10]

2. **Numerical Methods**: 2.1 Finding Roots - Newton-Raphson method; 2.2 Interpolation – Lagrange and cubic spline interpolations, 2.3 Numerical integration – Trapezoidal and Simpson's rule,The simple pendulum, multidimensional (Monte Carlo) numerical integration; 2.4 Ordinary differential equation, - Euler methods, Runge-Kutta Methods, second order differential equation, Phase space of a simple harmonic oscillator, One-Dimensional Schroedinger equation (example with anharmonic potential); 2.5 Partial differential equation - Laplaces equation, wave equations and heat equation (Students must be able to write code themselves in each topic with Fortran/C OR develop mathematica module) [T25]

3. **Applications of computational physics** – Ising model, Polytropic model, Plasma applications etc.
   [T10]

Text Books:

1. De Vries P. L. - **A first course in computational physics**, John wiley & Sons, New York (1994)

2. Franklin J. - **Computational Methods for Physics**, Cambridge University Press, Cambridge (2013)

References Books:

1. Koonin S. E., Meredith D. C. - **Computational Physics**, Westview press (1990)

2. Anagnostopoulos K .N. - **Computational Physics**, National Technical University, Athens (2014)

Phy653c: Project (3CH)

Nature of the course: Research Full Marks: 50 Pass Marks: 25

The optional second part of this course is a project work. In this course, a student can opt for theoretical, computational or experimental work. In either case, a student must demonstrate his ability to carry out either theoretical, computational calculation or experimental technique independently and at the end of his/her work, he/she must produce or write up. The work must be presented orally. The external examiner appointed by the department examines his/her project write up and the department, in an appropriate time, will conduct oral presentation. A marking scheme is as follows:

1. Project proposal presentation - 10
2. Problem identification & methods - 10
3. Final presentation - 30

Project Guidelines

1) A student can do project work only if a faculty or a physics teacher agrees to supervise his/her project work. A supervisor can take up to 10 project works at a time.
2) The nature of project work can be theoretical, computational or experimental. Whatever the nature, students should critically review literature of the area of interest and identify the problem specifically.
3) Students should prepare a proposal and submit it to the department within a month of third semester final examination. The general format of the proposal should like this:
   (a) Background/Introduction
   (b) Literature Review
   (c) Motivation/Objectives
   (d) Methodology

(e) Expected Result
(f) References (should be in PRL format)

The proposal defense will be held before mid-term examination of the fourth semester.

4) The final VIVA examination should be held within a month of the fourth semester final examination. The examination date will be proposed by the concerned colleges and is approved by the Dean office.
5) The format of the project should be same as the format of M.Sc. dissertation. The format will be decided by the Central Department Research Committee (CDRC).
6) There will be no additional fee for the project work. However, for the final VIVA examination, students need to pay Rs. 2500/- for the presentation program.
7) The evaluation will be made by HoD or program coordinator, supervisor, external and internal examiners. The scheme should be as follows:

(a) Proposal:	20% (HoD)
(b) Originality/creativity:	20% (Supervisor)
(c) In-depth Research:	20% (Internal Examiner)
(d) Interpretation	20% (External Examiner)
(e) Presentation:	20% (all)

8) A separate appreciation certificate will be given to the student who completes the project with A grade.

Phy661: Advanced Solid State Physics II (45L, 15T, 3CH)

Nature of the course: Theory Full Marks: 50 Pass Marks: 25

Course description:

This course aims at providing students with basic knowledge and skill in theoretical as well as experimental aspects of Solid State Physics.

Course objective:

- To acquaint student with the theoretical and experimental methods in Solid State Physics.
- To prepare them in developing skill to pursue further study and research in the field of physics.

Course Contents:

1. **Optical properties**: 1.1 General discussion of interaction of radiation and a solid 1.2 Penetration of light in a metal 1.3 Optical conductivity in simple metals 1.4 Interband absorption 1.5 Hagen-Ruben relations 1.6 Optical properties in the infrared [10 hours]

2. **Magnetism and magnetic resonance**: 2.1 Magnetic relaxation and resonance phenomena, 2.2 The Bloch equations and the complex susceptibility 2.3 Ferromagnetic resonance 2.4 Spin waves [10 hours]

3. **Superconductivity: 3**.1 The phenomena of Superconductivity 3.2 Thermodynamic properties 3.3 Flux exclusion and Meissner effect 3.4 London equation 3.5 Coherence length 3.6 Flux quantization in a superconducting ring 3.7 Ginzburg-Landau theory 3.8 Type I and Type II superconductors 3.9 Cooper pairs and BCS theory of Superconductor 3.10 Superconducting energy gap 3.11 Giaever and Josephson tunneling 3.12 High temperature Superconductors 3.13 Critical fields and critical currents [25 hours]

Text Books:

1. Ziman J. M. – **Principles of the theory of Solids**, Cambridge University Press, London (1972)

2. Ziman J. M.– **Electrons and Phonons**, Clarendron Press, Oxford (1960)

3. Ashcroft N. W and Mermin N. D. – **Solid State Physics**, Holt Rinehart and Winston, New York (1976)

4. M. Tinkham – **Introduction to Superconductivity**, McGraw-Hill Inc., New York

(1976)

Reference Books:

1. Schmidt V. V. – **The physics of superconductors**, Springer-Verlag, Berlin (1997)

2. K. Fossheim and A Sudbo – **Superconductivity Physics and Applications**, John wiley & Sons Ltd., England (2004)

3. Callaway J. – **Quantum Theory of Solid State**, Volume I and II Academic Press, New York and London (1974)

4. Christman J. R. – **Fundamentals of Solid State Physics**, John Wiley & Sons, New York (1988)

5. Kittel C. – **Quantum theory of solids**, John Wiley & Sons, New York (1967)

6. Seitz F. and Turnbull D. - **Solid State Physics**, advances in Research and Applications (complete set), Academic Press, New York (1956)

7. **Springer series in solid state science**, (complete set), Springer Verlag, Berlin (2012)

8. Harrison W.A. – **Solid State Theory**, Tata McGraw Hill, India (1977)

Phy662: Micro and Optoelectronics II (45L, 15T, 3CH)

Nature of the course: Theory Full Marks: 50 Pass Marks: 25

Course description

This course contains two sections. The first section deals with Microelectronics and second section deals with Optoelectronics. The course is designed to fulfill the following objectives.

Course objective

- To give the adequate knowledge in designing digital electronics circuits
- To give the principle of architecture of the microprocessor and its application
- To introduce the Optoelectronics theory and devices together with their application in communication system

Course contents:

1. **Signal Processing and Data Conversion:** 1.1 Signal and Signal Processing, 1.2 Sample and Hold System, 1.3 Analog Multiplexer and Demultiplexer, 1.4 D/A Converters, 1.5 A/D Converters. [9 hours]

2. **Very Large Scale Integrated System:** 2.1 Dynamic MOS Shift Registers, 2.2 CMOS Domino Logic, 2.3 Random Access Memory (RAM), 2.4 Read Write Memory Cells. [8 hours]

3. **Microprocessor system:** 3.1 Introduction, 3.2 Central Processing Unit (CPU) 3.3 Arithmetic Logic Unit (ALU), 3.4 General Purpose Registers, 3.5 Control Registers, 3.6 Instruction Registers and Decoder, 3.7 Timing and Control Unit, 3.8 Read and Write, 3.9 Architecture and Organization of 8085 Microprocessor. [13 hours]

4. **Optical Communication System:** 4.1 Modulation Schemes, 4.2 Free Space Communication, 4.3 Fiber Optical Communication Systems, 4.4 Operating Wavelength, 4.5 Emitter Characteristics and Emitter Design, 4.6 Detector Characteristics and Detector Design, 4.7 Choice of Fibers, 4.8 System Design Consideration, 4.9 Local Area Network, 4.10 Future Development. [15 hours]

Text Books:

1. Millman J., Grabel A. – **Microelectronics**, McGraw Hill International edition, New York (1987)

2. Wilson J., Hawkes J. F. B. – **Optoelectronics an inttroduction**, Prentice Hall, India (1889).

References:

1. Smith Sedra - **Microelectronics circuits**, Fifth edition, New York Oxford, Oxford University Press (2004)

2. Mukhopadhyay A. K. - **Microprocessor Microcomputer and their Applications** (second edition), Narosa Publishing House (1999)

3. Gaonkar R. S. - **Microprocessor Architecture**, Programming and Applications with the 8085, Fourth Edition, Penram International Publishing, India (1995).

4. Khere R. P. – **Fiber Optics and Optoelectronics**, Oxford University Press (2004)

5. Sarkar C. K., Sarkar D. C. – **Optoelectronics and Fiber Optics Communication**, New Age International (P) Limited, Publishers, New Delhi (2001)

Phy664: Atmospheric Physics II (45L, 15T, 3CH)

Nature of the course: Theory Full Marks: 50 Pass Marks: 25

Course Description:

The course aims to provide the knowledge and to prepare students for the higher studies and research in the field of atmospheric physics. The course is designed with the following objectives.

Course objective:

- To provide a broad knowledge of atmospheric physics.
- To prepare students to explore contemporary issues of atmospheric phenomena.
- To develop skills to observed and to find the solutions to the atmospheric problems.

Course Contents:

1. **Atmospheric diffusion:** 1.1 Mathematical descriptions of spatial and temporal distribution of contaminants, 1.2 Eulerian approach, 1.3 Lagrangian approach, 1.4 Governing equations in turbulence, 1.5 Validity conditions for Eulerian and Lagrangian approaches, 1.6 Diffusion from instantaneous and continuous sources, 1.7 Mean concentration, 1.8 Statistical theory of turbulence diffusion, 1.9 Motion of single particle relative to a fixed axis. [6 hours]

2. **Cloud microphysics:** 2.1 Nucleation of water vapor condensation, 2.2 Microstructure of warm clouds, 2.3 Cloud liquid water and entrainment, 2.4 Growth of cloud droplets, 2.6 Microphysics of cold clouds, 2.7 Formation of precipitation, 2.8 Artificial modification of clouds and precipitation, 2.8 Thunderstorm electrification, 2.9 Cloud and precipitation chemistry. [7 hours]

3. **Atmospheric dynamics:** 3.1 Kinematics of large-scale horizontal flow,3.2 Dynamics of horizontal flow, 3.3 Prominent wind systems: Geostrophic, gradient, and thermal wind systems, 3.4 Suppression of vertical motion, 3.5 Conservation law for vorticity, 3.6 Potential vorticity, 3.7: Primitive equations: Pressure coordinates, hydrostatic balance, thermodynamic energy equations, inferences of the vertical motion field, applications of primitive equations, 3.8 Atmospheric general circulation: Kinetic energy cycle, atmosphere as heat engine, 3.9 Atmospheric transport processes over Himalayan complex terrain, 3.10 Introduction of weather systems. [10 hours]

4. **Atmospheric boundary layer:** 5.1 Turbulence: Eddy and thermals, statistical description of turbulence, turbulence kinetic energy and turbulence intensity, turbulent transport and fluxes, turbulence closure, scales and similarity theory, 5.2 Surface energy balance: Radiative fluxes, bulk aerodynamic formulae, global surface energy balance, 5.3 Vertical structure: temperature, humidity, winds, diurnal

and regional variation of boundary-layer structure, stratification and stability, 5.4 Evolution of boundary-layer: entrainment, growth, cloud topped boundary-layer, stormy weather, 5.5 Effects on boundary-layer: terrain effects, sea breezes, forest canopy, and urban effects, 5.6 Context of boundary layer. [8 hours]

5. **Atmospheric waves:** 6.1 The Eliassen-Palm flux and evolution of atmospheric waves, 6.2 Pure gravity waves, 6.3 Inertia-gravity waves, 6.4 Rossby waves, 6.5 Kelvin waves, 6.5 Wave breaking and its effects, 6.6 Baroclinic instability. [6 hours]

6. **Climate dynamics:** 7.1 The present-day climate: annual mean conditions, diurnal and seasonal dependences, 7.2 Climate variability: Internal and coupled variability, 7.3 Externally forced climate variability: solar variability, volcanic eruptions, 7.4 Climate equilibrium, sensitivity and feedbacks, 6.5 Greenhouse warming: buildup of greenhouse gases, evidences of global warming and projections, short and long climatic forcers, 7.6 Climate monitoring and prediction, 7.8 Introduction to numerical climate models. [8 hours]

Text Books:

1. Wallace J. M. and Hobbs P. V. **– Atmospheric Science**, International Geophysics Series, Elsevier Inc. (2006)

2. Seinfeld J. H. and Pandits S. N. **- Atmospheric Chemistry and Physics**, John Wiley & Sons, Inc., New York (1998)

Reference Books:

1. Salby M. L. **- Fundamentals of Atmospheric Physics**, Academic Press, New York (1996)

2. Stull Ronald **- The Atmospheric Boundary Layer**, Kluwar Academic Publisher, Netherlands (1988)

5. Brasseur G. P., Orlando J. J. and Tyndall G. S. *(editors)* **- Atmospheric Chemistry and Global Change**, Oxford University Press (1999)

Phy665: Plasma Physics II (45L, 15T, 3CH)

Nature of the course: Theory Full Marks: 50 Pass Marks: 25

Course Description:

The main aim of this course is to provide basic knowledge of plasma physics and develop skill in pursuing research work in plasma applications.

Course Objectives:

The objective of this course is to apply the knowledge and to lay the foundation on the fundamental study / research in plasma physics.

Course Contents:

1. **Waves in Plasmas:** 1.1 Plasma oscillations, 1.2 Electron plasma waves, 1.3 Sound waves, 1.4 Ion waves, 1.5 Validity of plasma approximation, 1.6 Electrostatic electron oscillation perpendicular to magnetic field, 1.7 Electrostatic ion waves perpendicular to magnetic field, 1.8 The lower hybrid frequency, 1.9 Electromagnetic waves without and with magnetic field and their consequences, 1.10 Cut-off and resonances, 1.11 Hydromagnetic waves, 1.12 Magnetosonic waves [15 hours]

2. **Diffusion and Resistivity:** 2.1 Diffusion and mobility in weakly ionized gases, 2.2 Decay of plasma by diffusion, 2.3 Steady state solutions, 2.4 Recombination, 2.5 Diffusion across a magnetic field, 2.6 Collisions in fully ionized plasmas, 2.7 The single-fluid MHD equations, 2.8 Diffusion in fully ionized plasmas, 2.9 Bohm diffusion and neoclassical diffusion [10 hours]

3. **Equilibrium and Stability:** 3.1 Hydromagnetic equilibrium, 3.2 The concept of β, 3.3 Diffusion of magnetic field into a plasma, 3.4 Classification of instabilities, 3.5 Two-stream instability, 3.6 The “Gravitational” instability, 3.7 Resistive drift waves, 3.8 The Weibel instability [9 hours]

4. **Nonlinear Effects: 4.1** Sheaths - The planar sheath equation, 4.2 The Bohm sheath criterion, 4.3 The Child-Langmuir law, 4.4 Electrostatic probes: Langmuir probe, 4.5 Ion acoustic shock waves - The Sagdeev potential, 4.6 The critical Mach numbers, 4.7 Wave steepening, 4.8 The ponderomotive force [11 hours]

Text Books

1. Chen F. F. - **Introduction to Plasma Physics and Controlled Fusion** (second edition), Plenum Press (1984)

Reference Books

1. Krall N. A. and Trivelpiece A. W. - **Principles of Plasma Physics**, San Francisco Press (1986)

2. Chakraborty B. - **Principles of Plasma Mechanics**, John Wiley & Sons Inc (1991)

3. Bittencourt J. A. - **Fundamentals of Plasma Physics**, Springer (2004)

Phy666: Biomedical Physics II (45L, 15T, 3CH)

Nature of the course: Theory Full Marks: 50 Pass Marks: 25

Course Description:

This course is aimed to provide fundamental knowledge how physical laws are applied in medical field.

Objectives:

The objective of this course is to train the students to use the methods in formulating and solving the problems of Medical Physics. The course has been designed to provide the basic skills of computational Medical Physics also.

Course Contents (Medical Physics):

1. **Interactions of Radiation:** 1.1 Review of Radioactivity 1.2 Ionizing and Nonionizing Radiations 1.3 Interaction of Ionizing Radiation: Coherent Scattering, Photoelectric Absorption, Incoherent Scattering, Pair Production and Photodisintegration 1.4 Mixture Rule: Determination of Atomic and Electronic Cross section in a Compound 1.5 Measurement of Minimum Detectable Fraction 1.6 Interaction of Heavy Charged Particles and Fast Electrons 1.7 Neutron Capture and Radiative Capture 1.8 Neutron Activation Analysis (NAA) [7 hours]

2. **Radiation Quantity and Quality:** 2.1 Radiation Intensity, Radiation Exposure 2.2 Radiation Energy and Photon fluence per Roentgen 2.3 Ionization Measurement: Free Air Ionization Chamber, Thimble Chamber, Condenser Chamber and Electrometer [5 hours]

3. **Measurement of Radiation Dose:** 3.1 Units of Radiation Dose 3.2 Kinetic Energy Released in the Medium (KERMA) 3.2 Relation between KERMA, Exposure and Absorbed dose 3.3 Dosimetry: Calorimetric Dosimetry, Photographic Dosimetry, Chemical Dosimetry and Thermo-luminescence Dosimetry (TLD) [5 hours]
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4. **Interaction of X-rays and Gamma rays in the Human Body:** 4.1 f-factor 4.2 Attenuation of X-ray and Gamma rays in bones, muscles (soft tissue), Fats and Air Cavities 4.3 Contrast Medium [2 hours]

5. **Imaging Techniques:** 5.1 Gamma Camera 5.2Computed Tomography Scanning(CT Scanning) 5.3 Positron Emission Tomography (PET) imaging 5.4 Single Photon Emission Computed Tomography (SPECT) Imaging 5.5 Ultrasonography Imaging 5.6 Nuclear Magnetic Resonance (NMR) Imaging 5.7 Whole body counting 5.8 Electron Microscope [7 hours]

6. **Radiation Therapy:** 6.1 Radio-isotopes: Production and uses 6.2 Brachy-therapy and Tele-therapy 6.3 High Dose Rate (HDR) Brachy-therapy 6.4 Linear Accelerator (LINAC) 6.5 Cobalt-60 Tele-therapy Unit 6.6 Phantom 6.7 Quality Assurance (QA) of Radio-diagnosis and Radiotherapy Units [5 hours]

7. **Radiation Protection:** 7.1 Stochastic and Non-stochastic effect of radiation 7.2 Effect of Radiation at Subcellular and Cellular Level, Survival Curve Repair 7.3 Dose Limit and As Low As Reasonably Achievable (ALARA) 7.4 External and Internal Source of Radiation and Protection 7.5 Radiation Hazards ad Its Control [4 hours]

8. **Computational Medical Physics:** 8.1 Introduction to computer simulation methods, applications to physical systems 8.2 Simbiology: Modeling, Simulation, Estimation and Deployment 8.3 Monte Carlo Simulation technique 8.4 computational study of proteins and nucleic acid strands 8.5 Computational study of binding sites of macromolecules 8.6 Computational study of drug molecules 8.7 Computational Design of Drugs and their Functional Properties [10 hours]

Text Books:

1. Hendee W. R - **Medical Radiation Physics**, 4th edition, Year Book Medical Publishers INC. London (2002)

2. The Math Works, Inc.-**Learning Matlab & Simulink Student Version**, www. mathworks.com (2010)

Reference Books:

1. Khan F M - **The physics of Radiation Therapy**, 3rd edition, Williams and Wilkins, USA (2011)

Phy667: Gravitation & Cosmology II (45L, 15T, 3CH)

Nature of the course: Theory Full Marks: 50 Pass Marks: 25

Course Description:

The aim of the course is to impart the fundamental knowledge of general relativity and cosmology.

Course Objectives:

The objective of the course is to introduce the student to the theory of general relativity and cosmology. After the completion of this course, the student will have a grasp of the fundamentals of the theory of gravitation to pursue higher studies and research in this field

Course Contents:

1. **Linearized field equations:** 1.1 Linearization of the field equations, 1.2 Time independent and spherically symmetric field, 1.3 Solution of the linearized equation, 1.4 Gravitational waves [10 hours]

2. **Field equation in nonempty space:** 2.1 Energy momentum tensor, 2.2 Electromagnetic field, 2.3 Field equation in non empty space, 2.4 Classical limit of gravitational equations, 2.5 Equation of motion, 2.6 Conservation law in General relativity [12 hours]

3. **Stellar equilibrium and gravitational collapse:** 3.1 Relativistic stellar structure 3.2 Interior Schwarzschild solution, 3.3 Stellar stability, 3.4 Gravitational collapse [7 hours]

4. **Cosmology:** 4.1 Cosmological Principle, 4.2 Isotropy and homogeneity, 4.3 Cosmic microwave background radiation, 4.4 De Sitter space 4.5 Robertson Walker metric, 4.6 Kinematics in RW space, 4.7 Friedmann equilibrium thermodynamics, 4.11 Entropy [16 hours]

Text Books:

1. Weinberg S. - **Gravitation and Cosmology: Principles and Applications of the General Theory of Relativity**, John Wiley & Sons. New York (1972)

2. Misher C. W., Thorne K. S. and Wheeler J. A. - **Gravitation** - W. H. Freeman and Company, New York (1991)

Reference Books:

1. Adler R., Bazin M., Schiffer M. - **Introduction to general Relativity**, McGraw Hill Inc, New York (1975)

2. Kolb E. W. and Turner M. S. - **Early Universe**, addison Wesley (1990)

Phy668: Astrophysics II (45L, 15T, 3CH)

Nature of the course: Theory Full Marks: 50 Pass Marks: 25

Course Description:

The aim of the course is to impart the knowledge of Stellar and Galaxy Wvolution

Course Objectives:

The prime motive of this course is to give an overview of stellar- and galaxy evolution. In addition, it is expected that student can learn the basics of research in Observational and Computational Astronomy

Course Contents:

1. **Interstellar Medium:** 1.1 Components: gas, dust, magnetic field and cosmic rays 1.2 Classification of gas 1.3 Detection techniques for molecular, neutral and ionized Hydrogen 1.4 ISM cycle 1.5 Heating and cooling mechanism in ISM [6 hours]
2. **Star Formation:** 2.1 Molecular cloud 2.2 Jeans instability 2.3 Virial theorem 2.4 Jeans mass and length 2.5 Stages of star formation [5 hours]
3. **Stellar Evolution:** 3.1 Less massive star: red giant, He-flash, horizontal branch, instability, asymptotic giant branch, planetary nebula, white dwarf 3.2 Massive star: multiple burning, super giants, neutron drip, photodissociation, shock wave, supernova explosion, neutron star, black hole 3.2 Radiative energy transport [8 hours]
4. **Big Bang Nucleosynthesis**: 4.1 Planck scale, 4.2 GUT epoch, 4.3 Inflation 4.4 Electro-weak epoch 4.5 Quark epoch, 4.6 Hadron epoch, 4.7 Lepton epoch, 4.8 Photon epoch, 4.8 Dark epoch 4.9 Supporting facts 4.10 Unsolved issues: Horizon problem, flatness problem, monopole problem, Baryon asymmetry, Dark matter and dark energy problem 4.11 Contemporary rival models: de Sitter model, Einstein's static model, Oscillating Universe, Steady state theory [9 hours]
5. **Large Scale Structure Formation:** 5.1 Einstein field equation, 5.2 Structure of the space-time: Robertson-Walker metric, 5.3 Co-moving coordinate system 5.4 Eddington equation, 5.5 Density parameter, 5.6 Hubble Parameter [6 hours]
6. **Galaxy:** 6.1 Milky-Way: structure and formation 6.2 Classification of galaxies, 6.3 Galaxy rotation curve: dark matter, 6.4 Hubble law and age of the Universe 6.5 □CDM model 6.6 Cosmic microwave background radiation 6.7 COBE and WMAP results [7 hours]

7. **Computational Astrophysics**: Use of software 7.1 ALADIN, 7.2 IDL and others [4 hours]

Text Books

1. Karttunan H., Kröger P., Oja H., Poutanen M., Donner K.J., **- Fundamental Astronomy**, fifth edition Springer, (2007)

2. Padmanabhan T. - **An invitation to Astrophysics**, vol. 8, World Scientific (2006)

Reference Books

1. Stahler S. W. and Palla F. – **The Formation of Stars**, Wiely-VCH (2004)
2. Weinberg S. – **The First Three Minutes**, Fontana Paperback (1976)
3. Harwit Martin - **Astrophysical Concepts**, fourth edition, Springer, (2006)
4. Palene S. - **Schaum Outline Series: Astrophysics,** McGraw Hill (2004)
5. Choudhuri A. R. - **Astrophysics for Physicists**, Cambridge University Press (2010)

Phy699: Dissertation (6CH)

Nature of the course: Research Full Marks: 100 Pass Marks: 50

Course Description:

Phy 699 is a thesis paper of full mark 100 offered in the curriculum of the M. Sc. Fourth semester. A student opting for thesis prepares a proposal under the supervision of a thesis advisor and defends his/her proposal in the Department. Once accepted by the Department, a student can start his/her research work under the guidance of his/ her supervisor

Course Objectives:

- To provide student with skill and knowledge in conducting research on fundamental and application aspect of physics
- To train student in developing analytical as well as argumentative skill.

A student who completes and passes all his/ her first semester course with at least B-grade can opt for these courses in lieu of one of the elective courses prescribed in the M.Sc. physics third semester syllabus. The number of students accepted for the thesis work will be limited on the basis of resource persons and the materials available in the department. A student must complete this course within the academic calendar. However, a grace period of three moths may be extended to complete it beyond the calendar. A student's M.Sc. thesis must embody the results of guided research, preferably, be an original contribution to knowledge, and include materials worthy of publication, if possible. It is expected that the student learns and applies some theoretical or experimental techniques, not prescribed in text books, and demonstrates his ability to conduct an investigation to abstract principles upon which predictions can be made, to interpret the results of his research work in a logical manner and to present this results clearly in writing. To be acceptable to the department, the thesis upon completion must be recommended by his/her supervisor. Three spirally bound copies must be presented to the office of the Head of the Department to facilitative his/her final oral examination. Once these formalities are completed, a date of final oral examination will be fixed as per rule. The thesis should be submitted to the department after the inclusion of the comments made by the following examiners. The thesis evaluation committee consists of four members. The committee members are Head of the Physics Department, the thesis supervisor, and internal examiner and an external examiner. They will evaluate the student's thesis write up and oral presentation. They will grade the thesis individually. An average of four-member evaluation will be the final mark on this paper. If the grade is not exactly divisible by four, it will be rounded off to the next higher number. Please note that the thesis submitted to the Department/colleges is for the partial fulfillment of the requirement for the degree of Master of Science in physics at Tribhuvan University.

Note: *Colleges should follow the guidelines prepared by CDRC (Central Department Research Committee) regarding the format, supervision/co-supervision criteria and evaluation process and scheme.*

Dissertation Guidelines

1) A student can do dissertation work only if a faculty or a physics teacher agrees to supervise his/her dissertation work. A supervisor can take up to 10 dissertation works at a time.
2) The nature of dissertation work can be theoretical, computational or experimental. Whatever the nature, students should critically review literature of the area of interest and identify the problem specifically.
3) Students should prepare a proposal and submit it to the department within a month of third semester final examination. The general format of the proposal should like this:
   (a) Background/Introduction
   (b) Literature Review
   (c) Motivation/Objectives
   (d) Methodology
   (e) Expected Result
   (f) References (should be in PRL format)

   The proposal defense will be held before mid-term examination of the fourth semester.
4) The final VIVA examination should be held within a month of the fourth semester final examination. The examination date will be proposed by the concerned colleges and is approved by the Dean office.
5) Students should strictly follow the format of the M.Sc. dissertation. Any changes in the format will be decided by the Central Department Research Committee (CDRC).
6) For the final VIVA examination, students need to pay Rs. 5000/- for the presentation program.

Evaluation Scheme

1) There will be a four member evaluation board, as follows:

(a) HoD or M.Sc. Program Coordinator:	Head
(b) Supervisor	Member
(c) External Examiner	Member
(d) Internal Examiner	Member

   The external examiner will be appointed by the Dean office on the recommendation of HoD/program coordinator. HoD will consult Supervisor if necessary. The internal examiner will be appointed by HoD/Program coordinator.

2) The date of the final VIVA examination of dissertation will be fixed by the Central Department/Colleges. Central Department/colleges will fix a day (e.g., Friday) for the final VIVA presentation.

3) A separate evaluation form will be given to all four members of the evaluation committee during the VIVA examination that contains the following:
   (a) Introduction to the subject 10%
   (b) Literature review 10%
   (c) Motivation/Objectives 10%
   (d) Originality and creativity: 10%
   (e) In-depth Research: 10%
   (f) Methods 10%
   (g) Figures/plots/tables 10%
   (h) Interpretation 10%
   (i) Comparison with published work 10%
   (j) Presentation: 10%

4) The thesis will be graded on the basis of the following grading/GPA scheme:

Grade	GPA	%equivalent	Performance
A	4.0	90 and above	Distinction
A-	3.7	80-89.9	Very good
B+	3.3	70-79.9	First Division
B	3.0	60-69.9	Second Division
B-	2.7	50-59.9	Pass
F	0.0	Below 50	fail

Dissertation Final VIVA Examination

The final VIVA examination of the dissertation work can be conducted after fourth semester final examination. Students need to submit 3 copies of dissertation before the beginning of practical examination. The report should be in bind form (finally in the hard-cover binding) with the signature of the supervisor. The evaluation mode is given in the curriculum (above). Students need to pay a fix amount for the final examination.

QUESTION FORMAT FOR THEORY PAPERS

Compulsory Papers

Duration: 3 Hours **Full Marks: 60** **Pass Marks: 30**

Attempt all questions

1. **Long Question (Head+Body+Tail)** **[10]**
2. **Long Question (Head+Body+Tail)** **[10]**
3. **Long Question (Head+Body+Tail)** **[10]**

   OR

   Long Question (Head+Body+Tail)
4. **Short Question [Head+Body or Boday+Tail]** **[6]**
5. **Short Question [conceptual question]** **[6]**

   OR

   Short Question [conceptual question]
6. **Short Question [Numerical]** **[6]**
7. **Short Question [Numerical]** **[6]**
8. **Short Question [Numerical]** **[6]**

Elective Papers

Duration: 3 Hours **Full Marks: 60** **Pass Marks: 30**

Attempt all questions

1. **Long Question (Head+Body+Tail)** **[12]**
2. **Long Question (Head+Body+Tail)** **[12]**
3. **Long Question (Head+Body+Tail)** **[12]**

   OR

   Long Question (Head+Body+Tail)
4. **Short Question [conceptual question]** **[8]**

   OR

   Short Question [conceptual question]
5. **Short Question [Numerical]** **[8]**
6. **Short Question [Numerical]** **[8]**

Final Practical Examination

The marking scheme is as follows:

1. Day to day evaluation (internal) - 40%
2. Final Practical Examination - 60%

There will be 6 hours long practical examination as per calendar. The examination schedule is published by the department. An external examiner will be appointed by the Dean Office. The internal examiner will be appointed by the HoD. Students need to perform one experiment and write up the report that should contain following:

1. Working Formula and its description
2. Observation
3. Calculation
4. Plotting with error interpretation
5. Result and discussion
6. Conclusion or Final interpretation

Final Computational Physics Examination

The marking scheme is as follows:

3. Day to day evaluation (internal) - 40%
4. Final Practical Examination - 60%

There will be 6 hours long final examination as per calendar. The examination schedule is published by the department. An external examiner will be appointed by the Dean Office. The internal examiner will be appointed by the HoD. Students need to perform experiments in the computer. They are not allowed to bring their laptops in the exam. Students should submit the report in the computer.

Project Work Final VIVA Examination

The final VIVA examination of the project work will be conducted during fourth semester practical examination as per semester calendar. Students need to submit 3 copies of project report before the beginning of practical examination. The report should be in bind form with the signature of the supervisor. The evaluation mode is given in the curriculum (above). Students need to pay a fix amount for the final examination.