Master of Science in Physics

Curriculum

M.Sc. (Physics)

(Semester System)

Central Department of Physics
Tribhuvan University, Kirtipur
April 2017

Note: This curriculum is developed by the subject experts under consultation with subject standing committee and finalized by the physics subject committee full meeting held on 2073/12/27 (9 April 2017). Later, the curriculum of all four semesters is recommended by the Faculty Board, IoST, TU and finally approved by the Academic Council, TU.

Content

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 has implemented semester system from the year 2014. Since the year 2015, all constituent and affiliated colleges have introduced semester system in the nation.

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, Institute of Science & Technology, Tribhuvan University, Kirtipur. The applicant who fails to appear in the entrance examination or to obtain a minimum qualifying score will not be given admission.

Course Structure

Table 1: Credit hour distribution of compulsory theory courses, practical and elective courses for four semesters of M.Sc. (Physics) program.

Semester	Courses (Theory/Compulsory)				Practical (compulsory)	Elective Courses		Dissertation	Term paper or Seminar	Total CH
First	**3**	**3**	**3**	**3**	**4**	**-**	**-**	**-**	**-**	**16**
Second	**3**	**3**	**3**	**3**	**4**	**-**	**-**	**-**	**-**	**16**
Third	**3**	**3**	**3**	**-**	**4**	**2**	**2/0**	**-**	**0/2**	**17/17**
Fourth	**3**	**-**	**-**	**-**	**4**	**4**	**4/0**	**0/6**	**2/0**	**17/17**
	36 (54.5%)				**16 (18.2%)**	**12/6(18%/9%)**		**0/6 (9%)**	**2/2 (3%)**	**66**

There will be four semesters in two years. The semester duration will be 18 weeks (15 weeks for course work and 3 weeks for evaluation tests). A student should complete 66 credit hour (hereafter CH) courses in order to earn Master's degree in physics from Tribhuvan University. The credit hour distribution of courses in all four semesters is shown in Table 1.

A credit hour (CH hereafter) means teaching a theory course work for 60 minutes each week throughout the semester. For the laboratory work, 1 CH is equivalent to the 3 hours of lab work per week per semester. This course offers compulsory theoretical courses, laboratory work, computation work, elective and optional thesis/dissertation work in physics.

Table 2: A summary of credit hours of all compulsory and elective courses offered at Tribhuvan University for M.Sc. (Physics) from the year 2073.

Semester	Compulsory Courses	Elective Courses
First	16	-
Second	16	-
Third	15	26
Fourth	9	54
	56	**80**

Table 3: List of **compulsory courses**, their course code, CH, full and pass marks and the total number of theory (L), Practical (P) and and tutorial (T) classes

Semester	Course Code	Courses	CH	Full Marks	Pass Marks	Nature of Course	Class Hour
First	PHY501	Math Physics I	3	75	37.5	Theory	L45+T15
First	PHY502	Classical Mechanics	3	75	37.5	Theory	L45+T15
First	PHY503	Quantum Mechanics I	3	75	37.5	Theory	L45+T15
First	PHY504	Electronics	3	75	37.5	Theory	L45+T15
First	PHY505	Physics Lab 1					
	PHY505a	General Experiment	2	50	25	Practical	P90+T10
	PHY505b	Electronics Experiment	2	50	25	Practical	P90+T10
Second	PHY551	Quantum Mechanics II	3	75	37.5	Theory	L45+T15
Second	PHY552	Statistical Mechanics	3	75	37.5	Theory	L45+T15
Second	PHY553	Solid State Physics	3	75	37.5	Theory	L45+T15
Second	PHY554	Electrodynamics I	3	75	37.5	Theory	L45+T15
Second	PHY555	Physics Lab 2					
	PHY555a	General Experiment	2	50	25	Practical	P90+T10
	PHY555b	Electronics Experiment	2	50	25	Practical	P90+T10
Third	PHY601	Quantum Field Theory	3	75	37.5	Theory	L45+T15
Third	PHY602	Electrodynamics II	3	75	37.5	Theory	L45+T15
Third	PHY603	Math Physics II	3	75	37.5	Theory	L45+T15
Third	PHY604	Computational Physics Lab	4	100	50	Practical	P180+T20
Third	PHY605	Term Paper (III)[1]	2	50	25	Presentation	-
Fourth	PHY651	Particle Physics	3	75	37.5	Theory	L45+T15
Fourth	PHY652	Physics Lab 3					
	PHY653a	General Experiment	2	50	25	Practical	P90+T10
	PHY653b	Electronics Experiment	2	50	25	Practical	P90+T10
Fourth	PHY654	Term Paper (IV)[2]	2	50	25	Presentation	-
Total CH (Compulsory Courses)			54	1350	675	L540+P720+T260=1520	

Note: *Term Paper[1] and Term Paper[2] will be offered for thesis and non-thesis students in the third and fourth semesters, respectively.*

Table 4: List of **elective courses**, their course code, CH, full and pass marks and the total number of class and tutorial hours.

Semester	Course Code	Courses	CH	Full Marks	Pass Marks	Nature of Course	Class Hour
Third	PHY611	Advanced Solid State Physics I	2	50	25	Theory	L30+T10
Third	PHY612	Astrophysics I	2	50	25	Theory	L30+T10
Third	PHY613	Atmospheric Physics I	2	50	25	Theory	L30+T10
Third	PHY614	Biomedical Physics I	2	50	25	Theory	L30+T10
Third	PHY615	Condensed Matter Physics I	2	50	25	Theory	L30+T10
Third	PHY616	Galactic Physics I	2	50	25	Theory	L30+T10
Third	PHY617	General Theory of Relativity	2	50	25	Theory	L30+T10
Third	PHY618	Microprocessor & Optoelectronics	2	50	25	Theory	L30+T10
Third	PHY619	Nano Physics I	2	50	25	Theory	L30+T10
Third	PHY620	Physics of Materials I	2	50	25	Theory	L30+T10
Third	PHY621	Plasma Physics I	2	50	25	Theory	L30+T10
Third	PHY622	Solid Earth Geophysics I	2	50	25	Theory	L30+T10
Third	PHY623	Entrepreneurship for Physicist	Non-credit			Theory	L30+T10
Fourth	PHY661	Advanced Solid State Physics II	4	100	50	Theory	L60+T20
Fourth	PHY662	Astrophysics II	4	100	50	Theory	L60+T20
Fourth	PHY663	Atmospheric Physics II	4	100	50	Theory	L60+T20
Fourth	PHY664	Biomedical Physics II	4	100	50	Theory	L60+T20
Fourth	PHY665	Condensed Matter Physics II	4	100	50	Theory	L60+T20
Fourth	PHY666	Galactic Physics II	4	100	50	Theory	L60+T20
Fourth	PHY667	Gravitation & Cosmology	4	100	50	Theory	L60+T20
Fourth	PHY668	Microelectronics	4	100	50	Theory	L60+T20
Fourth	PHY669	Nano Physics II	4	100	50	Theory	L60+T20
Fourth	PHY670	Physics of Materials II	4	100	50	Theory	L60+T20
Fourth	PHY671	Plasma Physics II	4	100	50	Theory	L60+T20
Fourth	PHY672	Solid Earth Geophysics II	4	100	50	Theory	L60+T20
Fourth	PHY699	Dissertation	6	150	75	Presentation	-
Total CH (Elective Courses)			80				

A student can choose any two courses from the electives including dissertation. The elective course pool is shown in Table 5 below:

Table 5: Elective Paper Pool: students **should not** allow taking two courses from a pool.

Group A	Group B	Group C
THIRD SEMESTER		
Adv. Solid State Physics I Microprocessor & Optoelectronics Nano Physics I Solid State Geophysics I	Astrophysics I Atmospheric Physics I Condensed Matter Physics I General Theory of Relativity	Bio Medical Physics I Galactic Physics I Physics of Materials I Plasma Physics I
FOURTH SEMESTER		
Adv. Solid State Physics II Microelectronics Nano Physics II Solid State Geophysics II	Astrophysics II Atmospheric Physics II Condensed Matter Physics II Gravitation & Cosmology	Bio Medical Physics II Galactic Physics II Physics of Materials II Plasma Physics II

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 as a regular student in order to enroll for the dissertation.** The practical course in all semesters is compulsory.

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 10 students 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 hour 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**: 15 weeks (90 working days) in an academic semester.
b) Nature of the Classes:
 i) **Theory**: One theory paper of 75 marks (3 CH) will have 3 hours of lectures per week (45 minutes long four classes) throughout the semester. For a 3 CH 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 3 hours lab work per week.*** One practical paper of 4 CH should have 12 hours of practical per week throughout the semester. 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)

c) **Attendance:** 80 percent attendance in the class (theory, practical, tutorial) is required.

Evaluation

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

1) **Internal Examination:** The in-semester (internal) examination of theory papers 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	: 4%
Home Work	: 10%
Mid-Term Test	: 13%
Final-Term Test	: 13%

The mid and final term exam will be held for one hour. The full marks of the mid-term and final-term exams are suggested to be in 100 marks (later it can be reduced to the 13%). The copy will be checked in marks. The examination copy can be showed to the students by the concerned faculties in the class. Though department will not publish results of internal examination publicly. 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. The recommended format for the Mid-Term and Final-Term Examination will be as follows:

Mid-Term Exam:

Full Marks: 100	Pass Marks: 50	Duration: 60 minutes
Attempt all questions.		
1. Long Question (Head+Body+Tail) (18 minutes)		[30]
2. Long Question (Head+Body+Tail) (18 minutes) OR Long Question (Head+Body+Tail)		[30]
3. Short Question (Head+Tail OR Body+Tail) (12 minutes) OR Short Question (Head+Tail OR Body+Tail) (12 minutes)		[20]
4. Numerical (12 minutes)		[20]

Note: The question format can be revised by the faculties as per requirement.

Final-Term Exam:

Full Marks: 100	Pass Marks: 50	Duration: 60 minutes
Attempt all questions.		
1. Long Question (Head+Body+Tail) (18 minutes)		[30]
2. Long Question (Head+Body+Tail) (18 minutes) OR Long Question (Head+Body+Tail)		[30]
3. Short Question (Head+Tail OR Body+Tail) (12 minutes) OR Short Question (Head+Tail OR Body+Tail) (12 minutes)		[20]
4. Numerical (12 minutes)		[20]

Note: The question format can be revised by the faculties as per requirement.

2) **Final Examination:** Institute of Science and Technology, Tribhuvan University will conduct final examination. The students will have to pass each course at each level separately. The final examination in each course will be a written examination as follows:

CH	Full Marks	Pass Marks	Final Examination Duration
2	30	15	2 hours
3	45	22.5	2 hours
4	60	30	3 hours

The duration of practical examination will be **6 hours** for 2CH lab works. 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 two practical examinations per semester.

The format for the 2 hours (2 & 3 CH) and 3 hours (4 CH) final examinations will be as follows:

Final Exam (Compulsory Courses) **3 Credit Hour**

Full Marks: 45 Credit Hour: 3	Pass Marks: 22.5 Duration: 2 hours
Attempt all questions.	
1. Long Question	[10]
2. Long Question OR Long Question	[10]
3. Short Question OR Short Question	[5]
4. Short Question	[5]
5. Short Question	[5]
6. Numerical 1	[5]
7. Numerical 2	[5]

Final Exam (Elective Courses / Third Semester) **2 Credit Hour**

Full Marks: 30 Credit Hour: 2	Pass Marks: 15 Duration: 2 hours
Attempt all questions.	
1. Long Question	[8]
2. Long Question OR Long Question	[8]
3. Short Question OR Short Question	[6]
4. Numerical 1	[4]
5. Numerical 2	[4]

Final Exam (Elective Courses / Fourth Semester) **4 Credit Hour**

Full Marks: 60 Credit Hour: 4	Pass Marks: 30 Duration: 3 hours
Attempt all questions.	
1. Long Question	[12]
2. Long Question OR Long Question	[12]
3. Short Question OR Short Question	[8]
4. Short Question	[8]
5. Short Question	[8]
6. Numerical 1	[6]
7. Numerical 2	[6]

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.

Term Paper & Dissertation

1) A term paper is compulsory for the students. It contains a seminar and a report of his/her research activities under the supervision of faculties.

2) A student who opt 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. Practical Examination date
6. 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. All the colleges (constituent or affiliated) where M.Sc. (Physics) program is running, should strictly obey semester calendar published by the CDP.

COMPULSORY COURSES

FIRST SEMESTER

PHY501: Mathematical Physics I 3CH (45L+15T)

Nature of the course: Theory Full Marks: 75 Pass Marks: 37.5

Course Description

This course contains different areas of mathematics that are used extensively in the study of theoretical and applied 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. **Tensors and Differential Forms** **[10 hours]**
   - **1.1** Review of tensor analysis, inverse transformation, quotient rule, spinors,
   - **1.2** Pseudotensors and dual tensors,
   - **1.3** Tensors in general coordinates: Metric tensor, covariant and contravariant bases, covariant derivatives, evaluating christoffel symbols, tensor derivative operators,
   - **1.4** Jacobian and inverse Jacobian,
   - **1.5** Differential forms: Introduction, exterior algebra, complementary differential forms,
   - **1.6** Differentiating forms: Exterior derivatives, Maxwell's equations,
   - **1.7** Integrating forms: Stoke's, Green's and Gauss' theorems.

2. **Vector Space and Eigenvalue Problems** **[8 hours]**
   - **2.1** Vectors in function space: Schwarz inequality, orthogonal expansions and scalar product, Bessel's inequality, expansion of Dirac delta function,
   - **2.2** Gram-Schmidt orthogonalization,
   - **2.3** Operators: commutation, identity, inverse and adjoint, Basis expansion of operators and adjoint, self-adjoint operators,
   - **2.4** Invariants,
   - **2.5** Eigenvalue problems: Matrix and Hermitian problems, diagonalization, spectral decomposition, expectation values, normal and non-normal matrices.

3. **Integral Transforms** **[7 hours]**
   - **3.1** Fourier transform and convolution theorem,
   - **3.2** Signal processing applications,
   - **3.3** Discrete Fourier transforms,
   - **3.4** Laplace transform of derivatives and integrals,
   - **3.5** Derivative and integration of Laplace transform,
   - **3.6** Laplace convolution theorem,
   - **3.7** Inverse Laplace transforms,
   - **3.8** Integral equations.

4. **Sturm-Liouville Theory** **[4 hours]**

4.1 Introduction,
4.2 Hermitian operators, self adjoint ordinary differential equations,
4.3 Ordinary differential equation eigenvalue problems,
4.4 Variation method.

5. Green's Functions **[10 hours]**

5.1 Introduction,
5.2 One dimensional problems: General properties, Form of Green's function, other ordinary conditions, relation to integral equations,
5.3 Problems in two and three dimensions: self adjoint problems, eigenfunction expansions, form of Green's functions.

6. Group Theory **[12 hours]**

6.1 Introduction,
6.2 Representation of groups,
6.3 Symmetry and physics,
6.4 Discrete groups,
6.5 Direct products,
6.6 Symmetric group,
6.7 Continuous groups: Lie groups and their generators,
6.8 Groups SO(2) and SO(3),
6.9 Group SU(2) and SU(2)-SO(3) homomorphism,
6.10 Group SU(3),
6.11 Lorentz group,
6.12 Lorentz covariance of Maxwell's equations,
6.13 Space groups.

Textbook:

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

Reference Books:

1. Mathew, J. & Walker, R. – **Mathematical Methods in Physics,** Benjamin, Menlo Park, Second Edition (1970).
2. Margenu H. & Murphy G. M. – **Mathematics for Physics and Chemistry**, East West Press Pvt. Ltd., New Delhi (1964).
3. Spiegel, Murray R. – **Vector Analysis (Schaum Series),** McGraw Hill, London (1992).
4. Morse, P.M. & Feshbach H. – **Methods of Theoretical Physics,** Part I & II, McGraw Hill, New York (1953).

PHY502: Classical Mechanics 3CH (45L+15T)

Nature of the course: Theory Full Marks: 75 Pass Marks: 37.5

Course description:

This course contains a description and formulation of classical mechanics.

Objectives:

The objective of the 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. **An overview of Lagrangian formulation for discrete system: [8 hours]**
   - **1.1** Calculus of variation and its specific applications,
   - **1.2** Hamilton's principle for conservative and holonomic system, derivation of Lagrange's equation, Some applications of Lagrange's equation of motion,
   - **1.3** Extension of Hamilton's principle to non-holonomic systems (Method of Lagrange's undetermined multipliers) and its applications
   - **1.4** Conservation theorems and symmetry properties,
   - **1.5** Energy function and the conservation of energy.

2. **The Hamilton equations of motion: [4 hours]**
   - **2.1** Generalised momentum and cyclic coordinates,
   - **2.2** Legendre transformations and the Hamilton equation of the motion,
   - **2.3** Cyclic coordinates and conservation theorems,
   - **2.4** Derivation of Hamilton's equation from variational principle,
   - **2.5** The Principle of least action.

3. **The Central Force Problem: [8 hours]**
   - **3.1** Classification of orbits,
   - **3.2** The virial theorem,
   - **3.3** The differential equation of orbit and integrable power-law potentials,
   - **3.4** Conditions for closed orbits (Bertand's theorem),
   - **3.5** Kepler's problem: Inverse-square law of forces,
   - **3.6** The motion in time in the Kepler's problem,
   - **3.7** The Laplace-Runge-Lenz vector,
   - **3.8** Scattering in a central force field
   - **3.9** Transformation of the scattering problems to laboratory coordinates.

4. **Small oscillations: [3 hours]**
   - **4.1** Formulation of the problem
   - **4.2** The eigenvalue equation and principle axis transformation,
   - **4.3** Free vibrations of the linear tri-atomic molecule.

5. **Canonical transformation: [6 hours]**
   - **5.1** The equations of canonical transformation,
   - **5.2** The symplectical approach to canonical transformation,
   - **5.3** Poisson brackets and other canonical in variation

5.4 Equations of motion, infinitesimal canonical transformation, and Conservations theorems in the Poissons bracket formulation,
5.5 The angular momentum Poisson bracket relation,
5.6 Symmetry groups of the mechanical systems.

6. **Hamilton-Jacobi theory and action-angle variables: [6 hours]**
   6.1 The Hamilton-Jacobi equation for Hamilton's principle function,
   6.2 The Hamilton-Jacobi equations for Hamilton's characteristics function,
   6.3 Separation of variable in the Hamilton-Jacobi equation,
   6.4 Action-angle variables

7. **Lagrangian and Hamiltonian formulations for continuous systems and fields: [4 hours]**
   7.1 The transition from a discrete to a continuous system,
   7.2 The Lagrangian formulation for continuous system,
   7.3 Hamiltonian formulations,
   7.4 Quantization of electromagnetic field.

8. **Introduction to non Linear Dynamics: [6 hours]**
   8.1 Linear and nonlinear systems,
   8.2 Integration of second order non linear differential equations,
   8.3 Pendulum equation, Phase plane analysis of dynamical systems
   8.4 Linear stability analysis,
   8.5 Limit cycles.

Text books:

1. Golstein H., Poole C. and Safko John, **Classical Mechanics**, Pearson Education (2002).

Reference books:

1. Landau, L.D., Lifshitz E.M. – **Mechanics**, Vol. 1 (3rd ed.), Butterworth-Heinemann (1976).
2. Takwale, R.G and Puranik, P.S. – **Introduction to Clasical Mechanics**, Tata McGraw-Hill (1997).
3. Kibble, T.W.B. and Berkshire, F.H – **Classical Mechanics**, Prentice Hall (1996).
4. Aruldas G. – **Classical mechanics**, Prentice Hall of india Pvt Ltd (2008).
5. Darzin, P.G. and Johnson, R.S. – **Solitons - An Introduction**, Cambridge University Press (1989).

PHY503: Quantum Mechanics I 3 CH (45L+15T)

Nature of the course: Theory Full Marks: 75 Pass Marks: 37.5

Course Description:

This course contains a description and formulation of quantum mechanics.

Course 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. **Mathematical Tools of Quantum Mechanics: [12 hours]**
   - **1.1** One particle wave function space: vector space, scalar product, linear operator, closure relation,
   - **1.2** Discrete and continuous bases,
   - **1.3** State space, Dirac notation: ket and bra vectors, duel space, correspondence between ket and bra,
   - **1.4** Projection operator, Hermitian conjugation
   - **1.5** Representation in state space: orthonormalization relation, closure relation,
   - **1.6** Matrix representations of kets, bras, operators, change of representations,
   - **1.7** Eigenvalue equations,
   - **1.8** Observables: definition of an observable, the projectors,
   - **1.9** Sets of commuting observables, complete sets of commuting observables.

2. **Postulates of Quantum Mechanics: [6 hours]**
   - **2.1** Statement of the postulates,
   - **2.2** Physical interpretation,
   - **2.3** Physical implications of the Schrodinger equation,
   - **2.4** Conservation of probability,
   - **2.5** Equation of motion for an observable,
   - **2.6** Schrodinger, Heisenberg and Interaction pictures.

3. **Revisions of Barriers and Bound States in One Dimension: [4 hours]**
   - **3.1** Double well model of a molecule,
   - **3.2** Kronig-Penny model for metals.

4. **Spin and Magnetic Moment: [10 hours]**
   - **4.1** Revision of angular momentum, ladder operators in spherical coordinates
   - **4.2** Need for matrix representation of spin,
   - **4.3** Pauli spin matrices,
   - **4.4** Spinors and expectation values,
   - **4.5** Pauli operators,
   - **4.6** Magnetic moment of an electron: precession of an electron in a magnetic field,
   - **4.7** Magnetic resonance
   - **4.8** Space inversion and time reversal,
   - **4.9** Isospin.

5. **Addition of Angular Momenta:** **[8 hours]**
   5.1 Addition of two spins,
   5.2 Addition of two angular momenta: general method,
   5.3 Vector operators: Wigner-Eckart theorem,
   5.4 Identical particles and symmetry,
   5.5 Nuclear Forces.

6. **Stationary Perturbation theory:** **[5 hours]**
   6.1 Perturbation theory
   6.2 Non-degenerate case
   6.3 Simple applications
   6.4 Degenerate case, Simple cases of removal of degeneracy
   6.5 Exchange degeneracy
   6.6 Rayleigh Ritz Variation Method

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. Landau, L.D., Lifshitz E.M. – **Quantum Mechanics: Non-Relativistic Theory**, Vol. 3 (3rd ed.). Pergamon Press (1977).
3. Merzbacher, E. - **Quantum Mechanics,** 2nd ed., John Wiley, New York (1969).
4. Messiah, A. - **Quantum Mechanics,** John Wiley, New York (1963).
5. Thankappan, V. K. - **Quantum Mechanics,** Wiley Eastern Ltd., New Delhi (1993).

PHY504: Electronics 3 CH (45L+15T)

Nature of the course: Theory Full Marks: 75 Pass Marks: 37.5

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:

1. **Network Transformation and Resonance: [6 hours]**
   - **1.1** Reduction of Complicated Network, Conversions between T and π Sections,
   - **1.2** A.C. Bridge (Lattice Network), Sensitivity in Bridge Measurements,
   - **1.3** Definition of Q, Series Resonance and Band Width of the Series Resonant Circuit,
   - **1.4** Parallel Resonance Circuit or Anti-resonance, Condition for Maximum Impedance and Impedance Variation with Frequency,
   - **1.5** Band Width of Anti-Resonant Circuits, The General Case-Resistance Present in Both Branches and Anti-resonance at All Frequencies; Variable Phase-angle Circuit.

2. **Amplifier and Frequency response: [5 hours]**
   - **2.1** Review of Op-amp and its Applications: Control Sources
   - **2.2** Definition and Basic Concepts of Frequency Response, Series Capacitance and Low Frequency Response,
   - **2.3** Shunt Capacitance and High Frequency Response,
   - **2.4** Low and High Frequency Response of BJT and FET Amplifiers.

3. **Voltage Regulators: [4 hours]**
   - **3.1** Review of DC Power Supply
   - **3.2** Voltage Regulation, Series and Shunt Voltage Regulators,
   - **3.3** Switching Regulators

4. **Integrated Circuit Fabrication and Design: [4 hours]**
   - **4.1** Monolithic Integrated Circuit Technology,
   - **4.2** Fabrication of BJT, FET
   - **4.3** IC Diodes, Resistors

5. **Integrated Circuit Technology: [4 hours]**
   - **5.1** Basic Operational Characteristics and Parameters,
   - **5.2** CMOS Circuit: CMOS Inverter
   - **5.3** TTL Circuits: TTL Inverter, 2 Input TTL NAND Gate, Tri-state TTL Inverter
   - **5.4** Comparison of CMOS and TTL Performance.

6. **Digital Basics: [15 hours]**
   - **6.1** Introduction: Boolean Laws and Theorem,
   - **6.2** KarnaughMap and Simplifications (up to 4 Variables),

6.3 Multiplexers, De-multiplexers,
6.4 Encoders, Decoder
6.5 Parity Generators-Checkers,
6.6 2's Compliment Representation and its Arithmetic,
6.7 Arithmetic Building Blocks,The Adder and Subtracter.
6.8 Timer 555:Astable, Monostable
6.9 Shift Registers: Serial In – Serial Out, Serial In – Parallel Out, Parallel In – Serial Out, Parallel In – Parallel Out
6.10 Counters: MOD-8 Asynchronous/ Synchronous

7. Introduction to Digital Signal Processing: [7 hours]

7.1 Digital Signal Processing Basics,
7.2 Converting Analog Signals to Digital,
7.3 Analog-to-Digital Conversion Method: Flash AD
7.4 Digital -to- Analog Conversion Method: R-2R Ladder
7.5 Concept of Modulation: AM, FM
7.6 Introduction to Optical Fiber Waveguides and its Losses,
7.7 Introduction to Microprocessor 8085 System: Block Diagram, Simple Programming Concept (Addition of Hex-numbers)

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. Floyd T.L. – **Digital Fundamentals**, 8th edition, Pearson Education, Inc., 2004

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, Prentice-Hall of India Private Ltd., New Delhi (2004).
3. Malvino A.P and Leach D.P. – **Digital Principles and Application**, Tata McGraw Hill Publishing Company Ltd., New Delhi (1991).
4. Millman J. andHalkias C.C. –**Electronic Devices and Circuits**, McGraw Hill International Editions (1976).
5. Sarkar C.K. and Sarkar D.C. – **Optoelectronics and Fiber Optics Communication**, New Age International (P) Limited, Publishers, New Delhi (2001).
6. Wilson J. and Hawkes J.F.B. – **Optoelectronics-An Introduction**, Second edition, Prentice-Hall of India (2001).
7. Gaonkar R. S. – **Microprocessor Architecture, Programming, and Applications with the 8085**, Fourth edition, Penram International Publishing India (2000).

PHY505: Physics Lab 1 4 CH (P180+T20)

Course Description:
Physics lab 1 consists of two sections: (a) General Experiments and (b) Electronics experiments, each of two credit hours, as follows:

Course Code	Course Title	Credit Hour	Practical hour
PHY505a	**General Experiments**	**2**	**L90+T10**
PHY505b	**Electronic Experiments**	**2**	**L90+T10**

Students are required to perform at least 5 experiments in each course from the list.

Course Objectives
- To provide students with skill in the experimental methods.
- To make them capable of presenting their results/conclusions in a logical order.
- To make them to interpret results by performing error propagation, analysis and interpretation.
- To make them able to apply knowledge to practical applications.

Prerequisite
(a) Review of handling measuring equipments like Multimeter, micrometer, Spherometer, Oscilloscope etc.
(b) Statistical and Error analysis of many data by producing real data in lab using multimeter, micrometer etc.

PHY505a: General Experiments 2 CH (P90+T10)

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

The general experiments consist in four labs: (a) General Experiments (b) Optical Experiments, (c) Nuclear Experiments and (d) Computational Experiments. During this semester, students have to perform at least 5 experiments in 90 working hours in order to fulfill 2 CH. Students are required to perform 6 hours laboratory work every week. ***One credit hour lab work requires 3 hours lab work per week throughout the semester***. In addition, there will be 10 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. The marking scheme is as follows:

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

Course Contents:

1. Measurement of the charge of an electron by Millikan's method.
2. Measurement of the value of e/m for electron by any of following methods. (i) by fine beam tube method (ii) by using Magnetron (iii) by using CRT.
3. To design and study LCR (i) series (ii) parallel resonance circuits to obtain Q-factor.

4. To study and find wavelength of the interference of light by (i) the division of the wave front *e.g.,* (a) Fresnel's Biprism (b) Lloyd's mirror, and (ii) division of amplitude *e.g.,* (a) Michelson's interferometer.

5. Use phenomenon of interference of light to determine the thickness of a thin mica sheet or a thin paper by measurement of width of interference fringes in an air wedge.

6. Study the natural background radiation in the laboratory and outside. Discuss the possible sources of natural background radiation in the laboratory and outside.

7. (a) Study the diffraction phenomenon by (i) single slit (ii) double slit (iii) plane transmission grating and determine wavelength of sodium light in each case. (grating has separation of color for further use). (b) Use the phenomena of diffraction to find the lines per mm in a given grating using known wavelength of light.

8. Use hollow prism to (ii) study the variation of refractive index with concentration of sugar solution (ii) compare the refractive indices for different liquids like methanol, water, ethanol.

9. Verification of Dirac delta function by writing a computer code.

PHY505b: Electronics Experiments 2 CH (P90+T10)

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

The electronic experiments consist in three labs: (a) General Electronic Experiments (b) Oscilloscope Experiments (d) Computational Experiments. During this semester, students have to perform at least 5 experiments in 90 working hours in order to fulfill 2 CH. Students are required to perform 6 hours laboratory work every week. ***One credit hour lab work requires 3 hours lab work per week throughout the semester***. In addition, there will be 10 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. The marking scheme is as follows:

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

Course Contents:

1. Design and study the LOGIC gates: NOT, AND, OR, NOR & NAND using TTL. Also study the power loss in NOT gate.

2. Design and study the flip-flop using Universal gates.

3. Design and study multivibrators (i) astable (ii) monostable and (iii) bistable. Compare the results/outputs using timer.

4. Design and study the oscillators (i) Wein bridge (ii) Hartley (iii) Colpitt's and (iv) Phase shift. Understand the differences & similarities of all the above.

5. Design and study (i) CE (ii) CC & (iii) CS amplifiers.
6. Design and study the regulated variable power supply.

7. Construct and Study variable phase angle circuit.

Evaluation Scheme:

1. PHY505a and PHY505b will be examined separately for the duration of six hours in two different sessions. The external examiner(s) will be appointed by the Dean Office. The HoD or program coordinator will appoint internal examiner(s).

2. The final practical exam (60%) will be graded on the basis of the following marking scheme:

Record file:	20%	Experiment:	50%
Error Analysis:	10%	Viva:	20%

SECOND SEMESTER

PHY551: Quantum Mechanics II 3CH (45L+15T)

Nature of the course: Theory Full Marks: 75 Pass Marks: 37.5

Course Description

This course contains a formulation and application of quantum mechanics to the atoms and molecules.

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 Content:

1. **WKB approximation:** **[5 hours]**
   - **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.

2. **Electron in the electromagnetic field:** **[5 hours]**
   - **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.

3. **A Realistic Picture of Hydrogen Atom:** **[8 hours]**
   - **3.1** Mass correction,
   - **3.2** Spin-orbit interaction,
   - **3.3** Fine structure,
   - **3.4** Zeeman Effect: Weak Magnetic Field,
   - **3.5** Paschen-Back Effect: Strong Magnetic Field,
   - **3.6** Intermediate Field case,
   - **3.7** Hydrogen Atom in an Electric Field: Stark Effect,
   - **3.8** Hyperfine Structure.

4. **Helium atom:** **[4 hours]**
   - **4.1** Normal Helium atom: Variational Calculation,
   - **4.2** Excited states: 2*s* and 2*p*,
   - **4.3** Auto ionization.

5. **Many Electron Atom:** **[5 hours]**
   - **5.1** Central Field Approximation,

5.2 Thomas-Fermi atom,
5.3 Hartree Method of Self Consistent Fields,
5.4 Hartree Fock method,
5.5 Koopmans Theorem.

6. Molecules: [5 hours]

6.1 Basics of Born Oppenheimer Method,
6.2 H_2^+ ion,
6.3 Hydrogen Molecule,
6.4 Main Features of Bonding,
6.5 Quantum Resonance.

7. Time dependent perturbation: [8 hours]

7.1 Method of variation of constants,
7.2 Constant perturbation coupling between two discrete States: Fermi Golden Rule 1,
7.3 Periodic perturbation Coupling between two discrete States: Fermi Golden Rule 2,
7.4 Coupling with a continuum of Final States: Principle of Detailed Balance,
7.5 Selective Perturbations: Adiabatic and sudden approximations.

8. Spectra of Diatomic Molecule: [6 hours]

8.1 Electronic Spectra,
8.2 Vibration: Anharmonic Oscillator, Morse potential,
8.3 Vibration-Electronic Spectra: Progression,
8.4 Frank-Condon Principle,
8.5 Rotational Fine Structure,
8.6 Rotation Vibration Spectra,
8.7 Fortrat Diagram,
8.8 Vibrational Raman Spectra.

Text Books:

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

Reference Books:

1. Cohen-Tannoudji, C, Duui. B. & Laloe, F. **– Quantum Mechanics,** Vol. I & II, John Wiley (1977).
2. White, H. E. – **Introduction to Atomic Spectra,** International Edition, McGraw Hill, Singapore (1934).
3. Banwell, C. N. – **Fundamental of Molecular Spectroscopy,** 3rd ed., Tata McGraw Hill, Delhi (1994).
4. Merzbacher, E. - **Quantum Mechanics,** 2nd ed., John Wiley, New York (1969).
5. Sindhu, P. S. – **Molecular Spectroscopy,** Tata McGraw Hill, Delhi (1993).

PHY552: Statistical Mechanics 3CH (45L+15T)

Nature of the course: Theory Full Marks: 75 Pass Marks: 37.5

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: [15 hours]**
   - **1.1** Review of Thermodynamics,
   - **1.2** Statistical basis of thermodynamics,
   - **1.3** Macroscopic and microscopic states,
   - **1.4** Postulate of statistical mechanics,
   - **1.5** Phase space and ensemble,
   - **1.6** Liouville's theorem,
   - **1.7** Microcanonical ensemble,
   - **1.8** Derivation of thermodynamics,
   - **1.9** Classical ideal gas: Gibb's paradox and its resolution,
   - **1.10** Classical Harmonic Oscillators using Microcanonical ensemble,
   - **1.11** Concept of negative temperature,
   - **1.12** Canocical Ensemble, Partition function, Energy fluctuation in canonical ensemble,
   - **1.13** Grand canonical ensemble, Grand Partition function,
   - **1.14** Energy and density fluctuations in grand canonical ensemble,
   - **1.15** Classical ideal gas and Harmonic Oscillator problems in canonical and grand canonical ensemble,
   - **1.16** Equivalence of various ensembles,
   - **1.17** Generalized equipartition theorem – theorem of equipartition of energy and virial theorem.

2. **Quantum statistical mechanics: [10 hours]**
   - **2.1** Inadequacies (Limitations) of classical statistical mechanics
   - **2.2** Postulates of quantum statistical mechanics,
   - **2.3** Density matrix and its properties,
   - **2.4** Ensembles in quantum statistical mechanics – microcanonical, canonical, and grand canonical ensembles,
   - **2.5** Partition functions with examples including (I) an electron in magnetic field (II) a free particle in a box (III) a linear harmonic oscillator,
   - **2.6** Third law of thermodynamics,
   - **2.7** Symmetric and antisymmetric wave functions,
   - **2.8** The ideal gases: Microcanonical & grand canonical ensemble,
   - **2.9** Partition functions for diatomic molecule.

3. **Application of Ideal Bose and Fermi systems: [12 hours]**
   - **3.1** Thermodynamical behavior of ideal Bose gas, Photons –Black body radiation and Planck's law of radiation, thermodynamics of weakly degenerate Bose gas,

thermodynamics of strongly degenerate Bose gas; Bose-Einstein condensation, liquid helium-4, Bose-Einstein condensation in ultra-cold atomic gases

3.2 Phonons in solids, specific heat of solids,

3.3 Thermodynamical behavior of ideal Fermi gas – weakly and strongly degenerate Fermi gas, Free electron in metals,

3.4 Thermodynamic properties of relativistic Fermi gas, The theory of white dwarf stars.

.

4. Phase Transitions, Criticality and Universality: [8 hours]

4.1 Condensation of van der Waals gas,

4.2 A dynamical model of phase transitions,

4.3 Ising model in zeroth approximation,

4.4 The critical exponents,

4.5 Spontaneous magnetization,

4.6 The one dimensional Ising model.

Text books:

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

Reference books:

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

PHY553: Solid State Physics 3 CH (45 L+15T)

Nature of the course: Theory Full Marks: 75 Pass Marks: 37.5

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 lattices:** **[3 hours]**
   - **1.1** Bravais lattice and Primitive vectors,
   - **1.2** Simple cubic, body centered cubic and face centered cubic lattices, hcp and diamond structures, primitive unit cell,
   - **1.3** The reciprocal lattices: definitions and examples, first brillouin zone, lattice planes and Miller indices.

2. **Calculation of energy Bands:** **[5 hours]**
   - **2.1** The Tight binding method, APW method, KKR method and OPW method, pseudopotential methods.
   - **2.2** Energy bands of Na, Copper, Al,
   - **2.3** Qualitative features of energy bands of Transition metals and rare earth metals.

3. **Transport properties:** **[9 hours]**
   - **3.1** The semi-classical model of electron dynamics – Wave packets of Bloch electrons,
   - **3.2** Description of the semi-classical model, Comments and Restrictions
   - **3.3** Consequences of the semi-classical equations of motion
   - **3.4** Hall effects and magneto-resistance,
   - **3.5** The relaxation time approximation,
   - **3.6** General form of the non-equilibrium distribution function,
   - **3.7** Electrical conductivity,
   - **3.8** Thermal conductivity, thermoelectric effects.

4. **Superconductivity:** **[4 hours]**
   - **4.1** Experimental survey,
   - **4.2** Thermodynamics of superconducting transition,
   - **4.3** London equation,
   - **4.4** Flux quantization in a superconducting ring,
   - **4.5** Josephson superconducting tunneling.

5. **Plasmons, Polaritons, Polarons and excitons:** **[9 hours]**
   - **5.1** Dielectric function of the electron gas,
   - **5.2** Plasmons,
   - **5.3** Electrostatic screening,
   - **5.4** Polaritons,

5.5 Electron-electron interaction,
5.6 Electronphonon interaction- polarons,
5.7 Optical reflectance, Excitons,
5.8 Raman effects in crystals.

6. Alloys: **[3 hours]**
6.1 Substitutional solid solutions; Hume-Rothery Rules,
6.2 Order-disorder Transformations,
6.3 Phase diagrams, Kondo effects.

7. Surface and Interface physics: **[3 hours]**
7.1 Surface crystallography,
7.2 Surface electronic structure, solar cells and photovoltaic detectors,
7.3 Semiconducting lasers, Light-emitting diodes.

8. Nanostructures: **[9 hours]**
8.1 Imaging techniques for nanostructures,
8.2 Electronic structure of 1D systems,
8.3 Electrical transport in 1D,
8.4 Electronic structure of 0D systems,
8.5 Electrical transport in 0D,
8.6 Vibrational and Thermal properties of nanostructures.

Text Books:

1. Kittel C. **– Introduction to solid state physics,** 8th ed., John wiley & Sons (2005).

Reference Books:

1. Ashcroft N.W. & Mermin N.D. – **Solid state physics**, Thomson Brooks/Cole (2007).
2. Dekker A.J. – **Solid State Physics**, Macmillan (1993).
3. Ziman J.M. – **Principles of the Theory of solids**, Cambridge university press (1972).
4. Hook J.R. and Hall H.E. – **Solid State Physics**, 2nd ed., Wiley (1974).

PHY554: Electrodynamics I 3 CH (45L+15T)

Nature of the course: Theory Full Marks: 75 Pass Marks: 37.5

Course Description:

This course is aimed to provide fundamental knowledge about the electric and magnetic theories and their applications.

Objectives:

The objective of this course is to train the students to use the methods in formulating and solving the problems related to electric potential and fields.

Course Content:

1. **Introduction of Electrostatics: [2 hours]**
   - **1.1** Review of Electrostatics,
   - **1.2** Green's Theorem and Green Function,
   - **1.3** Formal Solution of Electrostatic Boundary-Value Problem with Green Function.

2. **Boundary – Value Problems in Electrodynamics: [6 hours]**
   - **2.1** Green Function for the Sphere: General Solution for the Potential,
   - **2.2** Conducting Sphere with Hemispheres at Different Potentials,
   - **2.3** Boundary Value Problems with Azimuthal Symmetry,
   - **2.4** Additional Theorem for Spherical Harmonics,
   - **2.5** Expansion of Green Function in Spherical coordinates.

3. **Multipoles, Electrostatics of Macroscopic Media, Dielectrics: [6 hours]**
   - **3.1** Multipole Expansion: Monopole, Dipole and Quadrupole,
   - **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 Problems with Dielectrics: a Point Charge Embedded in a Semi-infinite, Dielectric, Dielectric Sphere in a Uniform Electric Field.

4. **Introduction to Magnetostatics: [9 hours]**
   - **4.1** Vector Potential,
   - **4.2** Magnetic Fields of a Localized Current Distribution, Magnetic Moment,
   - **4.3** Force, Torque on and Energy of a Localized current Distribution in an External Magnetic Induction,
   - **4.4** Macroscopic Equations, Boundary Conditions on B and H,
   - **4.5** Methods of Solving Boundary Value Problems in Magnetostatics,
   - **4.6** Uniformly Magnetized Sphere,
   - **4.7** Magnetized Sphere in an External Field: Permanent Magnets,
   - **4.8** Energy in Magnetic Field.

5. **Maxwell's Equations: [6 hours]**
   - **5.1** Review of Maxwell's Displacement current; Maxwell Equation,
   - **5.2** Vectors and Scalars Potentials,
   - **5.3** Gauge Transformations, Lorentz 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.

6. **Plane Electromagnetic Waves, Wave Propagation and Waveguides: [6 hours]**
   6.1 Plane Waves in a Nonconducting Medium,
   6.2 Linear and Circular Polarization; stokes Parameters,
   6.3 Frequency Dispersion Characteristics of Dielectrics, Conductors, and Plasmas,
   6.4 Simplified Model of Propagation in the Ionosphere and Magnetosphere,
   6.5 Waveguides,
   6.6 Modes of rectangular Waveguides.

7. **Special Relativity [10 hours]**
   7.1 Review of Lorentz transformations and addition of velocities,
   7.2 Light cone, proper time and time dilation,
   7.3 Matrix representation of Lorentz transformations, infinitesimal generators,
   7.4 Thomas precession,
   7.5 Covariance of electromagnetic fields,
   7.6 Transformation of electromagnetic fields.

Text Book:

1. Jackson J. D. – **Classical Electrodynamics**, 3rd edition, John Wiley & Sons (1980).

Reference Texts:

1. Panofsky, W. K. H. and Philips – **Classical Electricity and Magnetism**, Addison – Wesley Publishing Company, Inc USA (1970).
2. Griffith D.J. – **Introduction to Electrodynamics**, Prentice Hall of India Private Limited, New Delhi, (2002).
3. Reitz J. R., Milford F. J, Christy R. W. –**Foundations pf Electromagnetic theory**, Narosa Publishing House, New Delhi, 3rd edition (1998).

PHY555: Physics Lab 2 4 CH (P180+T20)

Course Description:
Physics lab 2 consists of two sections: (a) General Experiments and (b) Electronics experiments, each of two credit hours, as follows:

Course Code	Course Title	Credit Hour	Practical hour
PHY555a	General Experiments	2	P90+T10
PHY555b	Electronics Experiments	2	P90+T10

Students are required to perform at least 5 experiments in each course from the list.

Course Objectives
- To provide students with skill 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.
- To make them to interpret results by performing error propagation, analysis and interpretation.

Prerequisite
Students are allowed to go to the computational lab for data processing. The fittings and error analysis will be done by using computer.

PHY555a: General Experiments 2 CH (P90+T10)

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

The general experiments consist in four labs: (a) General Experiments (b) Optical Experiments, (c) Nuclear Experiments and (d) Computational Experiments. In the second semester, students perform a few important physics experiments and develop the skill of error propagation, analysis and interpretation. During this semester, students have to perform at least 5 experiments in 90 working hours in order to fulfill 2 CH. Students are required to perform 6 hours laboratory work every week. ***One credit hour lab work requires 3 hours lab work per week throughout the semester***. In addition, there will be 10 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. The marking scheme is as follows:

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

Course Contents:

1. Study the absorption coefficients of α & β particles and γ radiation. Estimate the range of endpoint energy where applicable.

2. Study the hysteresis loss of the given materials and compare them.

3. Study the photocell and verify inverse square law. Hence determine Planck's constant and use it as a detector.

4. Study the heat capacity of given materials (use 0.1^{o} C sensitivity)

5. Study the resistance versus Temperature curve of the given thermistor material. Also design and study its use as a sensor.

6. Study the magnetic susceptibility of given dia- and paramagnetic substances.

7. Study the Hall coefficient of given n- & p-type materials and obtain the charge carrier density in each case and study the Hall mobility. (b) Also design and study use of n- & p- type materials to apply as fluxmeter probe.

8. (a) Study the monoatomic lattice vibration. Hence obtain the cut-off frequency of the given materials. (b) Study the diatomic lattice vibrations and determine the optical band gap

PHY555b: Electronics Experiments 2 CH (P90+T10)

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

The electronic experiments consist in three labs: (a) General Electronic Experiments (b) Oscilloscope Experiments, (c) Computational Experiments. In the second semester, students revise the experiments that were performed during B.Sc. and develop the skill of error propagation, analysis and interpretation. During this semester, students have to perform at least 5 experiments in 90 working hours in order to fulfill 2 CH. Students are required to perform 6 hours laboratory work every week. ***One credit hour lab work requires 3 hours lab work per week throughout the semester***. In addition, there will be 10 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. The marking scheme is as follows:

3. Day to day evaluation - 40%
4. Final Examination - 60%

Course Contents:

1. Design and study the filters (i) low pass (ii) high pass and (iii) band pass. Compare your results.

2. Design and study voltage multipliers (i) Doubler (ii) Tripler (iii) Quadrupler circuits.

3. Design and study Differential amplifier.

4. Design and study Op-amp (i) inverting (ii) non-inverting, (iii) unity gain. Also use it as (i) Differentiator (ii) integrator using (a) sine wave (b) square wave input signals.

5. Design and study (i) BCD (ii) TSL.

6. Design and study multiplexer/demultiplexer.

7. Design and study 1-bit memory and 1-bit comparator.

Evaluation Scheme:

1. PHY555a and PHY555b will be examined separately for the duration of six hours in two different sessions. The external examiner(s) will be appointed by the Dean Office. The HoD or program coordinator will appoint internal examiner(s).

2. The final practical exam (60%) will be graded on the basis of the following marking scheme:

Record file:	20%	Experiment:	50%
Error Analysis:	10%	Viva:	20%

THIRD SEMESTER

PHY601: Quantum Field Theory 3 CH (45L+15T)

Nature of the course: Theory Full Marks: 75 Pass Marks: 37.5

Course Description:

This course is aimed to provide knowledge regarding relativistic particles and the importance of field concepts for those systems.

Objectives:

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

Course Contents:

1. **Relativistic Single Particle Theory (Zero Spin): [5 hours]**
   - **1.1.** Klein-Gordon equation,
   - **1.2.** Physical Interpretation,
   - **1.3.** Charged Spin-zero Free Particle,
   - **1.4.** Eigenvalues of Operators,
   - **1.5.** Interaction with Electromagnetic Field.

2. **Relativistic single particle theory (Half Spin): [12 hours]**
   - **2.1** Dirac Equation: Dirac Matrices,
   - **2.2** Charge density and charge current density, basic matrices,
   - **2.3** Spin of a Dirac Particle,
   - **2.4** Free Particle Solutions: Dirac Positron,
   - **2.5** Solution for Neutrino,
   - **2.6** Velocity of Dirac Particle: Zitterbewegung,
   - **2.7** Magnetic Moment,
   - **2.8** Charge Conjugation,
   - **2.9** Exact Solution of Central potential problems: Hydrogen Atom,
   - **2.10** Dirac Particle in One-dimensional Box

3. **Method of Second Quantization: [6 hours]**
   - **3.1** Bosons,
   - **3.2** Fermions,
   - **3.3** System of Interacting Nosons: Superfludity,
   - **3.4** System of Interacting Fermions: Superconductivity.

4. **Klein-Gordon Field: [5 hours]**
   - **3.1** Klein-Gordon Field as Harmonic Oscillator,
   - **3.2** Klein-Gordon Field in Space-Time: Casualty,
   - **3.3** Klein-Gordon Propagator.

5. **Dirac Field: [12 hours]**
   - **4.1** Lorentz Invariance in Dirac Field,
   - **4.2** Weyl Spinors,

4.3 Dirac Matrices: spin and gamma,
4.4 Dirac Field Bilinears,
4.5 Quantization of the Dirac Field,
4.6 Dirac Propagator,
4.7 Discrete Symmetries in the Dirac Theory.

6. **Interacting Field:** **[5 hours]**
5.1 Perturbation Theory,
5.2 Perturbation Expansion of Correlation Function,
5.3 Wick's Theorem.

Text Books:

1. Peskin M. E and Schroeder D. V. – **An Introduction to Quantum Field Theory**, Perseus Books Publishing (1995).
2. Agrawal B. K. and Hari Prakash - **Quantum Mechanics**, Prentice Hall of India (1977).

Reference Books:

1. Weinberg, Steven – **The Quantum Theory of Fields**, Vol. I. Cambridge University Press, (2005).
2. Greiner, Walter – **Field Quantization,** Springer (2006).
3. Zee, Tony – **Quantum Field Theory in a Nutshell,** Princeton University Press (2003).
4. Nair, V. P. – **Quantum Field Theory: A Modern Perspective,** Springer (2005).
5. Griffiths, David – **Introduction to Elementary Particles**, Wiley (1987).
6. Wachter A. – **Relativistic Quantum Mechanics**, Springer (2011).

PHY602: Electrodynamics II 3 CH (45L+15T)

Nature of the course: Theory Full Marks: 75 Pass Marks: 37.5

Course Description:

The aim of the course is to impart knowledge of classical electrodynamics and an introduction of Quantum Electrodynamics. This is in continuation of the second semester course.

Objectives:

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

Course Contents:

1. **Relativistic electrodynamics:** **[12 hours]**
   - **1.1** Lagrangian and Hamiltonian of relativistic charged particle in external electromagnetic field,
   - **1.2** Motion in a Uniform, Static Magnetic Field,
   - **1.3** Motion in combined, Uniform, Static Electric and Magnetic Fields,
   - **1.4** Lagrangian for electromagnetic field,
   - **1.5** Canonical and symmetric stress tensors; Conservation laws,
   - **1.6** Solution of wave equation in covariant form.

2. **Scattering:** **[10 hours]**
   - **2.1** Energy transfer in a Coulomb collision between heavy incident particle and stationary free electron; energy loss in hard collisions,
   - **2.2** Energy loss from soft collisions; total energy loss,
   - **2.3** Density effects in collision, energy loss,
   - **2.4** Elastic scattering of fast particles by atoms,
   - **2.5** Mean Square of Scattering: Angular Distribution of Multiple Scattering.

3. **Radiation by moving charge:** **[12 hours]**
   - **3.1** Lienard - Wiechert potentials and fields for a point charge,
   - **3.2** Total power radiated by an accelerated charge,
   - **3.3** Angular distribution of radiation emitted by an accelerated charge,
   - **3.4** Radiation from extremely relativistic charge,
   - **3.5** Frequency and angular distribution of energy,
   - **3.6** Frequency spectrum of Radiation by relativistic charges in circular motion,
   - **3.7** Thomson scattering.

4. **Brehmsstrahlung**: **[3 hours]**
   - **4.1** Radiation emitted during collisions,
   - **4.2** Brehmsstrahlung in Coulomb collision (Classical Brehmsstrahlung only).

5. **Quantum Electrodynamics: Interaction of Light with Matter** **[8 hours]**
   - **5.1** Fermi's Method: A Discussion,
   - **5.2** Laws of Quantum Electrodynamics,
   - **5.3** Absorption of Light,
   - **5.4** Selection Rules,
   - **5.5** Equilibrium of Radiation,

5.6 Scattering of Light.

Text Book:

1. Jackson J. D.**– Classical Electrodynamics (3rd Ed),** John Wiley and Sons, New York (1998).
2. Feynman R. P., Huggins R. P., Yura H. T. – **Quantum Electrodynamics**, W. A. Benjamin Inc. (1961).

Reference Book:

1. Panofsky W.K.H. and Phillips M. **– Classical Electricity and Magnetism,** Addison - Wesley, Reading Mas (1962).
2. Greiner, Walter **– Classical Electrodynamics,** Springer-Verleg, New York (1998).
3. Griffiths David J. **– Introduction to Electrodynamics** (4th Ed.), Addison-Wesley (2013).
4. Peskin M. E and Schroeder D. V. – **An Introduction to Quantum Field Theory**, Perseus Books Publishing (1995).

PHY603: Math Physics II 3 CH (45L+15T)

Nature of the course: Theory Full Marks: 75 Pass Marks: 37.5

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 Variables:** **[15 hours]**

   1.1 Complex variables and functions,
   1.2 Cauchy – Riemann conditions: analytic functions,
   1.3 Derivatives of analytic functions,
   1.4 Cauchy integral theorem, formula and applications;
   1.5 Laurent expansion,
   1.6 Singularities: poles, branch points, analytic continuation,
   1.7 Calculus of residues and applications
   1.8 Evaluation of definite integrals,
   1.9 Evaluation of sums,
   1.10 Mapping and conformal transformations,
   1.11 Method of steepest descents,
   1.12 Dispersion relations.

2. **Probability and Statistics:** **[15 hours]**

   2.1 Review of probability,
   2.2 Random variables: discrete Probability, mean and variance,
   2.3 Moments of probability,
   2.4 Covariance and correlation, marginal and conditional probability,
   2.5 Distribution functions: binomial, Poisson and Gauss normal distributions,
   2.6 Transformation of random variables,
   2.7 Error propagation,
   2.8 Fitting curves to data,
   2.9 The χ^2 distribution,
   2.10 Student-t- distribution,
   2.11 Confidence intervals,
   2.12 Error analysis

3. **Curvature & Field Equation:** **[15 hours]**

   3.1 The Riemann Tensor,
   3.2 Properties of Riemann Tensor,
   3.3 Riemannian Curvature,
   3.4 The Ricci Tensor,
   3.5 Zero Curvature and Euclidian Metric,

3.6 Flat Riemannian Spaces,
3.7 Normal Coordinates,
3.8 Schur's Theorem,
3.9 The Einstein Tensor,
3.10 The Einstein Field Equation.

Textbooks:

1. Arfken G.B., Weber H.J. and Harris F.E – **Mathematical Methods for Physicists**, 7^{th} Edn., Academic Press, Amsterdam (2013).
2. Spiegel Murray R. – **Theory and Problems of Statistics (Schaum Series),** McGraw Hill, London (1992).
3. Key D. K – **Tensor Calculus,** Schaum Series, McGraw Hill, London (1988).

Reference Books:

1. Mathew, J. & Walker, R. – **Mathematical Methods in Physics,** Benjamin, Menlo Park, Second Edition (1970).
2. Riley K.F., Hobson M.P. and Bence S. J., **Mathematical Methods for Physics and Engineering**, 3^{rd} Edn., Cambridge University Press, New York (2006).
3. Copson, E.T. – **An Introduction to the Theory of Functions of Complex Variable,** Oxford Clarendon Press (1935).
4. Margenu & Murphy – **Mathematics for Physicist and Chemist**, East, West Press Pvt. Ltd., New Delhi (1964).
5. Morse, P.M. & Feshbach H. – **Methods of Theoretical Physics,** Part I & II, McGraw Hill, New York (1953).

PHY604: Computational Physics Lab 4 CH (P180+20T)

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

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.

Prerequisite

(1) Students should have appropriate laptop of their own. He/She should bring it in the class as well. The class-work and home-work should be done in their laptops. The required software will be installed by the department.

(2) Fundamental knowledge about the operating system *Linux* is highly recommended.

Course Contents

1. **Introduction:** **[20 hours]**
   - **1.1** Motivation,
   - **1.2** Important invention by computational physics,
   - **1.3** Error, Precision, and Stability in Computational Science,
   - **1.4** Limitations of Computational Physics.

2. **Basics of Computational Physics:** **[40 hours]**
   - **2.1** Operating Systems – MS Windows and Linux,
   - **2.2** Editors in Linux,
   - **2.3** Plotting programs – Gnuplot/Xmgrace with examples,
   - **2.4** Mathematica,
   - **2.5** Programing language(s)– Fortran/C.

3. **Numerical Methods**: **[120 hours]**
   - **3.1** Functions and Roots:
     - 3.1.1 Finding Roots of a function; Newton-Raphson method,
     - 3.1.2 Rates of convergence,
     - 3.1.3 Accelerating the rate of convergence,
     - 3.1.4 An Example from Quantum Mechanics.
   - **3.2** Interpolation and Extrapolation:
     - 3.2.1 Lagrange interpolation,
     - 3.2.2 Cubic spline interpolations,
     - 3.2.3 Approximation of derivatives,
     - 3.2.4 Richardson extrapolation,
     - 3.2.5 Curve fitting by least squares,
     - 3.2.6 Nonlinear least squares.
   - **3.3** Numerical integration:
     - 3.3.1 Trapezoidal Rule,
     - 3.3.2 Simpson's Rule,

3.3.3 The simple pendulum,
3.3.4 Multidimensional numerical integration,
3.3.5 Monte Carlo numerical integration.

3.4 Ordinary differential equation
3.4.1 Euler methods,
3.4.2 Runge-Kutta Methods,
3.4.3 Second order differential equation,
3.4.4 Phase space of a simple harmonic oscillator,
3.4.5 One-Dimensional Schroedinger equation (example with anharmonic potential).

3.5 Partial differential equation:
3.5.1 Laplaces equation,
3.5.2 Wave equations and heat equation.

Note: *Students must be able to write code themselves in each topic with Fortran/C OR develop mathematica module*

4. **Applications of computational physics** **[20 hours]**
   4.1 Simulation of Ising model,
   4.2 ALADIN2.5 in Astrophysics.

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).
3. Scarborough J.B. – **Numerical Analysis,** John Hopkins Press, USA (1962).
4. Press, M. et al. – **Numerical Recipe in C**, Cambridge University Press, or, Foundation Book, India (1998).

PHY605: Term Paper (III) 2 CH

Nature of the course: Research/Presentation Full Marks: 50 Pass Marks: 30

Course Description:

This course develops the skill of research work in Physics.

Objectives:

The course will give an exposure to the students regarding the problem identification in the various areas of research work in Physics by performing book, literature review and finally deliver a presentation followed by VIVA examination.

Term Paper Guidelines

1) A student can do project work only if a physics faculty of the department agrees to guide his/her Term Paper. The criteria for the '***Term Paper Guidance***' will be developed by the Central Department Research Committee (CDRC).

2) Term Paper will be carried out in groups of either two or three students under a project. They should work as a team for their objectives. This course will be offered in the third semester to the students who already enrolled for the dissertation, and the rest students with two elective papers will do it in the fourth semester.

3) The nature of Term Paper work can be field oriented, theoretical, computational, observational and experimental. Whatever the nature of the work, students should **critically review literature** of the area of interest and identify the problem specifically. It is expected that the problem can be addressed through a method.

4) Students should prepare a one-page proposal (title with a brief description) and submit it to the department within 2 months of the beginning of third semester. Supervisor should sign the proposal.

5) The Term Paper report should be submitted by students separately. The format of the Term Paper report will be decided by the Central Department Research Committee (CDRC). There will be a final presentation by the group followed by VIVA examination. The final VIVA examination will be held within one months of third semester practical examination. The Dean Office will appoint the external examiner of final VIVA examination. The evaluation committee for the final VIVA examination consist 4 members - HoD or program coordinator, supervisor, external and internal examiner.

6) There will be additional fee for the Term Paper. It should be paid by the student during submission. The remuneration for the evaluation committee will be the same as the M.Sc. Project Work decided by the IoST, TU in the year 2072.

Text Books:

1. All related literatures, masters' dissertation and Ph.D. thesis of various areas of Physics can be reading/performing material for term paper.

Reference Books:

1. All the books that are the text books and reference book of M.Sc. first to fourth semester curriculum can be reference material for the term paper.

FOURTH SEMESTER

PHY651: Particle Physics 3 CH (45L+15T)

Nature of the course: Theory Full Marks: 75 Pass Marks: 37.5

Course Description:

This course is aimed to provide knowledge regarding applications of quantum mechanics for high energy particles.

Objectives:

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

Course Content:

1. **Scattering – Method of Partial Waves: [10 hours]**
   1.1 Scattering of a wave packet,
   1.2 Elastic Scattering of Plane Waves: Cross-Section,
   1.3 Method of Partial Waves,
   1.4 Scattering by a Finite Range Central Potential, optical theorem, phase shift,
   1.5 General Finite Potential,
   1.6 Square Well Potential,
   1.7 Scattering by Complex Potential: Breit-Wigner formula,
   1.8 Coulomb Scattering.

2. **Scattering – Method of Perturbation: [10 hours]**
   4.1 Perturbation Approximation,
   4.2 Green Function,
   4.3 Born Approximation: Born formula,
   4.4 Validity of Born approximation,
   4.5 Applications: screening coulomb potential, square well potential, Gaussian potential.

3. **Particle Interactions**: **[7 hours]**
   3.1 Introduction to Feynman diagrams, Feynman rules
   3.2 Particle exchange: forces and potentials, calculation of amplitudes
   3.3 Range of forces,
   3.4 Yukawa potential,
   3.5 Observable quantities: cross sections and decay rates: amplitudes, cross-sections and unstable states.

4. **Particle phenomenology - Leptons: [6 hours]**
   5.1 Lepton multiplets and lepton numbers,
   5.2 Neutrinos,
   5.3 Neutrino mixing and oscillations,
   5.4 Neutrino masses,
   5.5 Universal lepton interactions – the number of neutrinos.

5. **Particle phenomenology - Quarks: [7 hours]**
   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.

6. **Future Prospects:** **[5 hours]**
6.1 The standard model,
6.2 Symmetries and conservation laws,
6.3 Higgs boson,
6.4 Grand unification,
6.5 Supersymmetry,
6.6 Particle astrophysics.

Text books:

1. Martin B. R. – **Nuclear and Particle Physics**, John Wiley & Sons (2006).
2. Agrawal, B. K. & Prakash, H. – **Quantum Mechanics,** Prentice Hall of India, New Delhi (1997).

Reference books:

1. Griffiths, David – **Introduction to Elementary Particles**, Wiley (1987).
2. Perkins D. H. – **Elementary Particle Physics**, Addison Wesley Publisbing Company Inc. (1986).
3. Martin B. R. & G. Shaw – **Particle Physics**, JohnWiley & Sons Ltd, The Atrium, Southern Gate, Chichester,West Sussex, United Kingdom (2008).
4. Perkins D. H. – **Introduction to High Energy Physics**, Cambridge University Press, 4th Edition (2001).
5. Feynman R. P., Huggins R. P., Yura H. T. – **Quantum Electrodynamics**, W. A. Benjamin Inc. (1961).
6. Peskin M. E and Schroeder D. V. – **An Introduction to Quantum Field Theory**, Perseus Books Publishing (1995).

PHY652: Physics Lab 3 4 CH (P180+T20)

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

Course Description:
Physics lab 3 consists of two sections: (a) General Experiments and (b) Electronics experiments, each of two credit hours, as follows:

Course Code	Course Title	Credit Hour	Practical hour
PHY652a	General Experiments	2	P90+T10
PHY652b	Electronics Experiments	2	P90+T10

Students are required to perform at least 5 experiments in each course from the list.

Course Objectives
- To provide students with skill 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.
- To make them to interpret results by performing error propagation, analysis and interpretation.

PHY652a: General Experiments 2 CH (P90+T10)

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

The general experiments consist in four labs: (a) General Experiments (b) Optical Experiments, (c) Nuclear Experiments and (d) Computational Experiments. In the fourth semester, students perform important physics experiment and learn the result through detailed analysis. During this semester, students have to perform at least 5 experiments in 90 working hours in order to fulfill 2 CH. Students are required to perform 6 hours laboratory work every week. ***One credit hour lab work requires 3 hours lab work per week throughout the semester***. In addition, there will be 10 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 6 experiments from the list (given below). The marking scheme is as follows:

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

Course Contents:

1. Study the Frank-Hertz Experiment to study the quantum nature of the substances.
2. Study the half life of the given radioactive substance.
3. Study the Cauchy's constants for given prisms (i) crown glass (ii) flint glass and hence compare them.
4. Study the Pyranometer to measure the solar radiation flux density (W/m^2). Also use it as a detector.

5. Use Febry-Perrot interferometer to study the Zeeman effect.

6. Study the forbidden gap of the given materials by using four probe methods.

7. Study the Fourier series and Transform by using Oscilloscope.

8. Study the damped harmonic oscillator to find damping constant, frequency, under damping, over damping and critical damping.

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PHY652b: Electronics Experiments 2 CH (P90+10T)

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

The electronic experiments consist in three labs: (a) General Electronic Experiments (b) Oscilloscope Experiments (c) Computational Experiments. In fourth semester, students develop skill of designing physics experiment and discuss the results through error propagation, analysis and interpretation. During this semester, students have to perform at least 5 experiments in 90 working hours in order to fulfill 2 CH. Students are required to perform 6 hours laboratory work every week. ***One credit hour lab work requires 3 hours lab work per week throughout the semester***. In addition, there will be 10 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 6 experiments from the list (given below). The marking scheme is as follows:

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

Course Contents:

1. Design and use Op-amp to generate (i) Square (ii) Triangular (iii) Saw-tooth & (iv) Sine wave signals.

2. Design and study AM circuit.

3. Design and study D/A & A/D converter.

4. Design and study pulse amplifier.

5. Construct a dynamo circuit. By changing the speed of the motor, generate the ac signal and measure its frequency using Lisajous pattern.

6. To perform given program by using 8085 microprocessor : (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)

7. To perform given program by using 8085 microprocessor : (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.

8. To perform given program by using 8085 microprocessor : (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

Evaluation Scheme:

1. PHY652a and PHY652b will be examined separately for the duration of six hours in two different sessions. The external examiner(s) will be appointed by the Dean Office. The HoD or program coordinator will appoint internal examiner(s).

2. The final practical exam (60%) will be graded on the basis of the following marking scheme:

Record file:	20%	Experiment:	50%
Error Analysis:	10%	Viva:	20%

PHY653: Term Paper (IV) 2 CH

Nature of the course: Research/Presentation Full Marks: 50 Pass Marks: 30

Course Description:

This course develops the skill of research work in Physics.

Objectives:

The course will give an exposure to the students regarding the problem identification in the various areas of research work in Physics by performing book, literature review and finally deliver a presentation followed by VIVA examination.

Term Paper Guidelines

1) A student can do project work only if a physics faculty of the department agrees to guide his/her Term Paper. The criteria for the '***Term Paper Guidance***' will be developed by the Central Department Research Committee (CDRC).

2) Term Paper will be carried out in groups of either two or three students under a project. They should work as a team for their objectives. This course will be offered in the fourth semester to the students who have chosen two elective courses (non-dissertation student).

3) The nature of Term Paper work can be field oriented, theoretical, computational, observational and experimental. Whatever the nature of the work, students should **critically review literature** of the area of interest and identify the problem specifically. It is expected that the problem can be addressed through a method.

4) Students should prepare a one-page proposal (title with a brief description) and submit it to the department within 2 months of the beginning of third semester. Supervisor should sign the proposal.

5) The Term Paper report should be submitted by students separately. The format of the Term Paper report will be decided by the Central Department Research Committee (CDRC). There will be a final presentation by the group followed by VIVA examination. The final VIVA examination will be held within one months of fourth semester practical examination. The Dean Office will appoint the external examiner of final VIVA examination. The evaluation committee for the final VIVA examination consist 4 members - HoD or program coordinator, supervisor, external and internal examiner.

6) There will be additional fee for the Term Paper. It should be paid by the student during submission. The remuneration for the evaluation committee will be the same as the M.Sc. Project Work decided by the IoST, TU in the year 2072.

Text Books:

1. All related literatures, masters' dissertation and Ph.D. thesis of various areas of Physics can be reading/performing material for term paper.

Reference Books:

1. All the books that are the text books and reference book of M.Sc. first to fourth semester curriculum can be reference material for the term paper.

ELECTIVE COURSES

THIRD SEMESTER

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List of elective courses offered for M.Sc. (Physics) at Tribhuvan University. The credit hour, pass and full marks, nature of the course and class hours are given.

Course Code	Courses	CH	Full Marks	Pass Marks	Nature of Course	Class Hour
PHY611	Advanced Solid State Physics I	2	50	25	Theory	L30+T10
PHY612	Astrophysics I	2	50	25	Theory	L30+T10
PHY613	Atmospheric Physics I	2	50	25	Theory	L30+T10
PHY614	Biomedical Physics I	2	50	25	Theory	L30+T10
PHY615	Condensed Matter Physics I	2	50	25	Theory	L30+T10
PHY616	Galactic Physics I	2	50	25	Theory	L30+T10
PHY617	General Theory of Relativity	2	50	25	Theory	L30+T10
PHY618	Microprocessor & Optoelectronics	2	50	25	Theory	L30+T10
PHY619	Nano Physics I	2	50	25	Theory	L30+T10
PHY620	Physics of Materials I	2	50	25	Theory	L30+T10
PHY621	Plasma Physics I	2	50	25	Theory	L30+T10
PHY622	Solid Earth Geophysics I	2	50	25	Theory	L30+T10
PHY623	Entrepreneurship for Physicist	non-credit			Theory	L30+T10
		26				

Note: Students are required to take at least one course from the above table. Two elective courses can be taken if students are not offered dissertation. The course PHY623 is the non-credit course. Interested students are required to pay separately for the non-credit course.

Elective Paper Pool: Students should not allow taking two courses from a pool.

Group A	Group B	Group C
Adv. Solid State Physics I	Astrophysics I	Bio Medical Physics I
Microprocessor & Optoelectronics	Atmospheric Physics I	Galactic Physics I
Nano Physics I	Condensed Matter Physics I	Physics of Materials I
Solid State Geophysics I	General Theory of Relativity	Plasma Physics I

PHY611: Advanced Solid State Physics I 2 CH (L30+T10)

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 Content:

1. Introduction: **[2 hours]**

1.1 Non-interacting Electron Gas.

2. Born-Oppenhemier Approximation: **[3 hours]**

2.1 Basic Hamiltonian,
2.2 Adiabatic Approximation,
2.3 Reduced electron problem.

3. Second Quantization: **[5 hours]**

3.1 Bosons,
3.2 Fermions,
3.3 Fermion operators.

4. Hartree-Fock Approximation: **[4 hours]**

4.1 Noninteracting limit,
4.2 Hartree-Fock Approximation,
4.3 Diagrams.

5. Interacting electron gas: **[4 hours]**

5.1 Uniform electron gas,
5.2 Hartree-Fock excitation spectrum,
5.3 Cohesive energy of metals.

6. Local magnetic moments in metals: **[4 hours]**

6.1 Local moments: Phenomenology,
6.2 Mean-field solution.

7. Quenching of local moments: **[8 hours]**

7.1 The kondo problems,
7.2 Kondo Hamiltonian,
7.3 Why is J negative?
7.4 Scattering and resistivity minimum,
7.5 Electron-impurity scattering amplitude,
7.6 Kondo temperature.

7.7 Poor man's scaling.

Text Book:

1. Philip Phillips – **Advanced Solid State Physics**, Cambridge university Press, 2nd ed., Cambridge (2012).

Reference Books:

1. Taylor P. & Heinonen O. – **Quantum approach to condensed matter physics**, Cambridge University Press, (2002).
2. Altland A. and Simons B. – **Condensed matter field theory**, Cambridge University Press, south asian ed. (2008).
3. Wen Xiao-Gang – **Quantum field theory of many-body systems**, Oxford University Press, New York (2004).
4. Mahan G. – **Many-particle Physics**, 3rd ed., Springer (India), Pvt. Ltd., New Delhi (2008).

PHY612: Astrophysics I — 2 CH (L30+T10)

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 Astrophysics.

Course Objectives:

The prime motive of this course is to give an overview of basic astronomy and stellar physics.

Course Content:

1. **General Astronomy** **[6 hours]**
   - **1.1** History & developments of Astronomy,
   - **1.2** Stellar spectra,
   - **1.3** Harvard classification,
   - **1.4** Yerkes classification,
   - **1.5** Astronomical time scales: nuclear time scale,
   - **1.6** Thermal and dynamical time scales,
   - **1.7** Mass-luminosity-age relation of the main sequence star,
   - **1.8** Theory of random walk: photon in the star,
   - **1.9** Local Thermodynamical equilibrium.

2. **Stellar Magnitude:** **[5 hours]**
   - **2.1** Stellar magnitude: apparent and absolute,
   - **2.2** Opacity: distance-magnitude-extinction relation,
   - **2.3** Colour index: Reddening of light,
   - **2.4** Colour excess: Photometry.

3. **Pressure Exerted by the Stellar Interior:** **[6 hours]**
   - **3.1** Non-degenerate gas pressure: Chemical composition of the star,
   - **3.2** Degenerate (both relativistic and non-relativistic) gas pressure,
   - **3.3** Pressure exerted by the photons in the star: radiation pressure.

4. **Internal Equilibrium Conditions:** **[6 hours]**
   - **4.1** Hydrostatic equilibrium: pressure gradient,
   - **4.2** Mass-continuity relation: mass gradient,
   - **4.3** Radiative and convective energy transport: temperature gradient,
   - **4.4** Luminosity gradient.

5. **Stellar Model:** **[7 hours]**
   - **5.1** Linear stellar model.
   - **5.2** Polytrophic model: Lane-Emden differential equation & its solution.
   - **5.3** Polytrophic model: electron degenerate star.
   - **5.4** Polytropic Model: neutron degenerate star.

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).

PHY613: Atmospheric Physics I 2 CH (L30+T10)

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. The Earth atmosphere: **[2 hours]**

1.1 **Scope,** definitions and terms of reference,
1.2 Optical properties of the atmosphere,
1.3 Structureand chemical composition of the atmosphere.

2. Atmospheric thermodynamics: **[8 hours]**

2.1 Gas laws,
2.2 Virtual temperature,
2.3 Hydrostatic equation,
2.4 The first law of thermodynamics,
2.5 Adiabatic processes,
2.6 Water vapor in air,
2.7 Atmospheric stability,
2.8 Thermodynamic diagram: SkewT-lnP diagram and its applications.

3. Absorption and scattering of solar radiation: **[8 hours]**

3.1 Solar and terrestrial radiation,
3.2 Radiation spectrum and quantitative description,
3.3 Solar constant and insolation outside the atmosphere,
3.4 Physics of scattering, absorption and emission,
3.5 Broadening of absorption lines,
3.6 Computation of solar heating rates,
3.7 Representation of polarized light and Stokes parameter,
3.8 Rayleigh scattering: theoretical development.

4. The ionosphere: **[6 hours]**

4.1 Formation and nature of ionosphere layers,
4.2 Diffusive equilibrium,
4.3 Chapman's theory of a production layer,
4.4 Rate of production of ions,
4.5 Peak electron concentration,
4.6 Determination of number density of electrons,
4.7 Transmission of radio waves.

5. Radiative transfer in the atmosphere: [8 hours]

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,
5.7 Concept of transmission function,
5.8 Band models: single spectra line, regular band model, statistical band model, Curtis-Godson approximation.

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).

PHY614: Biomedical Physics I 2 CH (L30+T10)

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

Course Description:

This course develops the formulation of biomedical physics 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 biomedical physics, and upgrade skills of computational biomedical physics.

Course Content:

1. Physics of Macromolecules: **[5 hours]**

- **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.

2. Physics of Proteins: **[5 hours]**

- **2.1** The Goals of Protein Physics,
- **2.2** Conformations of Polypeptide Chains,
- **2.3** Protein Globule-Structure and Stability,
- **2.4** Protein folding
- **2.5** Antigens and Antibodies: Structures, Iodination of Antibodies.

3. Physics of Enzymes: **[5 hours]**

- **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.

4. Physics of Nucleic Acids: **[5 hours]**

- **4.1** Structures of DNA and RNA,
- **4.2** Replication of DNA,
- **4.3** Electrostatic Potential of DNA, Genetic Code,
- **4.4** Fluorescence of Biomolecules
- **4.5** Protein Biosynthesis,
- **4.6** Types of RNA
- **4.7** Genetic disorder and cause of cancer

5. Computational Biomedical Physics-I: **[10 hours]**

- **5.1** Introduction to Molecular Dynamics and Simbiology,
- **5.2** MD of a Protein:Generation of Structure Files,

5.3 Analysis: a. Equilibrium Properties: RMSD, MB Distribution, Energies, Temperature Distributions, Specific Heat, b. Non-equilibrium properties: Heat Diffusion,Temperature Echos,

5.4 Computational Design of Bio-molecules and Study of their Functional Properties.

Text Books:

1. Tuszynski J. A., Kurzynski M. – **Introduction to Molecular Biophysics**, CRS Press, New York (2003).
2. Volkenstein M. V. – **Biophysics**, Mir Publishers, Moscow (1983).
3. Phillips J. – **Computational Biophysics**, University of Illinois at Urbana-Champaign, NIH Resource for Macromolecular Modelling and Bioinformatics, Beckman Institute (2012).

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. Narayanan P. **– Essentials of Biophysics**, New Age International Publishers, New Delhi (2008).
4. The Math Works, Inc. – **Learning Matlab & Simulink Student Version**, www. mathworks.com (2010).

PHY615: Condensed Matter Physics I 2 CH (L30+T10)

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 condensed matter physics to solve real physical problems.

Course Objectives:

The objective of this course is to train the students in the methods of condensed matter physics and apply them to solve the real problems.

Course Content:

1. Introduction: **[8 hours]**

- **1.1** An example H_2O,
- **1.2** Hard sphere liquids,
- **1.3** Liquid crystals,
- **1.4** Quasicrystals,
- **1.5** Magnetic order,
- **1.6** Random isotopic fractals,
- **1.7** Spatial correlations in classical systems,
- **1.8** Symmetry, order parameters and models.

2. Mean-field theory: **[10 hours]**

- **2.1** Landau theory,
- **2.2** Bragg-william theory,
- **2.3** The Ising model,
- **2.4** The liquid-gas transition,
- **2.5** The liquid-solid transition,
- **2.6** Variational mean field theory.

3. Field theories, critical phenomena, & renormalization group: **[12 hours]**

- **3.1** Breakdown of mean-field theory,
- **3.2** Construction of field theory,
- **3.3** The self-consistent field approximation,
- **3.4** Critical exponents, universality, and scaling,
- **3.5** The Kadanoff construction,
- **3.6** One-dimensional Ising model.

Text Books:

1. Chaikin P.M. and Lubensky T.C. – **Principles of Condensed Matter Physics**, Cambridge University Press (1995).

Reference Books::

1. Isihara A. – **Condensed Matter Physics**, Oxford University Press (1991).

PHY616: Galactic Physics I 2 CH (L30+T10)

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 galaxy, group of galaxies and their physics.

Course Objectives:

The objective of the course is to introduce the student to the galactic physics.

Course Contents:

1. **Milky Way:** **[8 hours]**
   - **1.1** Structure: disk and bulge,
   - **1.2** Stellar and galactic halo,
   - **1.3** Globular cluster,
   - **1.4** Galactic centre,
   - **1.5** Arms of the galaxy: differential rotation,
   - **1.6** Star formation in the arm,
   - **1.7** Formation of Milky way: monolithic collapse model,
   - **1.8** Hierarchy model.

2. **Classification of Galaxies:** **[10 hours]**
   - **2.1** Elliptical galaxy,
   - **2.2** Lenticular galaxy,
   - **2.3** Spiral galaxy,
   - **2.4** Spiral barred galaxy,
   - **2.5** Irregular galaxy,
   - **2.6** Hubble's classification,
   - **2.7** De Vaucouleurs system,
   - **2.8** Yerkes (or Morgan) scheme,
   - **2.9** Density profile of galaxies,
   - **2.10** Surface brightness of galaxies.

3. **Stellar Dynamics in Galaxies:** **[12 hours]**
   - **3.1** Deriving masses from Virial theorem,
   - **3.2** Luminosity-velocity relation,
   - **3.3** Crossing and relaxation time,
   - **3.4** Star-star encounters,
   - **3.5** Gravitational potential in the galaxy,
   - **3.6** The continuity equation,
   - **3.7** Collissionless Boltmann Equation,
   - **3.8** Orbits of stars in galaxies.

Text Books

1. Jones Bryn & Saha P. – **The Galaxy**, Queen Mary University of London (2004).

Reference Books:

1. Karttunan H., Kröger P., Oja H., Poutanen M., Donner K.J., **- Fundamental Astronomy**, fifth edition, Springer (2007).
2. Longair M. – **Galaxy Formation**, Springer (1998).
3. Binny J. – **Galactic Astronomy**, Princeton Series in Astrophysics, Princeton Univ. (1981).
4. Webb J. R. – **Extragalactic Astrophysics**, Morgan & Claypool Publishers (2016).

PHY617: General Theory of Relativity 2 CH (L30+T10)

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.

Course Objectives:

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

Course Contents:

1. **Introduction:** **[8 hours]**
   - **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.

2. **Tensor Analysis:** **[12 hours]**
   - **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.

3. **Field equations in free space:** **[10 hours]**
   - **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.

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: Microprocessor & Optoelectronics 2 CH (L30+T10)

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 Microprocessor. The course is designed to fulfill the following objectives.

Course objective

- To introduce the Optoelectronics theory and devices together with their application in communication system
- To give the principle of architecture of the microprocessor and its application

Course content:

1. Optical Fiber Waveguides: **[8 hours]**

- **1.1** Introduction,
- **1.2** Optical Fiber Waveguides,
- **1.3** Losses in Fibers,
- **1.4** Fiber Joining,
- **1.5** Measurement of Fiber Characteristics,
- **1.6** Fiber Materials and Fiber Cables.

2. Optical Communication System: **[12 hours]**

- **2.1** Modulation Schemes,
- **2.2** Free Space Communication,
- **2.3** Fiber Optical Communication Systems,
- **2.4** Operating Wavelength,
- **2.5** Emitter Characteristics and Emitter Design,
- **2.6** Detector Characteristics and Detector Design,
- **2.7** Choice of Fibers,
- **2.8** System Design Consideration,
- **2.9** Local Area Network,
- **2.10** Future Development.

3. Microprocessor system: **[10 hours]**

- **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,

3.10 Introduction to 8085 Assembly Language Programming.

Text Books:

1. Wilson J., Hawkes J. F. B. – **Optoelectronics an introduction**, Second Edition, Prentice Hall, India (1889).
2. Gaonkar R. S. - **Microprocessor Architecture, Programming and Applications with the 8085**, Fourth Edition, Penram International Publishing, India (1995).

Reference Books:

1. Khere R. P. – **Fiber Optics and Optoelectronics**, Oxford University Press (2004).
2. Sarkar C. K., Sarkar D. C. – **Optoelectronics and Fiber Optics Communication**, New Age International (P) Limited, Publishers, New Delhi (2001).
3. Mukhopadhyay A. K. - **Microprocessor Microcomputer and their Applications**, Second Edition, Narosa Publishing House (1999).

PHY619: Nano Physics I 2 CH (L30+T10)

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 Nano Physics.

Course Objectives:

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

Course Content:

1. **Introduction:** **[6 hours]**
   - **1.1** Nanometers, Micrometers, Millimeters,
   - **1.2** Moore's Law,
   - **1.3** Esaki's Quantum Tunneling Diode,
   - **1.4** Quantum Dots of Many Colors,
   - **1.5** GMR 100Gb Hard Drive "Read" Heads,
   - **1.6** Accelerometers in a Car,
   - **1.7** Nanopore Filters,
   - **1.8** Nanoscale Elements in Traditional Technologies.

2. **Systematics of making things smaller, Pre-quantum**: **[4 hours]**
   - **2.1** Mechanical Frequencies Increase in Small Systems,
   - **2.2** Scaling Relations Illustrated bya Simple Harmonic Oscillator,
   - **2.3** Scaling Relations Illustrated byS imple Circuit Elements,
   - **2.4** Thermal Time Constants and Temperature Differences Decrease,
   - **2.5** Viscous Forces Become Dominant for Small Particles in Fluid Media,
   - **2.6** Frictional Forces can Disappear in Symmetric Molecular Scale.

3. **Limit to smallness**: **[3 hours]**
   - **3.1** Particle (Quantum) Nature of Matter: Photons, Electrons, Atoms, Molecules,
   - **3.2** Biological examples of Nano-motors and Nano-devices,
   - **3.3** How small can one make it?

4. **Quantum Technologies Based on Magnetism, Electron and Nuclear Spin, and Superconductivity**: **[15 hours]**
   - **4.1** Two Nuclear Spin Effects: MRI (Magnetic Resonance Imaging),
   - **4.2** Electron Spin ½ as a Qubit for a Quantum Computer: Quantum Superposition, Coherence,
   - **4.3** Hard and Soft Ferromagnets,
   - **4.4** The Origins of GMR (Giant Magnetoresistance): Spin-dependent Scattering of Electrons,
   - **4.5** Spin Injection: the Johnson–Silsbee Effect,
   - **4.6** Superconductors and the Superconducting (Magnetic) Flux Quantum,
   - **4.7** Josephson Effect and the Superconducting Quantum Interference Detector (SQUID).

Textbook

1. Wolf, E.L. – **Nanophysics and Nanotechnology**, Wiley VCH, Weinheim (2006).

Reference Books

1. Mitin V. V., Kochelap V. A. and Strocio M. A. – **Introduction to nanoelectronics**, Cambridge University Press, Cambridge (2008).
2. Davies J.H. – **The physics of low dimensional semiconductors**, Cambridge University Press, Cambridge (2005).

PHY620: Physics of Materials I 2 CH (L30+T10)

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 material physics.

Course Objectives:

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

Course Content: Physics of Liquids and Liquid Metals

1. **General Properties of liquids:** **[3 hours]**
   - **1.1** Introduction,
   - **1.2** Molecular distribution function,
   - **1.3** Cluster & virial expansion of the Equation of state.

2. **Non conducting liquids & Liquid metals:** **[8 hours]**
   - **2.1** Pair potential function for non-conducting liquids,
   - **2.2** Dipolar attraction and repulsive and Repulsive terms,
   - **2.3** Atom-atom scattering experiments,
   - **2.4** Evaluation of the constants of the model potential,
   - **2.5** The effective inter atomic potential and pair potential in metals,
   - **2.6** Resistivity of liquid metals,
   - **2.7** Liquid alloys -Theory of mixture, Classical thermodynamics of mixtures, Statistical thermodynamics of mixtures, Ideal solutions, Regular solutions.

3. **Relation between pair distribution function & Pair potential**: **[7 hours]**
   - **3.1** The Yvon-born-Green equation,
   - **3.2** The Percus-Yevick equation,
   - **3.3** Solution of P-Y equation for hard sphere,
   - **3.4** Relationship between g(r) & u(r),
   - **3.5** Measurement of pair distribution function by neutron, X-ray and electron scattering methods.

4. **Correlation function**: **[5 hours]**
   - **4.1** The van-Hove distribution function,
   - **4.2** The measurement of dynamic correlation function by neutron and X-ray scattering methods,
   - **4.3** Structure factor,
   - **4.4** Relation between macroscopic properties & structure factors.

5. **Long period and Short period modes of single particle motion:** **[7 hours]**
   - **5.1** Einstein's random walk theory,
   - **5.2** Langevin Equation,
   - **5.3** Velocity correlation function,

5.4 Relation between velocity correlation function and diffusion constant,
5.5 Velocity correlation function for Brownian motion.

Text books:

1. Egelstaff P.A.– **An introduction to the Liquid State**, Academic press, London (1967).

References:

1. Hansen J.P. & Mc Donald I.R. - **Theory of simple liquids**, Academic press, London (1986).
2. Croxton A. - **An introduction to the Liquid State Physics**, John wiely & Sons, New York (1975).
3. Guggenheim E.A. – **Mixtures**, Oxford at the Clarendon press, Oxford (1952).

PHY621: Plasma Physics I — 2 CH (L30+T10)

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 Content:

1. **Introduction** **[5 hours]**
   - **1.1** Occurrence of plasmas in nature,
   - **1.2** Definition of plasma: Comparison with ordinary air,
   - **1.3** Concept of temperature,
   - **1.4** Debye shielding,
   - **1.5** The plasma parameter,
   - **1.6** Criteria for plasmas,
   - **1.7** Applications of plasma physics.

2. **Single-Particle Motions** **[10 hours]**
   - **2.1** Uniform E and B fields: E = 0, Finite E, Gravitational field,
   - **2.2** Nonuniform B field: Grad-B drift, Curvature drift, Magnetic mirrors,
   - **2.3** Nonuniform E field,
   - **2.4** Time-varying E field,
   - **2.5** Time-varying B field,
   - **2.6** Adiabatic invariants: μ, J and Φ.

3. **Introduction to Special Plasmas** **[7 hours]**
   - **3.1** Non-neutral plasmas,
   - **3.2** Solid, ultra-cold plasmas,
   - **3.3** Pair-ion plasmas,
   - **3.4** Dusty plasmas,
   - **3.5** Helicon plasmas,
   - **3.6** Plasmas in space,
   - **3.7** Atmospheric-pressure plasmas: The Paschen curve, Townsend theory of ionization, Dielectric barrier discharges, RF pencil discharges,
   - **3.8** Semiconductor etching.

4. **Fusion Energy** **[8 hours]**
   - **4.1** Importance of confinement, Lawson criterion,
   - **4.2** Magnetic fusion: Pinches and pulsed power, Magnetic mirrors, Stellarators, Tokamaks,

4.3 Inertial Fusion: Direct-drive and indirect-drive fusion, fast ignition and shock ignition.

Text Book:

1. Chen F. F. – **Introduction to Plasma Physics and Controlled Fusion (3rd ed.),** Springer International Publishing (2016).

Reference Books:

1. Bittencourt J. A. – **Fundamentals of Plasma Physics** (4th ed.), Springer-Verlag (2004).
2. Chen F. F. and Chang J. P. – **Lecture Notes on Principles of Plasma Processing**, Plenum/Kluwer Publisher (2002).
3. Lieberman M. A. and Lichtenberg A. J. – **Principles of Plasma Discharges and Materials Processing** (2nd ed.), John Wiley & Sons, Inc. (2005).
4. Duderstadt J. J. and Moses G. A. – **Inertial Confinement Fusion**, John Wiley and Sons (1982).

PHY622: Solid Earth Geophysics I 2 CH (L30+T10)

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 geophysics of the Earth.

Course Objectives:

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

Course Content:

1. **History of development and scope of geophysics**: **[3 hours]**
   - **1.1** Hypothesis for the origin of solar system,
   - **1.2** Shape and size of the Earth, gravity formula and rotation of the Earth.

2. **Importance of heat flow:** **[5 hours]**
   - **2.1** Thermal history of the earth,
   - **2.2** Sources of heat generation and temperature distribution inside the earth,
   - **2.3** Liquid nature of the outer core,
   - **2.4** Terrestrial heat flow.

3. **Internal structure and constitution of Earth**: **[14 hours]**
   - **3.1** Crust, mantle and core,
   - **3.2** Characteristics of lithosphere and asthenosphere,
   - **3.3** Causes of geodynamic process, geodynamic models,
   - **3.4** Contintntal drift, sea floor spreading,
   - **3.5** Mechanism of plate tectonics and its geological implications,
   - **3.6** New global tectonics and plate margin process geomagnetic time scale,
   - **3.7** Beinoff zones,
   - **3.8** Oceanic ridges,
   - **3.9** Evolution of triple junction,
   - **3.10** Trenches and island arcs, hot spots,
   - **3.11** Geodynamics of Indian subcontinent and formation of Himalayas,
   - **3.12** Iso-stacy, Airy.

4. **Global tectonics:** **[8 hours]**
   - **4.1** Deformation in the crust and the mantle,
   - **4.2** Transform and transcurrent faults,
   - **4.3** Faulting systems,
   - **4.4** Subduction zones,
   - **4.5** Mountain ranges,
   - **4.6** Mechanism of continental collision.

Text books:

1. Lowrie, William - **Fundamentals of Geophysics**, Cambridge University Press (1997).
2. Stacey, F.D. - **Physics of the Earth**, Brookfield Press, Brisbane (3rd ed) (1977).

3. Seth Stein and Michael Wysession – **An Introduction to Seismology, Earthquakes, and Earth Structure**, Blackwell Publishing House (2003).

Reference Books:

1. Kearey P. and Vine F.J. – **Global tectonics**, Blackwell Publishing (2^{nd} ed) (1996).
2. Bullen, K.E. and Bolt, B.A. – **An Introduction to Theory of Seismology,** (4^{th} ed), Cambridge University Press (1985).
3. Richter, C.F. – **Elementary Seismology**, Narosa Publishing House, India (1969).
4. Aki, K. and Richards, P.G. – **Quantitative Seismology - Theory and Methods**, WH Freeman and Company, New York (1980).
5. Kayal, J.R. – **Microearthquake Seismology and Seismotectonics of South Asia,** Springer (2008).

PHY623: Entrepreneurship for Physicists Non-Credit (L30)

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

Course Description:

This course aims to prepare the students for the possibility of starting their own entrepreneurial ventures with successful identification of venture opportunities and preparation of a business plan.

Course Objectives:

- Empowering necessary knowledge and skills to start new business venture
- Preparing consultant or facilitator to individual/institution aspiring for business ventures
- Developing expertise in identifying prospective business ventures and preparing plan
- Promoting self employment and creating new jobs

Course Content:

1. **Overview of the basics of Entrepreneurship:** **[6 hours]**
   1.1 Concept and elements of entrepreneurship,
   1.2 Entrepreneur and entrepreneurship,
   1.3 Entrepreneurial role in the economy,
   1.4 Emerging challenge and trends in entrepreneurship (internet and e-commerce).

2. **Entrepreneurship Growth:** **[3 hours]**
   2.1 Factors affecting entrepreneurship growth,
   2.2 Entrepreneurial thought, process and approaches.

3. **Creativity and Innovation:** **[6 hours]**
   3.1 Concept and development of creativity,
   3.2 Sources of innovation.
   3.3 History and development of successful physics entrepreneurs

4. **Entrepreneurial Risk Stress and Management:** **[5 hours]**
   4.1 Entrepreneurial risk and types,
   4.2 Entrepreneurial stress, types and sources,
   4.3 Management of stress.

5. **Business opportunity Identification:** **[2 hours]**
   5.1 Concept, sources and methods of generating new ideas

6. **Feasibility studies:** **[6 hours]**
   6.1 Concept and components,
   6.2 Business description, marketing and financial component,
   6.3 Development and production,
   6.4 Organization and management and forms of ownership.
   6.5 Selection of best option.

7. **Institutional Support to Entrepreneurship:** **[2 hours]**

7.1 Need, institutions (government, non-government and others) involved for entrepreneurial development, support modus,

7.2 Present status of institutional support and its strengths and weaknesses.

Text Books:

1. Dollinger, M.J.- **Entrepreneurship: Strategies and Resources**, Pearson Education (2003).

Reference Books:

1. Hisrich, R.D.,Peters, M.P. and Shepherd, D.A.- **Entrepreneurship,** Tata McGraw Hill Publishing Company (2007).
2. Kuratko, D.F. and Hodgetts, R.M. – **Entrepreneurship: Theory, Process and Practice**, Thomson Asia Pvt. Ltd (2005).

Course Offer Conditions:

Under the following conditions this course will be offered:

(1) The department and the colleges may or may not offer this course depending upon their plan.

(2) There will be 12-15 seminars by the experts (Entrepreneur, Industrialist, Lower, Educationalist, Executive directors of the business sector, research sector, NGO, INGO program directors, ADB program directors, Bankers, etc) in the field. Students should attend 100% seminar to earn this course.

(3) 15-18 lectures will be delivered by visiting TU faculties of other departments, colleges and expert faculties of the department. The name of the experts will be decided by the subject committee.

(4) There will be final-term examination (duration 2 hours) of this course. Students should earn B grade in the examination to earn this course.

(5) There will be no final examination of this course.

(6) There will be additional fee for this course, will be paid during fourth semester enrollment.

ELECTIVE COURSES

FOURTH SEMESTER

.
List of elective courses offered for M.Sc. (Physics) at Tribhuvan University. The credit hour, pass and full marks, nature of the course and class hours are given.

Course Code	Courses	CH	Full Marks	Pass Marks	Nature of Course	Class Hour
PHY661	Advanced Solid State Physics II	4	100	50	Theory	L60+T20
PHY662	Astrophysics II	4	100	50	Theory	L60+T20
PHY663	Atmospheric Physics II	4	100	50	Theory	L60+T20
PHY664	Biomedical Physics II	4	100	50	Theory	L60+T20
PHY665	Condensed Matter Physics II	4	100	50	Theory	L60+T20
PHY666	Galactic Physics II	4	100	50	Theory	L60+T20
PHY667	Gravitation & Cosmology	4	100	50	Theory	L60+T20
PHY668	Microelectronics	4	100	50	Theory	L60+T20
PHY669	Nano Physics II	4	100	50	Theory	L60+T20
PHY670	Physics of Materials II	4	100	50	Theory	L60+T20
PHY671	Plasma Physics II	4	100	50	Theory	L60+T20
PHY672	Solid Earth Geophysics II	4	100	50	Theory	L60+T20
PHY699	Dissertation	6	150	75	Presentation	-
		54				

Note: Students are required to take at least one course from the above table. Two elective courses can be taken if students are not offered dissertation.

Elective Paper Pool: Students should not allow taking two courses from a pool.

Group A	Group B	Group C
Adv. Solid State Physics II	Astrophysics II	Bio Medical Physics II
Microelectronics	Atmospheric Physics II	Galactic Physics II
Nano Physics II	Condensed Matter Physics II	Physics of Materials II
Solid State Geophysics II	Gravitation & Cosmology	Plasma Physics II

PHY661: Advanced Solid State Physics II 4 CH (L60+T20)

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

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 Content:

1. **Density functional theory:** **[6 hours]**
   - **1.1** The Hohenburg-Kohn theorem,
   - **1.2** Kohn-Sham formalism,
   - **1.3** Local density and the generalized gradient approximation,
   - **1.4** Electronic structure calculations.

2. **Screening and plasmons;** **[8 hours]**
   - **2.1** Thomas-Fermi screening,
   - **2.2** Plasma oscillations,
   - **2.3** Linear response theory,
   - **2.4** Dielectric response function,
   - **2.5** Stopping power of a plasma.

3. **Bosonization:** **[6 hours]**
   - **3.1** Luttinger liquid,
   - **3.2** Pair binding,
   - **3.3** Excitation spectrum.

4. **Electron-lattice interaction:** **[8 hours]**
   - **4.1** Harmonic chain,
   - **4.2** Acoustic phonons,
   - **4.3** Electron-phono interaction,
   - **4.4** Ultrasonic attenuation,
   - **4.5** Electrical conduction,
   - **4.6** Phono drag,
   - **4.7** Sound propagation.

5. **Superconductivity:** **[16 hours]**
   - **5.1** Superconductivity: phenomenology,
   - **5.2** Electron-phono effective interaction,
   - **5.3** Model interaction,
   - **5.4** Cooper pairs,
   - **5.5** Fermi-liquid theory,
   - **5.6** Pair amplitude,

5.7 BCS ground state,
5.8 Pair fluctuations,
5.9 Ground state energy,
5.10 Critical magnetic field,
5.11 Energy gap,
5.12 Quasi-particle excitation,
5.13 Thermodynamics,
5.14 Experimental applications,
5.15 Josephson Tunneling.

6. Quantum phase transition: **[8 hours]**
6.1 Quantum rotor model,
6.2 Scaling,
6.3 Mean-field solution,
6.4 Landau-Ginzburg theory,
6.5 Transport properties,
6.6 Experiments.

7. Quantum Hall Effect: **[8 hours]**
7.1 What is quantum about Hall effect,
7.2 Landau levels,
7.3 Role of disorder,
7.4 Currents at the edge,
7.5 Laughlin liquid.

Text Books:

1. Philip Phillips – **Advanced Solid State Physics** (2nd ed.), Cambridge university Press (2012).

Reference Books:

1. Taylor Philip & Heinonen Olle – **Quantum approach to condensed matter physics**, Cambridge university Press, (2002).
2. Altland Alexander and Simons Ben – **Condensed matter field theory**; Cambridge university Press, south asian ed. (2008).
3. Wen Xiao-Gang – **Quantum field theory of many-body systems,** Oxford university Press, (2004).
4. Mahan Gerald – **Many-particle Physics**, 3rd edition, Springer (India), Pvt. Ltd., New Delhi (1990).

PHY662: Astrophysics II 4 CH (L60+T20)

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

Course Description:

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

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 Content:

1. **Stellar Energy Sources:** **[6 hours]**
   - **1.1** Proton-proton chain,
   - **1.2** CNO cycle,
   - **1.3** Triple alpha process, oxygen, carbon and silicon burning, photo-dissociation,
   - **1.4** Solar neutrino problem: resolution,
   - **1.5** Nuclear coulomb energy,
   - **1.6** Nuclear reaction cross-section.

2. **Stellar Evolution:** **[10 hours]**
   - **2.1** H-R diagram: main sequence,
   - **2.2** H-R diagram: post main sequence,
   - **2.3** Schonberg-Chandrashekhar limit,
   - **2.4** Giant branch,
   - **2.5** Helium flash,
   - **2.6** Horizontal branch,
   - **2.7** Instability: variable star,
   - **2.8** Asymptotic giant branch,
   - **2.9** Planetary nebula and White dwarf,
   - **2.10** Super Giant,
   - **2.11** Neutron drip,
   - **2.12** Photodissociation,
   - **2.13** Supernova explosion.

3. **Interstellar Medium:** **[7 hours]**
   - **3.1** Components: gas, dust, magnetic field and cosmic rays,
   - **3.2** Classification of H-gas: HI, HII and H-ionized,
   - **3.3** Detection techniques for molecular, neutral and ionized Hydrogen,
   - **3.4** ISM cycle: Heating and cooling mechanism in ISM,
   - **3.5** Interstellar extinction curve

4. **Star Formation:** **[8 hours]**
   - **4.1** Molecular cloud,
   - **4.2** Jeans instability,
   - **4.3** Virial theorem,
   - **4.4** Jeans mass and length,
   - **4.5** Metallicity and planet formation,

4.6 H-R diagram: pre-main sequence.

5. **Big Bang Nucleosynthesis**: **[12 hours**]
   - **5.1** Thermal history of the Universe,
   - **5.2** Photons,
   - **5.3** Polarization,
   - **5.4** Adiabatic expansion,
   - **5.5** Radiation/matter domination,
   - **5.6** Electro-weak interactions,
   - **5.7** Photons and Leptons decoupling,
   - **5.8** Big-Bang nucleosynthesis,
   - **5.9** Supporting facts,
   - **5.10** Unsolved Issues: Horizon problem,
   - **5.11** Flatness problem,
   - **5.12** Monopole problem,
   - **5.13** Baryon asymmetry,
   - **5.14** Dark matter and dark energy problem,
   - **5.15** Contemporary models: Steady state, Static and Oscillating Universe.

6. **Large Scale Structure Formation:** **[7 hours]**
   - **6.1** Einstein field equation,
   - **6.2** Structure of the space-time: Robertson-Walker metric,
   - **6.3** Co-moving coordinate system: Hubble law,
   - **6.4** Eddington equation,
   - **6.5** Density parameter, Hubble Parameter.

7. **Galaxy:**
   - **7.1** Milky-Way: structure and formation, **[10 hours]**
   - **7.2** Classification of galaxies,
   - **7.3** Galaxy rotation curve: dark matter,
   - **7.4** ΛCDM model,
   - **7.5** Cosmic microwave background radiation: COBE and WMAP results,
   - **7.6** Galaxy Evolution,
   - **7.7** Hierarchy Model.

Text Boooks:

1. Karttunan H., Kröger P., Oja H., Poutanen M., Donner K.J., **- Fundamental Astronomy** (5th ed.) Springer, (2007).
2. Roos M. – **Introduction to Cosmology** (3rd ed.), John Wiley & Sons (2003).

Reference Books

1. Padmanabhan T. - **An Invitation to Astrophysics**, vol. 8, World Scientific (2006).
2. Stahler S. W. and Palla F. – **The Formation of Stars**, Wiely-VCH (2004).
3. Weinberg S. – **The First Three Minutes**, Fontana Paperback (1976).
4. Harwit Martin - **Astrophysical Concepts** (4th ed.), Springer (2006).
5. Palene S. - **Schaum Outline Series: Astrophysics,** McGraw Hill (2004).
6. Choudhuri A. R. - **Astrophysics for Physicists**, Cambridge University Press (2010).

PHY663: Atmospheric Physics II 4 CH (L60+T20)

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

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 chemistry: [8 hours]

- **1.1** Composition of tropospheric air,
- **1.2** Tropospheric trace gases,
- **1.3** Tropospheric aerosols,
- **1.4** Air pollution,
- **1.5** Tropospheric chemical cycles,
- **1.6** Stratospheric chemistry: Chapman's theory and anthropogenic perturbations.

2. Atmospheric diffusion: [8 hours]

- **2.1** Mathematical descriptions of spatial and temporal distribution of contaminants,
- **2.2** Eulerian approach,
- **2.3** Lagrangian approach,
- **2.4** Governing equations in turbulence,
- **2.5** Validity conditions for Eulerian and Lagrangian approaches,
- **2.6** Diffusion from instantaneous and continuous sources,
- **2.7** Mean concentration,
- **2.8** Statistical theory of turbulence diffusion.

3. Cloud microphysics: [8 hours]

- **3.1** Nucleation of water vapor condensation,
- **3.2** Microstructure of warm clouds,
- **3.3** Cloud liquid water and entrainment,
- **3.4** Growth of cloud droplets,
- **3.5** Microphysics of cold clouds,
- **3.6** Formation of precipitation,
- **3.7** Thunderstorm electrification,
- **3.8** Cloud and precipitation chemistry.

4. Atmospheric dynamics: [12 hours]

- **4.1** Kinematics of large-scale horizontal flow,
- **4.2** Dynamics of horizontal flow,
- **4.3** Prominent wind systems: Geostrophic, gradient, and thermal wind systems,
- **4.4** Suppression of vertical motion,

4.5 Conservation law for vorticity,
4.6 Potential vorticity,
4.7 Primitive equations: Pressure coordinates, hydrostatic balance, thermodynamic energy equations,
4.8 Atmospheric general circulation.

5. Atmospheric boundary layer: [12 hours]

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,
5.3 Vertical structure: temperature, humidity, winds, variation of boundary-layer structure, stratification and stability,
5.4 Evolution of boundary-layer,
5.5 Effects on boundary-layer: terrain effects, sea breezes, forest canopy, and urban effects,
5.6 Context of boundary layer.

6. Climate dynamics: [12 hours]

6.1 The present-day climate,
6.2 Climate variability,
6.3 Externally forced climate variability,
6.4 Climate equilibrium, sensitivity and feedbacks,
6.5 Greenhouse warming and climatic forcers,
6.6 Climate monitoring and prediction,
6.7 Introduction to numerical climate models.

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. Ronald Stull **– The Atmospheric Boundary Layer**,, Kluwar Academic Publisher, Netherlands (1988).
3. Brasseur G. P., Orlando J. J. and Tyndall G. S. (editors) – **Atmospheric Chemistry and Global Change**, Oxford University Press, Oxford (1999).

PHY664: Biomedical Physics II 4 CH (L60+T20)

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

Course Description:

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

Objectives:

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

Course Content:

1. Physics of Cell and Cell Membrane: [7 hours]

1.1 Organization of Animal Cell,
1.2 Structure of Cell Membrane, Fluid Mosaic Model, Fick's Law of Diffusion,
1.3 Theory of Electro-diffusion,
1.4 Active Membrane Transport,
1.5 Passive Membrane Transport, Hodkin-Katz Formula.

2. Neurophysics: [5 hours]

2.1 Structure of Nerve Cell,
2.2 Axon and nerve Impulse, Conducting properties of neurons
2.3 Generation and Propagation of Nerve Impulse: Hodkin and Huxley Theory,
2.4 EEG and EMG.

3. Blood Flow and Heart Action: [3 hours]

3.1 Blood Flow and Mechanics of the Heart,
3.2 Electrical Activities: ECG, Einthoven's Triangle.

4. Interactions of Radiation: [5 hours]

4.1 Review of Radioactivity,
4.2 Ionizing and Nonionizing Radiations
4.3 Mixture Rule: Determination of Atomic and Electronic Cross section in a Compound,
4.4 Measurement of Minimum Detectable Fraction,
4.5 Neutron Activation Analysis (NAA).

5. Radiation Quantity and Quality: [5 hours]

5.1 Radiation Intensity, Radiation Exposure,
5.2 Radiation Energy and Photon Fluence per Roentgen
5.3 Ionization Measurement: Free Air Ionization Chamber, Thimble Chamber, Condenser Chamber and Electrometer.

6. Measurement of Radiation Dose: [5 hours]

6.1 Units of Radiation Dose,
6.2 Kinetic Energy Released in the Medium (KERMA)
6.3 Relation between KERMA, Exposure and Absorbed Dose,

6.4 Dosimetry: Calorimetric Dosimetry, Photographic Dosimetry, Chemical Dosimetry and Thermo-luminescence Dosimetry (TLD).

7. Interaction of X-rays and Gamma rays in the Human Body: [3 hours]

7.1 f-factor,
7.2 Attenuation of X-ray and Gamma rays in Bones, Muscles (soft tissue), Fats and Air Cavities,
7.3 Contrast Medium

8. Imaging Techniques: [8 hours]

8.1 Gamma Camera,
8.2 Computed Tomography Scanning(CT Scanning)
8.3 Positron Emission Tomography (PET) imaging
8.4 Single Photon Emission Computed Tomography (SPECT) Imaging,
8.5 Ultrasonography Imaging,
8.6 Nuclear Magnetic Resonance (NMR) Imaging,
8.7 Whole body counting,
8.8 Electron Microscope.

9. Radiation Therapy: [5 hours]

9.1 Radio-isotopes: Production and Uses,
9.2 Brachy-therapy and Tele-therapy,
9.3 High Dose Rate (HDR) Brachy-therapy,
9.4 Linear Accelerator (LINAC),
9.5 Cobalt-60 Tele-therapy Unit,
9.6 Phantom,
9.7 Quality Assurance (QA) of Radio-diagnosis and Radiotherapy Units.

10. Radiation Protection: [4 hours]

10.1 Stochastic and Non-stochastic Effect of Radiation,
10.2 Effect of Radiation at Subcellular and Cellular Level, Survival Curve Repair,
10.3 Dose Limit and As Low As Reasonably Achievable (ALARA),
10.4 External and Internal Source of Radiation and Protection,
10.5 Radiation Hazards ad Its Control.

11. Computational Biomedical Physics-II: [10 hours]

11.1 Computational study of Proteins and Nucleic Acid Strands,
11.2 Steered Molecular Dynamics: Constant Velocity Pulling, Constant Force Pulling and Analysis of Results,
11.3 Computational Study of Binding Sites of Macromolecules,
11.4 Computational Study of Drug Molecules,
11.5 Computational Design of Drugs and their Functional Properties.

Text Books:

1. Tuszynski J. A., Kurzynski M.- **Introduction to Molecular Biophysics**, CRS Press, New York (2003).
2. Volkenstein M. V.- **Biophysics**, Mir Publishers, Moscow (1983).

3. Hendee W. R - **Medical Radiation Physics**, 4th edition, Year Book Medical Publishers INC. London (2002).
4. Phillips J. – **Computational Biophysics**, University of Illinois at Urbana-Champaign, NIH Resource for Macromolecular Modelling and Bioinformatics, Beckman Institute (2012).

Reference Books:

1. Khan F M - **The physics of Radiation Therapy** (3^{rd} ed.), Williams and Wilkins, USA (2011).
2. The Math Works, Inc.-**Learning Matlab & Simulink Student Version**, www. mathworks.com (2010).

PHY665: Condensed Matter Physics II 4 CH (L60+T20)

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

Course Description:

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

Course Objectives:

The objective of this course is to train the students in the methods of condensed matter physics and apply them to solve the real problems.

Course Content:

1. Dynamics- Correlation and Response: **[13 hours]**

- **1.1** Dynamic correlation and Response function,
- **1.2** The Harmonic oscillator,
- **1.3** Elestic waves and phonons,
- **1.4** Diffusion,
- **1.5** Langevin theory.

2. Topological defects: **[14 hours]**

- **2.1** Characterization of topological defects,
- **2.2** Examples of topological defects,
- **2.3** Energies of vortices and dislocations,
- **2.4** Vortex- unbinding and Kosterlitz-Thouless transition.

3. The behavior of electron systems: **[10 hours]**

- **3.1** Fermi-liquid theory,
- **3.2** Dieelctric functions and plasmons,
- **3.3** Long-distance impurity effects in metals,
- **3.4** Hubbard Model,
- **3.5** Anderson Model.

4. Electron correlation: **[6 hours]**

- **4.1** Correlation energy,
- **4.2** Electron-hole droplets,
- **4.3** Heavy fermion systems.

5. Two dimensional electron systems: **[8 hours]**

- **5.1** Realization of two dimensional electron system,
- **5.2** Phase transition in 2D electron system,
- **5.3** Quantum Hall effects.

6. Superconductivity and Superfluidity: **[9 hours]**

- **6.1** The phenomena of superconductivity,
- **6.2** Superfluidity of He^4,
- **6.3** Energy dispersion and vortex motion,
- **6.4** Sound in liquid He ,
- **6.5** Superfluidity of He^3.

Text Books:

1. Chaikin P.M. and Lubensky T.C. – **Principles of Condensed Matter Physics**, Cambridge University Press (1995).

Reference Books::

1. Isihara A. – **Condensed Matter Physics**, Oxford University Press (1991).

PHY666: Galactic Physics II 4 CH (L60+T20)

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 galaxy, group and clusters of galaxies and their physics.

Course Objectives:

The objective of the course is to introduce the student to the galactic and extragalactic physics.

Course Contents:

1. **Galactic Dynamics:** **[12 hours]**
   - **1.1** Orbits of stars in the Galaxy,
   - **1.2** Solution of collisionless Boltmann equation,
   - **1.3** Plummer potential,l
   - **1.4** Jean's Equation,
   - **1.5** Jean's equation in axisymmetric system,
   - **1.6** Jean's equation in spherical symmetric system,
   - **1.7** Use of Jean's equations,
   - **1.8** N-body simulations.

2. **Large Scale Structure Formation:** **[12 hours]**
   - **2.1** Newtonian Cosmology: closed flat and open Universe,
   - **2.2** Einstein field equation,
   - **2.3** Cosmological constant,
   - **2.4** Structure of the space-time: Robertson-Walker metric,
   - **2.5** Declaration parameter: closed, flat and open Universe,
   - **2.6** Co-moving coordinate system: Hubble law,
   - **2.7** Eddington equation,
   - **2.8** Density parameter, Hubble Parameter.

3. **Chemical Evolution of Galaxies:** **[10 hours]**
   - **3.1** Chemical abundances,
   - **3.2** Chemical enrichment,
   - **3.3** Galactic chemical evolution,
   - **3.4** Interstellar gas in the galaxy,
   - **3.5** G-Dwarf problem,
   - **3.6** Solution to the G-Dwarf problem,
   - **3.7** Element ratio.

4. **Rotation Curves of Galaxies:** **[12 hours]**
   - **4.1** Theoretical background,
   - **4.2** Dark matter distribution,
   - **4.3** Gravitational lensing and the dark matter,
   - **4.4** Lensing equation,
   - **4.5** Time delays,
   - **4.6** Einstein radius,
   - **4.7** Einstein ring,

4.8 Critical surface density,
4.9 The lensing potential,
4.10 Arrival time surface,
4.11 Magnification,
4.12 Galaxy clusters,
4.13 Microlensing in the Milky-way.

5. Clusters of Galaxies: **[6 hours]**

5.1 Cluster classification,
5.2 Abell cluster: richness and distance class,
5.3 Merging cluster,
5.4 X-ray cluster.

6. Galaxy evolution **[8 hours]**

6.1 Angular momentum of galaxies,
6.2 Pancake model,
6.3 Primordial vorticity theory,
6.4 Hierarchy model,
6.5 Li model,
6.6 Supercluster,

Text Books

1. Jones Bryn & Saha P. – **The Galaxy**, Queen Mary University of London (2004).

Reference Books:

1. Karttunan H., Kröger P., Oja H., Poutanen M., Donner K.J., **- Fundamental Astronomy**, fifth edition, Springer (2007).
2. Longair M. – **Galaxy Formation**, Springer (1998).
3. Binny J. – **Galactic Astronomy**, Princeton Series in Astrophysics, Princeton Univ. (1981).
4. Webb J. R. – **Extragalactic Astrophysics**, Morgan & Claypool Publishers (2016).

PHY667: Gravitation & Cosmology 4 CH (L60+T20)

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

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: **[10 hours]**

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.

2. Field equation in nonempty space: **[12 hours]**

3.1 Energy momentum tensor,
3.2 Electromagnetic field,
3.3 Field equation in non empty space,
3.4 Classical limit of gravitational equations,
3.5 Equation of motion,
3.6 Conservation law in General relativity.

3 Schwarzschild solution: **[8 hours]**

3.1 Schwarzschild solution,
3.2 Perihelia shift,
3.3 Null geodesic and bending of light,
3.4 Schwarzschild coordinates and Kruskal co-ordinates.

4 Stellar equilibrium and gravitational collapse: **[10 hours]**

4.1 Relativistic stellar structure
4.2 Interior Schwarzschild solution,
4.3 Stellar stability,
4.4 Gravitational collapse,
4.5 Virial theorem,
4.6 Jeans mass and length.

5 Cosmology: **[20 hours]**

5.1 Cosmological Principle,
5.2 Isotropy and homogeneity,
5.3 Cosmic microwave background radiation: Isotropy,
5.4 Cosmic microwave background radiation: Temperature fluctuation,
5.5 De Sitter space,
5.6 De Sitter cosmology,

5.7 Robertson Walker metric,
5.8 Kinematics in RW space,
5.9 Co-moving coordinate system: Hubble Law
5.10 Friedmann equilibrium thermodynamics,
5.11 Entropy.

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: Microelectronics 4 CH (L60+T20)

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

Course description:

This course deals with Microelectronics. The course is designed to fulfill the following objectives.

Course objective:

To give the adequate knowledge in designing digital electronics circuits

Course content:

1. Integrated Circuit Fabrication and Design: [20 hours]

- **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.

2. Signal Processing and Data Conversion: [8 hours]

- **2.1** Signal and Signal Processing,
- **2.2** Sample and Hold System,
- **2.3** Analog Multiplexer and Demultiplexer,
- **2.4** D/A Converters,
- **2.5** A/D Converters.

3. Combinatorial Digital Circuits: [20 hours]

- **3.1** Standard Gate Assemblies,
- **3.2** Binary Adders,
- **3.3** Arithmetic Functions,
- **3.4** Digital Comparator,
- **3.5** Parity Checker-Generator,
- **3.6** Decoder-Demultiplexers,
- **3.7** Data Selector Multiplexers,
- **3.8** Encoder,
- **3.9** Read Only Memory (ROM),
- **3.10** Two-Dimensional Addressing of a ROM,
- **3.11** ROM Applications,
- **3.12** Programmable ROMs (PROMs),
- **3.13** Erasable PROMs,
- **3.14** Programmable Array Logic,
- **3.15** Programmable Logic Arrays.

4. Very Large Scale Integrated System: **[12 hours]**

- **4.1** Dynamic MOS Shift Registers,
- **4.2** Ratioless Shift-Register Stages,
- **4.3** CMOS Domino Logic,
- **4.4** Random Access Memory (RAM),
- **4.5** Read Write Memory Cells,
- **4.6** Bipolar RAM Cells,
- **4.7** Charge-Coupled Device (CCD),
- **4.8** CCD Structures.

Text Books:

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

Reference Books:

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

PHY669: Nano Physics II — 4 CH (L60+T20)

Nature of the course: Theory — Full Marks: 100 — Pass Marks: 50

Course Description:

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

Course Objectives:

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

Course Content: Electronic Transport in Mesoscopic systems

1. **Preliminary concepts**: **[10 hours]**
   - **1.1** 2-Dimensional electron gas,
   - **1.2** Effective mass, Density of states,
   - **1.3** Characteristic lengths,
   - **1.4** Low field magnetoresistance,
   - **1.5** High field magnetoresistance,
   - **1.6** Transverse modes,
   - **1.7** Drift velocity or Fermi velocity.

2. **Conductance from Transmission**: **[15 hours]**
   - **2.1** Resistance of a ballistic conductor,
   - **2.2** Landauer formula,
   - **2.3** Where is the Resistance,
   - **2.4** What does a voltage probe measure?
   - **2.5** Non-zero temperature and bias,
   - **2.6** Exclusion principle,
   - **2.7** Use of Landauer-Buetticker formula.

3. **Transmission function, S-matrix and Green’s functions**: **[15 hours]**
   - **3.1** Transmission function and S-matrix,
   - **3.2** Combining S-matrices,
   - **3.3** Green’s functions,
   - **3.4** S-matrix and Green’s functions,
   - **3.5** Tight-binding model,
   - **3.6** Self-energy,
   - **3.7** Relation to other formalism,
   - **3.8** Feynman paths.

4. **Quantum Hall effect**: **[5 hours]**
   - **4.1** Origin of zero resistance,

4.2 Effect of backscattering.

5. **Localizations and Fluctuations**: **[7 hours]**
   - **5.1** Localization length,
   - **5.2** Weak localization,
   - **5.3** Effect of magnetic field,
   - **5.4** Conductance fluctuations,
   - **5.5** Diagrammatic perturbation theory.

6. **Double barrier tunneling**: **[8 hours]**
   - **6.1** Coherent resonant tunneling,
   - **6.2** Effect of scattering,
   - **6.3** Single electron tunneling.

Textbook:

1. Datta S. **– Electronic Transport in Mesoscopic systems,** Cambridge University Press, Cambridge (2003).

Reference Books

1. Mitin V. V., Kochelap V. A. and Strocio M. A. – **Introduction to nanoelectronics**, Cambridge University Press, Cambridge (2008).
2. Davies J.H. – **The physics of low dimensional semiconductors**, Cambridge University Press, Cambridge (2005).

PHY670: Physics of Materials II 4 CH (L60+T20)

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

Course Description:

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

Course Objectives:

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

Course Content: Physics of Liquid Crystals

1. **Liquid Crystals**: Main types & properties **[8 hours]**
   - **1.1** Introduction,
   - **1.2** The building blocks,
   - **1.3** Nematics & Cholesterics,
   - **1.4** Smectics,
   - **1.5** Columnar phases,
   - **1.6** More on long-, quasiling-, and short-range order,
   - **1.7** Remarkable features of liquid crystals.

2. **Long and Short Range Order in Nematics**: **[4 hours]**
   - **2.1** Definition of order parameter,
   - **2.2** Statistical theories of the Nematic order,
   - **2.3** Phenomenological description of the nematic-isotropic transition,
   - **2.4** Mixtures.

3. **Phase Transitions in smectics:** **[8 hours]**
   - **3.1** The A↔ N transition,
   - **3.2** Smectic A- smectic C transition,
   - **3.3** Transition involving hexatic phases.

Physics of Polymers

4. **Synthesis of polymers:** **[5 hours]**
   - **4.1** Basic definition, nomenclature and classification of polymers,
   - **4.2** Molar mass and degree of polymerization,
   - **4.3** Synthesis of polymers.

5. **Static conformations**: **[10 hours]**
   - **5.1** A single chain ,
   - **5.2** The notion of an ideal chain,

5.3 A real chain a good solvent,
5.4 The Flory calculation of the Exponent v,
5.5 Constrained chains.

6. **Polymer melts**: **[6 hours]**
   6.1 Molten chains are ideal,
   6.2 Microscopic studies of correlations in melts.

7. **Polymer solutions in good solvents** **[5 hours]**
   7.1 The mean field picture (Flory-Huggins theory),
   7.2 Scaling laws for a thermal solvent,
   7.3 Confined polymer solutions.

8. **Incompatibility and Segregation**: **[6 hours]**
   8.1 General principles,
   8.2 Polymer-polymer systems,
   8.3 Polymer plus poor solvents,
   8.4 Polymer plus polymer plus solvent.

9. **Dynamics of a single chain:** **[7 hours]**
   9.1 Historical background,
   9.2 Dynamic scaling in good solvents,
   9.3 Special flow problems,
   9.4 Problems of internal friction.

Text Books

1. de Gennes P.G. and Prost J. – **The physics of Liquid Crystals**, Clarendon Press, Oxford, (1993).
2. Young R.J. and Lovell P.A. – **Introduction to Polymers**, Chapman and Hall, London, 2nd ed., (1994).
3. de Gennes P.G. – **Scaling Concepts in Polymer Physics**, Cornell University Press (1993).

Reference Books

1. Chandrashekhar S. – **Liquid Crystal**, Cambridge University Press, London (1977).
2. Billmeyer F.W. – **Textbook of Polymer Science**, John Wiley & Sons (Aisa), Singapore (1994).
3. Doi M. and Edwards S.F. – **The Theory of Polymer Dynamics**, Clarendon Press, Oxford (1998).

PHY671: Plasma Physics II 4 CH (L60+T20)

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

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. **Plasmas as Fluids** **[7 hours]**
   - **1.1** Introduction: The dielectric constant of a plasma,
   - **1.2** The fluid equation of motion: The convective derivative, The stress tensor, Collisions, Comparison with ordinary hydrodynamics, Langmuir's paradox, Equation of continuity, Equation of state, The complete set of fluid equations,
   - **1.3** Fluid drifts perpendicular to B,
   - **1.4** Fluid drifts parallel to B: Boltzmann relation,
   - **1.5** The plasma approximation.

2. **Waves in Plasmas** **[16 hours]**
   - **2.1** Plasma oscillations,
   - **2.2** Electron plasma waves,
   - **2.3** Ion waves,
   - **2.4** Validity of the plasma approximation,
   - **2.5** Comparison of ion and electron waves,
   - **2.6** Electrostatic electron oscillations perpendicular to B,
   - **2.7** Electrostatic ion waves perpendicular to B,
   - **2.8** The lower hybrid frequency,
   - **2.9** Electromagnetic waves with $B_0 = 0$, experimental applications,
   - **2.10** Electromagnetic waves perpendicular to B_0: Ordinary wave and Extraordinary wave,
   - **2.11** Cutoffs and resonances,
   - **2.12** Electromagnetic waves parallel to B_0: The Whistler mode, Faraday rotation,
   - **2.13** Hydromagnetic waves: Alfvén speed,
   - **2.14** Magnetosonic waves,
   - **2.15** The CMA diagram.

3. **Diffusion and Resistivity** **[10 hours]**
   - **3.1** Diffusion and mobility in weakly ionized gases: Collision parameters, Diffusion parameters,
   - **3.2** Decay of a plasma by diffusion: Ambipolar diffusion, Diffusion in a slab, Diffusion in a Cylinder,
   - **3.3** Steady state solutions: Constant ionization function, Plane source, Line source
   - **3.4** Recombination,
   - **3.5** Diffusion across a magnetic field,
   - **3.6** Collisions in fully ionized plasmas: Plasma resistivity, Mechanics of Coulomb collisions, Physical meaning of η,

3.7 The single-fluid MHD equations,
3.8 Diffusion of fully ionized plasmas,
3.9 Solutions of the diffusion equation,
3.10 Bohm diffusion and neoclassical diffusion.

4. Equilibrium and Stability **[6 hours]**

4.1 Hydromagnetic equilibrium,
4.2 The concept of β,
4.3 Diffusion of magnetic field into a plasma,
4.4 Classification of instabilities,
4.5 Two-stream instability,
4.6 The gravitational instability.

5. Kinetic Theory **[9 hours]**

5.1 Equations of kinetic theory: Boltzmann equation, Vlasov equation, Krook collision term, Fokker–Planck equation,
5.2 Derivation of the fluid equations: Equation of continuity, Momentum equation,
5.3 Plasma oscillations and Landau damping: The meaning of Landau damping, The kinetic energy of a beam of electrons, The effect of initial conditions,
5.4 BGK and Van Kampen modes.

6. Nonlinear Effects **[12 hours]**

6.1 Sheaths: The necessity for sheaths, The planar sheath equation, The Bohm sheath criterion, The Child–Langmuir law, Electrostatic probes, Langmuir probes,
6.2 Ion acoustic shock waves: The Sagdeev potential, The critical Mach numbers, Wave steepening, Double layers,
6.3 The ponderomotive force: Self-focusing of laser,
6.4 Plasma echoes,
6.5 Reconnection,
6.6 Turbulence,
6.7 Sheath boundaries.

Text Book:

1. Chen F. F. – **Introduction to Plasma Physics and Controlled Fusion (Third edition),** Springer International Publishing (2016).

Reference Books:

1. Krall N. A. and Trivelpiece A. W. – **Principles of Plasma Physics**, San Francisco Press (1986),
2. Bittencourt J. A. – **Fundamentals of Plasma Physics** (Fourth edition), Research Gate (on-line) (2017),
3. Goldston R. J. and Rutherford P. H. – **Introduction to Plasma Physics**, IOP Publishing Ltd (1995).

PHY672: Solid Earth Geophysics II 4 CH (L60+T20)

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

Course Description:

The main aim of this course is to provide basic knowledge of geophysics of the Earth.

Course Objectives:

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

Course Contents:

1. **Origin of the geomagnetic field: [15 hours]**
   - **1.1** Polar wandering,
   - **1.2** Secular-variation and westward drift,
   - **1.3** Reversal of geomagnetic field,
   - **1.4** Geomagnetic storms,
   - **1.5** Paleomagnetism,
   - **1.6** Earth's current,
   - **1.7** Sunspot,
   - **1.8** Solar flares,
   - **1.9** Lunar and solar variations,
   - **1.10** Paleomagnetic studies of rock samples and their applications in geophysics,
   - **1.11** Radiometric dating principles and age of rocks and the Earth.

2. **Earthquake Seismology and Earth's Interior: [15 hours]**
   - **2.1** Elastic Waves,
   - **2.2** Snell's Law: the ray parameter,
   - **2.3** Surface waves,
   - **2.4** Body waves,
   - **2.5** Free oscillations,
   - **2.6** Earthquake phases,
   - **2.7** Travel-time,
   - **2.8** Inversion,
   - **2.9** Velocity structures,
   - **2.10** Hypocenter determination,
   - **2.11** Velocity Structure of the Earth.

3. **Earthquake and Himalayan Seismicity: [20 hours]**
   - **3.1** Concepts of focus, focal depth,
   - **3.2** Epicenter,
   - **3.3** Intensity and magnitude scales,
   - **3.4** Magnitude and frequency occurrence relation,
   - **3.5** Energy of earthquakes,
   - **3.6** Foreshocks and aftershocks,
   - **3.7** Elastic rebound theory,
   - **3.8** Earthquake precursors and prediction,
   - **3.9** Effects of earthquake,

3.10 Plate tectonics and Himalayan tectonics,
3.11 Global seismicity,
3.12 Seismicity of Himalayas,
3.13 Major earthquakes in Himalayas (emphasis on Nepal earthquakes of 1934, 1988 and 2015),
3.14 Seismic networks and EEWS (Earthquake Early Warning System) in Nepal.

4. **Earthquake Hazard and Risk**: **[10 hours]**
4.1 Earthquake hazard and risk,
4.2 mitigation of earthquake risk,
4.3 Seismic zoning and microzoning,
4.4 Earthquake resistant design and retro-fitting.

Text books:

1. Lowrie, Willium - **Fundamentals of Geophysics**, Cambridge University Press (1997).
2. Stacey, F.D. - **Physics of the Earth**, Brookfield Press, Brisbane (3rd ed) (1977).
3. Seth Stein and Michael Wysession – **An Introduction to Seismology, Earthquakes, and Earth Structure**, Blackwell Publishing House (2003).

Reference Books:

1. Kearey P. and Vine F.J. – **Global tectonics**, Blackwell Publishing (2nd ed) (1996).
2. Bullen, K.E. and Bolt, B.A. – **An Introduction to Theory of Seismology,** (4th ed), Cambridge University Press (1985).
3. Richter, C.F. – **Elementary Seismology**, Narosa Publishing House, India (1969).
4. Aki, K. and Richards, P.G. – **Quantitative Seismology - Theory and Methods**, WH Freeman and Company, New York (1980).
5. Kayal, J.R. – **Microearthquake Seismology and Seismotectonics of South Asia,** Springer (2008).

PHY699: Dissertation (6CH)

Nature of the course: Research Full Marks: 150 Pass Marks: 75

Course Description:

PHY699 is a dissertation work for the M.Sc. (Physics) students. This course provides an opportunity to the students to carry out original research work under the supervision of permanent physics faculty.

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 as a regular student** can opt for dissertation course in lieu of one of the elective courses prescribed in the M.Sc. physics third semester syllabus. 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, computational 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.

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. The criteria for the supervisor and co-supervisor will be decoded by CDRC.

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. In addition, that problem should be solved by using appropriate method.

3) Students should prepare a proposal and submit it to the department within two months of the beginning of the third semester. 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 (PRL format)

   The proposal defense will be held before third semester mid-term.

4) The final VIVA examination should be held within three of the fourth semester result. 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) Before the final VIVA examination, plagiarism will be checked by the appropriate software. Students need to have 'plagiarism clearance' from the CDRC.

7) 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.

3) 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

4) A separate evaluation form will be given to all four members of the evaluation committee during the VIVA examination. The format of the '***Evaluation Form***' is given in Appendix A

RESPONSIBILITIES OF EXAMINERS

The responsibilities of the supervisor, HoD, Internal examiner and external examiner will be as follows:

(1) Supervisor: Before the submission, supervisor needs to revise full text including content, format and technical languages. The originality of the content should be critically checked by the Supervisor. Co-supervisor can represent supervisor during the VIVA examination in the absence of Supervisor. VIVA examination can he held in the absence of both Supervisor and co-supervisor, if he/she has authorized another permanent faculties of the central department to take the responsibility.

(2) **HoD:** HoD will critically check the format including reference style of the dissertation and make a overlook on the content in order to select internal examiner. If format and the content is appropriate, HoD will appoint internal examiner for evaluating the content. HoD will consult supervisor to give three names for the external examiner, and send it to the Dean office. Finally, Dean Office will appoint external examiner. HoD will contact internal examiner, supervisor and external examiner to fix the date of the VIVA examination. If HoD is absent or on leave, a nominated member of CDRC can take HoD's responsibility in the VIVA examination.
Note: *In the TU constituent college, this responsibility will be carried by the coordinator of the program. In the absence of coordinator, this responsibility will go the head of the department of that subject.*

(3) Internal Examiner: The responsibility of internal examiner is to go through the detail contents (literature review, methodology, result and discussion including interpretation of the result and future works) of the submitted thesis. In addition, the originality of the content, falsification, fabrication and plagiarism will be checked by the internal examiner. If internal examiner found that the content is not appropriate for the masters' level, or there is a lot of duplication from other thesis or works, dissertation can be returned to the students with comments so that he/she can do further work and re-submit the dissertation. In any case, internal examiner should provide a written comment (form is given below) to the evaluation committee after the VIVA examination.

(4) External Examiner: The external examiner should critically review the dissertation and prepare a quationare for the students. These questions should be discussed in detail so that a proper evaluation can be carried out. In addition, any technical mistakes should be checked by the external examiner. No VIVA examination will be conducted in the absence of external examiner.

(5) Official Work: The official works includes transportation (to send dissertation to the external examiner's office or home) and processing (data entry, letter correspondence, library entry, others).

VIVA EXAMINATION PROCEDURE

1. Students should send a single pdf file of the dissertation in the e-mail address cdrc@tucdp.edu.np to the Central Department Research Committee (CDRC).

2. CDRC will check the plagiarism using software. After '**plagiarism clearance'**, students are allowed to submit 3 copies of dissertation with the signature of supervisor in loose-binding in their colleges.

3. The department will send dissertation to the Exam Section of the Dean Office, requesting for the appointment of external examiner. The department will suggest the names of three possible external examiners. After the appointment of the external examiner, dissertation will be sent to the external examiner.

4. The HoD (or program coordinator) will appoint internal examiner officially and send dissertation to him/her.

5. The official language of the VIVA exam will be English. The presentations, query/answer session should be in English. Students are asked to present their thesis in 30 minutes.

6. The floor will be open for the external and internal examiner after the completion of the student's presentation. The floor will be open for all later.

7. The evaluation form should be filled and submitted by the internal, external examiners, supervisor and HoD.

8. Students should carefully note the comments made on his/her dissertation during the VIVA examination. He/she should revise dissertation and submit 3 copies with hard-cover binding.

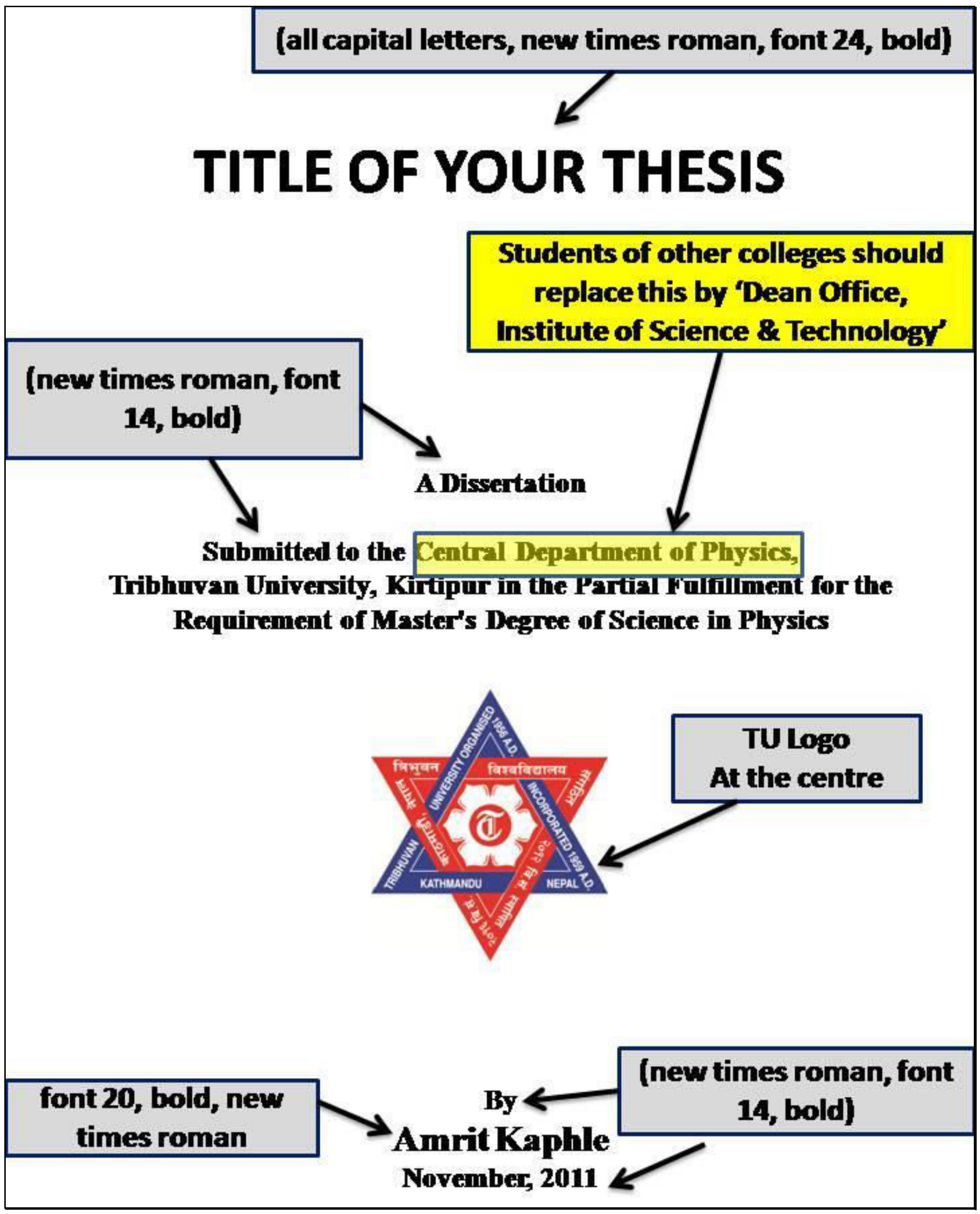
9. Student should electronically submit three CDs to the department. In the CD, final pdf file of the dissertation, appendix matter and final presentation slide should be added. A final corrected pdf file of the approved dissertation should be sent to the CDRC in the e-mail address cdrc@tucdp.edu.np.

10. Finally department will send final score confidentially to the Exam Section of the Dean Office, IoST, TU.

11. The duration between the submission of the thesis by the students and the final VIVA examination should not be less than 5 working days. At least 5 working days should be given for the examiners in order to evaluate dissertation.

M.Sc. (Physics) Thesis/Dissertation Format

1. M.Sc. (Physics) **dissertation** should be written in scientific English, font new times roman, size 12, spacing 1.5 and in a style consistent with that of the scientific/technical communication.
2. The **title** of the dissertation should be concise, but informative enough to instruct the non-expert reader and to facilitate information retrieval. Do not introduce new terminology in titles.
3. The format of the **cover page** is given (below). Thesis should be **hard cover binding** with the cover print same as the cover page. *The examination roll number should be written just below the name of the student.*



4. The author must carefully **proofread** the paper to eliminate grammatical errors, misspellings, and omission of symbols. The text should be directed at a **general readership**, not specialists. Avoid

acronyms and jargon, even if they seem of common usage. If unavoidable, define them in the text. The page number should be given at the centre of the bottom page. The title & chapter running is proffered.

5. **Notation** should be unambiguous, concise, and consistent with standard usage. Introduce new terminology or notation only when clearly needed.
6. There must be an **abstract** of no more than 1500 characters, including spaces, which should be self-contained (no footnotes) for use in abstracting journals and databases. References, comments and replies should not include an abstract.
7. **Acknowledgment page** should be used to recognize named individuals who contributed scientifically to the specific research of the paper, to cite the funding agencies that provided financial support for the work, and to note the affiliation of institutions in the byline with a larger system.
8. The **front matter** should be as follows:

   Recommendation **i** (*page number in roman*)
   (TU Logo, Full name, address of the supervisor & co-supervisor(s), their signature with statement)
   Acknowledgement **ii** (*page number in roman*)
   (follow guideline text above)
   Evaluation **iii** (*page number in roman*)
   (Full name, position and affiliation of the supervisors, head of dept, external, internal examiners, date in AD)
   Abstract **iv** (*page number in roman*)
   (follow guideline text)
   Content **v** (*page number in roman*)
9. The **main matter** should be as follows:

   Chapter 1: Introduction or Background or any terminology that introduces the research work.

   Chapter 2: Theory related matter or literature review or whatever needed.

   Chapter 3: Methods or Database or Experimental Design or Algorithm or Region of Interest or whatever needed (depending on the nature of the work)

   Chapter 4: Result and Discussion or whatever needed (depending on the nature of the work)

   Chapter 5: Conclusion or Concluding Remarks & Future work or Future Prospectus

   References

   Appendix
10. All equations should be clearly **displayed** (*with equation number: chapter number dot equation number*), and not inline text. As an example

$$f(x) = a_0 + \sum_{n=1}^{\infty}\left(a_n \cos\frac{n\pi x}{L} + b_n \sin\frac{n\pi x}{L}\right) \tag{3.4}$$

Here 3.4 represents 4^{th} equation of the third chapter. All the *variables* should be *italic* and **vectors** should be **bold** in the equation as well as in the tex. Students are allowed to put vector sign as well (in the equation as well as in the tex).

11. Figures (axis description, inset, explanations in the box in the field of the figure) should be readable. In the figure, full caption with reference/source (if needed) should be given below the figure. For an example:

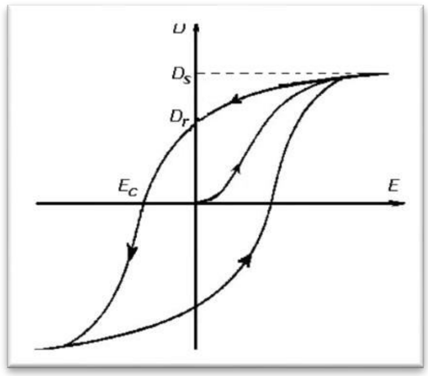


Figure 3.4: Electric displacement field *D* of a ferroelectric material as the electric field *E* is first decreased, then increased. The curves form a hysteresis loop [7].

Here [7] represents the reference from which figure is cited/explained. All figures should be explained or described in the tex, wherever needed.

12. Table (numbers, particulars, etc) should be readable. Table caption (with table number: chapter number dot table number) should be given at the top of the table. In the caption, each column should be explained clearly. For an example:

Table 3.4: A list of Galaxies that have Active Galactic Nuclei at their centre. First column lists the name of the galaxy. The next two columns give longitude (L) and latitude (B) of the galaxy. The last column represents the redshift of respective galaxies. [9]

Name	L	B	z
SDSS2349	236.82	27.72	0.0894
SDSS2350	236.86	27.75	0.0889
SDSS2351	236.89	27.85	0.0905
SDSS2352	236.98	27.92	0.0899
SDSS2353	237.00	27.83	0.0898
SDSS2354	237.01	27.87	0.0881
SDSS2355	237.36	27.10	0.0909

13. Reference style

In the text: References in text, should be in the form "Smith, Doe, and Jones [2]," or "………recent experiments [5,6]". The names of all authors of cited papers should normally be given in the references except when the number of authors is very large (say, more than 10).
The reference style should be as follows:

[cited number] Authors (first name in abbreviation & family name), journal name (standard abbreviated form), volume number (boldface), page, and year (in bracket) [cited number] Authors (first name in abbreviation & family name), book title, editor(s), publisher, and year of publication;

Examples:

Journals:

[1] J. M. Smith, R. Brown, and C. Green, Phys. Rev. B **26**, 1 (1982).

[2] R. Brown, Phys. Rev. B **26**, 706 (1982).

Books:

[3] J. M. Smith, *Molecular Dynamics*, Vol. 20, p. 20, Academic, New York (1980).

[4] R. Brown, in *Charge Density Waves in Solids*, edited by C. Green, Modern Problems in Condensed Matter Sciences Vol. 25, North-Holland Amsterdam, (1989).

Report:

[5] C. Green, University of Wisconsin, Madison, Report No. MAD/PH/650 (1991).

Conference Proceeding:

[6] J. M. Smith, in Proceedings of the Topical Meeting on *CP* Violation, 20-24 Sept. 1989, ed.: W. Bhattacharya, PHI (1990).

Ph.D. & Masters' Thesis:

[7] S. Paudel, *A New Far Infrared Nebula at -60^o Latitude*, M.Sc. (Physics) Dissertation, Central Department of Physics, Tribhuvan University, Nepal (2013).

Arxiv:

[8] E. Armsdorfer, J. Kristen, arXiv130207434N (2013).

Webpage:

[9] http://adsabs.harvard.edu/cgi-bin/ (viewed on 11 Aug. 2014).

It is important to confirm the accuracy of bibliographic information in references.

14. In order to **reproduce** figures, tables, etc., from another journal, authors must show that they have complied with the requirements of the publisher of the other journal, possibly including written agreement of both publisher and author of the originally published work. The software license should have obtained wherever used in the work. In addition official letter from the laboratory (if outside) is required.

15. Two electronic copies (single pdf file and the appendix material, including database: in CD/DVD) and 3 hardcopies of the dissertation should be submitted.

This format should be strictly followed by the M.Sc. (Physics) students of both semester system and annual system of all campuses, colleges of the nation affiliated with Tribhuvan University. New format will be effective from 1st Magh 2071.

All colleges are required send a hard copy and an electronic copy of dissertation to the Central Department of Physics before the viva examination.

Central Department Research Committee (CDRC)

CDRC meeting held on 5th December 2014 approved above format as well as guideline for masters' dissertation in Physics.

1. Prof. Dr. Binil Aryal — Chair
2. Prof. Dr. Uday Raj Khanal — member
3. Prof. Dr. Jeevan Jyoti Nakarmi — member
4. Dr. Raju Khanal — member
5. Dr. Narayan Prasad Adhikari — member

RECOMMENDATION (IoST, 2015)

M.Sc. Dissertation

On the basis of the study and consultation with the head of departments of various central departments, professors, external and internal examiners of a few departments and senior retired professors, we recommend remuneration for M.Sc. dissertation in two categories on the basis of credit hour, as follows:

Category A

The dissertation that carries 6 or less than 6 credit hour belongs to this category. The remuneration for '*Category A*' department is as follows:

Supervisor	HoD	External	Internal	Tea/Biscuit	Official Work	Total (Rs.)
4000	750	1500	1000	400	350	8,000

Category B

The dissertation that carries more than 6 credit hour belongs to this category. The remuneration for '*Category B*' department is as follows:

Supervisor	HoD	External	Internal	Tea/Biscuit	Official Work	Total (Rs.)
5500	750	2000	1200	400	350	10,200

Project Work or Term Paper

There will be a single category for the project work (whatever the credit hour) for all central departments. For the project work, the remuneration will be as follows:

Supervisor	HoD	External	Internal	Tea/Biscuit	Official Work	Total (Rs.)
2000	500	1000	500	200	100	4,300

Note: *All the recommendation mentioned above are applicable to the TU constituent colleges where M.Sc. program is running.*

APPENDIX A

Format of Dissertation Evaluation Sheet

Central Department of PHYSICS

Institute of Science & Technology, Tribhuvan University, Kirtipur

Thesis Evaluation Form

Name: ……………………………………………………………………………………

Title of Thesis: ……………………………………………………………………………

……………………………………………………………………………………………

Examination Roll No.: _______________ _ Date: ________________________

EVALUATION SCHEME

Evaluation Criteria	Evaluation	Equivalent Score	Score
Problem Identification	10%	100	
Research Design	10%	100	
Execution/Procedure	10%	100	
Research Results	10%	100	
Analysis / Interpretation	10%	100	
Conclusions, Future works	10%	100	
Justification of the sources and literature used	10%	100	
Writings	10%	100	
Presentation	10%	100	
Viva Voce Performance	10%	100	
Total		Average	
GPA			
Grade			

Additional Comments:……………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

Date, Name and signature of the examiner

____ ______________________________

Supervisor/ External Examiner/ Internal Examiner/HoD

(tick any one)